

i-RIC 2024

INTERNATIONAL RESEARCH & INNOVATION CONFERENCE

PROCEEDING

“HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY”

24 & 25 JULY

20
24

PROCEEDING I-RIC 2024

INTERNATIONAL RESEARCH AND INNOVATION CONFERENCE

“HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY”

24 & 25 JULY

20
24

All rights reserved. No part of the articles, illustrations, photos and contents in this proceeding may be republished, reprinted, reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without written permission from the Director of Politeknik Nilai.

Published by:

Politeknik Nilai Negeri Sembilan (PNS)
Kompleks Pendidikan Bandar Enstek,
71760, Bandar Enstek,
Negeri Sembilan

2024

eISBN 978-967-2742-35-7

TABLE OF CONTENT

No.	Content	Page
1	Preface	xii
2	Editorial Board	xiii
3	List of Panel Reviewers	xiv-xv
4	List of Articles	1
	A. Engineering and Technology	
	The Study of Land Surface Temperature in Kulim Hi-Tech Using Landsat OLI 8 <i>Zuraini Basarudin^{1*}, Nurul Atiqah Suhaime², Amirul Afiq Azman³, & Mohd Farid Fahmi Abdul Halim⁴</i>	2-10
	The Study of Noise Emission Level Along KTM Kajang Railway Track to Surrounding Premises <i>Karthigeyan Ramachandran^{1*}, Mohd Eizzuddin Mahyeddin² & Mohd Kamaruzaman Musa³</i>	11-14
	Programme Educational Objectives (PEO) Attainment for Diploma in Electronic Engineering (Communication) at Politeknik Sultan Salahuddin Abdul Aziz Shah <i>M. Ramli^{1*} & R. M. Zali²</i>	15-24
	Raspberry Pi Wlan Cast as A Teaching and Learning Aid in Lecture Halls <i>Mohd Hafiz Haron^{1*}, Muhammad Tarmizi Ab Aziz² & Mohd Firdaus Ibrahim³</i>	25-37
	Remote Lab: An Enhancement in Technical and Vocational Education Training (TVET) <i>Vaina Malar Panneer Selvan^{1*} & Uma Devi Nadarajah²</i>	38-49
	PLC Based Automatic Mini Conveyor Control System Trainer Prototype Design Development <i>Bakiss Hiyana Abu Bakar^{1*}, Mokhtar Bin Hashim² and Sharmiza Kamaruddin³</i>	50-57
	The Impact of Intersection Design on Traffic Volume and Road Service Level <i>Zuraidah Hashim^{1*}, Adilen @ Lucia Suil² & Khairul Nizam Mat Amin³</i>	58-62
	Power Consumption Analysis of Centrifugal Force Apparatus TM 600 <i>Arman Md Said^{1*} & Ahmad Fariz Fauzi²</i>	63-68

Comparative Analysis of Charcoal and Banana Stem Fiber Filters in Fat, Oil, And Grease Traps: A Chemical Parameter Evaluation <i>Nor Aziah Fatma Abdul Ayah @ Abdul Aziz^{1*}, Mohd Azriman Mat Ali² & Rahayu Mhd Adnan³</i>	69-75
Development of a Wind-Powered Battery Bank for Mobile Phone <i>Noranizah Solihin^{1*} & Luqman Hazim Sakariah²</i>	76-83
Smart Early Detection of Rheumatoid Arthritis Tool on Nails with A Certainty Factor Technology Approach Based on Image Processing <i>Abi Mufid Octavio¹, Andinusa Rahmandhika^{2*}, Muhammad Lutfi Kamal³, Nuri Virdausia⁴, Frenischa Yincenia Wijaya⁵, Desta Karina⁶ & Achmad Fauzan Hery Soegiharto⁷</i>	84-88
Effect of Channel Model on Flame Stability in Meso-Scale Combustor <i>Murjito^{1*}, Achmad Fauzan Hery Soegiharto², Yogi Danu Krisnanto³ & Farhan Rahmatullah⁴</i>	89-96
Design of Learnifybot: Supporting Hands-On Experience of Stem Education in Malaysia <i>Juliyanna Aliman^{1*}, Ariffuddin Ibrahim² & Er Zhi Han³</i>	97-103
Design of Cloud-Based Hydroponic Plant Monitoring System Using Aiven Cloud MySQL Database <i>Ariffuddin Ibrahim^{1*}, Juliyanna Aliman² & Muhammad Syafiq Lim³</i>	104-110
Evaluation of Tourism Development Potential of Traditional Villages in Sichuan <i>Zhou Zi Hua¹, Omar Jamaludin^{1*} & Doh Shu Ing¹</i>	111-124
Benefit of Bim at Design and Planning Stage: A Review <i>Huang Lei¹, Shu Ing Doh^{2*} & Zhang Bai Feng³</i>	125-131
Production of Biochar from Sugarcane Biomass under Slow Pyrolysis Process <i>Is Aizat Samsuri^{1*}, Auni Nurain Borhan², Nurul Insyirah Mohamad Noor³ & Nor Ahmad Danial Abdul Wahab⁴</i>	132-137
The Development of Indoor Hydroponic System <i>Johari Ahmad Ghazali^{1*}, Shanley Oyerd Bong² & Mohammad Qusayhairie Mohd Khairul³</i>	138-144
Evaluation of Biopesticides as a Sustainable Alternative for Controlling Pests on <i>Lactuca Sativa</i> (Green Coral Salad) <i>Muhammad Fadhli Tariq Ishak^{1*}</i>	145-147
Using Aloe Vera as Alternative to Rooting Hormone in <i>Petunia Hybrida</i> <i>Muhammad Fadhli Tariq Ishak^{1*}</i>	148-151

Integrating Biomimetic Design Principles from The Namib Desert Beetle into Landscape Rain Harvesting Systems to Enhance Water Collection Efficiency and Sustainability: An Early Phase <i>Mohd Khairil Hilmi Abd Halim^{1*}</i>	152-155
--	---------

Numerical Study of The Thermal Characteristics of an Integrated Solar Collector-Storage System <i>Nasser Yahya Ayed Alahmary^{1*}, Mohamad Kchaou² & Mohammed Alquraish³</i>	156-167
---	---------

Fabrication of Cat Bath Station Using Foot Paddling System <i>Mohd Rosli Saad^{1*}, Jessica Clair Peter Nonok² & Elyana Ann Rosly³</i>	168-174
---	---------

Crashing Infrastructure Projects Considering Scheduling Flexibility <i>Ali Alyami^{1*}, Mohamed Alsharyah² & Mohammed Kchaou³</i>	175-181
--	---------

B. Business and Management

Leveraging Risk Management to Enhance ESG Performance <i>Ahmad Saiful Azlin Puteh Salin^{1*}, Roslan Abd Wahab,¹ Amizahanum Adam¹ & Wan Razazila Wan Abdullah¹</i>	183-189
--	---------

The Knowledge and Practices Environmental Among Students of Kuching Polytechnic Sarawak <i>Faridah Che In^{1*}, Suraya Yope@Yahya² & Noorul`Ashikin Md Salih³</i>	190-194
--	---------

Unveiling Greenwashing: Risks in Sustainability and ESG Reporting <i>Nurul Nazlia Jamil^{1*} & Ersya Tri Wahyuni²</i>	195-206
---	---------

Is the Business Incubation Program a Catalyst in Implementing Digital Entrepreneurship Education? Developing a Multiple Case Study in Malaysian Polytechnics <i>Nur Syahirah Rosli^{1*}, Suhaida Abdul Kadir², Rahimah Jamaluddin³ & Enio Kang Mohd Sufian Kang⁴</i>	207-215
--	---------

C. Education, Teaching, and Learning

Immersive Learning Experience <i>Akhlak Islamiyyah</i> via Augmented Reality (AKHAR): ADDIE Model Approach <i>Mastura Mohamad¹, Norsalwati Mohd Razalli^{1*}, Asri Sabri¹, Zainal Ariffin Ahmad² & Ari Budiharto³</i>	217-222
--	---------

YouTube for Research Courses: Implications on Learner Satisfaction & Subject Performance <i>Nurul Hidayana Mohd Noor^{1*}</i>	223-228
--	---------

Engaging Culinary Students Through Game-Based Learning: Assessing the Culinaryconquest Board Game <i>Wan Ruhaiifi Wan Yub Ibrahim^{1*}, Ahmad Ikhwan Fitri Arefin² & Mohamad Arif Abdul Kadir³</i>	229-234
---	---------

The Development of Jawi Tutor Mobile Application using Kodular <i>Farrah Waheda Abdullah^{1*}, Nurzaitul Natasya Forkan¹ & Siti Nur'ain Maligan¹</i>	235-243
Evaluation of Pedestrian Walkways Quality at POLISAS CAMPUS using P-Index and PLOS Methods <i>Adilen @ Lucia Suil^{1*}, Tee Lian Yong² & Zuraidah Hashim³</i>	244-250
Cultivating a Culture of Trust: Enhancing Organizational Effectiveness in Malaysian Technical Education <i>Ying-Leh Ling^{1*}, Cynthia Yu Shung Chen² & Charles Muling Libau³</i>	251-256
The Effectiveness of the GDB Compiler: Online Tool for Student Learning in Programming C++ <i>Noor Afzan Ahmad^{1*}, Anis Awi² & Zuraidah Mohd Ramly³</i>	257-262
Maker Market Use: Case Survey in Temerloh Community College <i>Rozallienny Zainal^{1*} & Paliza Deraman²</i>	263-268
The Usefulness of Steps to Effective Presentation (StEP) for Beginners Module in Improving Student Presentation Skills at Sarikei Community College <i>Lesta Engkamat^{1*}, Mohammad Zahir Mohd Yazid², Ngu Toh Onn³ & Ying-Leh Ling (Ph.D)⁴</i>	269-274
The Perception of Mechatronic Engineering Diploma Students at Polytechnic Sultan Azlan Shah Towards the Implementation of Interactive Augmented Reality (AR) Visualization for Autonomous Vehicle Robots <i>Ninie Farahana Kamarulzaman^{1*}, Nur Raihana Sukri² & Limi Chong³</i>	275-281
An Analysis of Grammatical Errors in Students' Written Assignment: A Thorough Look at Dialogue Writing <i>Nor Azma Manan^{1*} & Lukman Hakimi Ahmad²</i>	282-289
The Development of Switchless for Multi-Level User <i>Mohd Saifuddin Ahmad^{1*}, Muhammad Ahmad Kamal² & Maheran Sulaiman¹</i>	290-298
Portable Solar Kit as a Teaching Tool for the Course SEE 10013: Electrical Fundamental of Certificate of Electrical Technology Programme <i>Muhamad Hafiz Abd Razak^{1*}, Jamil Sharipuddin² & Mohd Soffian Abdul Samat³</i>	299-304
Compact Solar Fish Dryer <i>Siti Saleha Abdul Azis^{1*}, Mohamad Asyraf Othoman² & Adzuieen Nordin²</i>	305-310

Tahap kemahiran, Kefahaman dan Minat Pelajar Melalui Bengkel Penghasilan Produk Berinovasi sebagai Program Pembelajaran Sepanjang Hayat <i>Ariffuddin Ibrahim^{1*} & Juliyanna Aliman²</i>	311-317
Stakeholders Perspectives on Industry Engagement Sessions in Final Year Project (FYP) Title Refinement <i>Aminah Bibi Bawamohiddin^{1*}, Munirah Abdullah¹ & Nor Hanani Mohd Yusoff¹</i>	318-323
Analysis of Malaysian Polytechnic Students that Successful Commissioned RELASIS Brigade Credit Co-Curriculum Course towards Producing Quality TVET Graduates <i>Mohammad Fahmy Ibrahim^{1*}, Kamarul Ariffin Abd Rashid² & Norfazila Ahmad³</i>	324-330
Tiktok Addiction and its Impact on Academic Performance among Teenagers <i>Amirah Othman^{1*} & Mohamad Hafizul Mohd Zaid²</i>	331-340
D. Health and Life Sciences	
Preliminary Investigation on the Use of Organic Waste as a Medium for Fast-Acting Biofiltration Systems <i>Mohamad Azlan Yusuff Abdul Rahim^{1*}, Mugilan Nalliannan², Darshini Sree Ahnathan³ & Azizah Alias⁴</i>	342-346
The Effectiveness of Tannic Acid from Tea Waste as a Coagulant for Reducing Solids & Cod in Wastewater Treatment <i>Mohamad Azlan Yusuff Abdul Rahim^{1*}, Is Aizat Samsuri², Nurul Syafika Zulkifli³, Siti Nurafiqah Nasir⁴ & Muhammad Hariz Hazwan Hamidi⁵</i>	347-350
Study of Malay Traditional Architecture Approach in Landscape Architecture Design <i>Mohamad Hafiz Sulaiman^{1*}</i>	351-357
The Potential of Shrub Plants as Soil Erosion Control <i>Mohamad Hafiz Sulaiman^{1*}</i>	358-363
Climate Change Increases the Risk of Infectious Diseases and Solutions to Address the Issues <i>Rabiatul Adawiyah Mohd Radzuan¹ & Nur Adibah Mohidem^{1*}</i>	364-379
Telang Flower: A Novel Approach to Pharmaceutical Innovation in Malaysia <i>Saiful Mohamed Shuib^{1*}, Elena Anwar² & Anwar Abdul Rahman³</i>	380-386
Development of Bio-Board from Reutilization of Spent <i>Pleurotus Cajor-Saju</i> Substrate <i>Muhammad Naim Razali^{1*} & Shaveena Devi Venilen²</i>	387-392

E. Social Sciences

Consumer Rights: What Consumers Should Know in Dealing with E-Commerce Transactions <i>Nur Farahin Afiqah Daud¹</i>	394-399
Mastery Level of Generic Skills Among Students' Community College of Sarawak Region Through Teaching and Learning Processes Via Genral Courses (MPU) <i>Chong Chiew Ching¹, Liu Tse Hui² & Ngu Toh Onn³</i>	400-405
Development of Tofu Sausage Tomyam <i>Nur Nafisa Shafie@Mohd Alias^{1*}, Latifah Mahmood² & Norzilahwati Md Noh³</i>	406-409
Retail Management Education in Malaysia: Identifying and Integrating Essential Skills <i>Nur Aliyah Azizi^{1*} & Noor Rahayu Mohd Salleh²</i>	410-415
Students' Intention Towards Sustainability: The Moderating Role of Emotional Intelligence <i>Siti Yummy Faridatul Akmar Mohamad¹</i>	416-421
Literasi Kewangan Pelajar Diploma Pengajian Perniagaan Jabatan Perdagangan Politeknik Ungku Omar <i>Sazaliana Shairali^{1*} & Yanti Yusop²</i>	422-428
Effects of Biofeedback Training on Heart Rate Variability and Performance of College Golf Players <i>Huang Donghai¹, Muhammad Nubli Abdul Wahab^{2*} & Zhang Xiuling³</i>	429-434
Levels of Student Involvement in Green Programs and Their Impact on Environmental Stewardship Attitudes <i>Zainatun Nisa Sapaat¹ & Halizah Alwi²</i>	435-440
Islamic Digital Marketing Template for Asnaf in Perlis <i>Izwan Nurli Mat Bistaman^{1*}, Muhammad Nurfiqri Mohd Hajar² & Razinda Tasnim Abdul Rahim³</i>	441-445

F. Logistic and Supply Chain Management

The Influence of Organizational Ambidexterity, Business Strategies, and Supplier Performance on Customer Satisfaction, and Its Implications on Logistics Performance at Bandung Main Branch Office of PosIND <i>Yogi Sudrajat^{1*} & Saptono Kusdanu Waskito¹</i>	447-453
Analysis of Factors That Influence the Effectiveness of Export Performance (Case Study at PT. Sinergi Mitra Lestari Indonesia) <i>Anida Wafiq Adawiyah S. Log¹ & Erna Mulyati, S.T., M.T²</i>	454-460

Analysis of Factors That Influence the Effectiveness of Hazardous and Toxic Materials Waste Warehouse Management at the Company PT Sinergi Mitra Lestari Indonesia <i>Muhammad Andrey Alfian, S. Log.¹, Dr. Erna Mulyati, S.T., M.T.²</i>	461-467
Challenges and Strategies for Rice Price Stability: A Systematic Review of Supply Chain Dynamics in Indonesia During Critical Periods <i>Rizki Alifnur Harmawan^{1*} & Erna Mulyati²</i>	468-476
Analysis and Implementation of the User-Centered Design Method in Designing a Web-Based Bidding Participation Information System: A Case Study at PT Pos Indonesia (PERSERO) <i>Kokoh Handoko^{1*} & Agus Purnomo¹</i>	477-483
The Impact of Digital Transformation, Logistics Competence, Transformational Leadership on Business Model Innovation and Its Implications for Company Performance <i>Realyta B. U. Sirait¹ & Saptano Kusdanu Waskito²</i>	484-490
A Literature Review: Analysis of Courier Business Strategies in Facing Global Challenges <i>Emay Marsita¹ & Maniah²</i>	491-500
From Farm to Fork: Leveraging Blockchain Technology to Improve Food Supply Chain Integrity in Indonesia <i>Syifa Salsabila¹ & Agus Purnomo²</i>	501-512
Integrating Advance Technology and Logistics Customer Service for Optimal Logistics Performance: A Study at Shopee Express Pangalengan Branch <i>Muhamad Faisal Nasrudin^{1*} & Agus Purnomo¹</i>	513-524
The Impact of Ambidextrous Leadership, Logistics Organizational Culture, Logistics Organizational Structure, On Logistics Innovation and Its Implications for Company Performance PT Pos Indonesia Bangkalan Branch Office <i>Ahmad Rosadi¹ & Saptano Kusdanu Waskito²</i>	525-529
Risk Management Design in Optimizing Employee Performance with The Approach of Enterprise Risk Management (ERM) <i>Ramadani Al Mantinu^{1*}</i>	530-537
Proposed Logistics Distribution Pattern for Regional Head Election in Bulukumba Regency (Case Study of the 2024 Regional Head Election) <i>Mirza Azzahra Damayanti¹ & Melia Eka Lestiani²</i>	538-551
The Impact of Export Parcel Price, Parcel Service Quality, and Logistics Service Innovation on Purchasing Decisions and the Implications for Company Performance at PT PosIND KCU Denpasar <i>Depi Darpiyan¹ & Erna Mulyati²</i>	552-557

The Impact of Dedicated Storage and Class-Based Storage Methods on the Warehouse Layout of KPK PosIND Jakarta Centrum on the Distance and Time of Item Movement <i>Hendri Lasmana¹ & Agus Purnomo²</i>	558-568
The Effect of Express Mail Service (EMS) Tariff, Direct Flight, and Logistics Competence on Service Quality and the Implications for Company Performance at PT PosIND KCU Denpasar <i>Yullia Ika Setyanhi¹ & Erna Mulyati²</i>	569-572
The Role of Dynamic Logistic Capabilities which is Influenced by Customer Experience and Operational Excellent for PT Pos Indonesia Regional West Java <i>Arif Yudha Wahyudi & Agus Purnomo M. T. (Dr.)</i>	573-576

PREFACE

It is a great privilege for us to present the proceedings of the International Research and Innovation Conference (i-RIC 2024) to the authors and delegates. We hope that you will find it useful, exciting, and inspiring. The International Research and Innovation Conference (i-RIC 2024) was held online from 24 to 25 July 2024, organized by Politeknik Nilai in collaboration with Universitas Logistik dan Bisnis Internasional (ULBI) with the theme, “Harmony in Diversity: Fostering Unity Sustainable Research and Innovation Society.”

i-RIC 2024 aims to gather more researchers, students, government agencies, and private sectors in an event with a larger international impact. The organization of this program also serves as a platform for sharing research findings, ideas, and knowledge among members of polytechnics, community colleges, higher education institutions, public universities, as well as government and private agencies involved. Researchers, academics, and experts from various sectors will have a global stage at i-RIC 2024 to discuss the latest findings and research that support sustainable development goals. The conference aims to generate knowledge to make our world greener and better for us and our future generations.

There were 4 keynote speeches covering different areas of the conference. The first day started with Associate Professor Dr. Ir. Agus Purnomo (ULBI Indonesia) talk on "How to Boost Green Supply Chain Resilience?" and Professor Dr. Mohamed Kchaou (University of Bisha, Saudi Arabia; University of Sfax, Tunisia) on "Latex Based Membrane for Oily Wastewater Treatment Technology Process and Perspectives". The second day featured Professor Dr. Recai Kus (Selcuk University, Turkey) on "Load Optimization of AISI 1040 and AISI 5140 Joint" and Dr. Umawathy a/p Technamurthy (Universiti Kebangsaan Malaysia) with her talk on "Harnessing the Potential of Maker Education in Enhancing Student Learning Outcomes".

A total of 124 presenters participated in the parallel presentation sessions, which ran smoothly over the two-day event supported by 109 i-RIC 2024 organizing committees. This included 16 online presentation moderators, 42 reviewers, 19 judges, and all participants who took the time to attend the online sessions. A total of 124 research papers and 56 innovations were presented in this program across 7 fields, namely:

- A. Engineering and Technology
- B. Business Management
- C. Education, Teaching, and Learning
- D. Health and Life Sciences
- E. Social Sciences
- F. Information Communication Technology
- G. Logistics and Supply Chain

Information regarding i-RIC 2024 can be accessed through the Program Book at <https://heyzine.com/flip-book/521619ef82.html> and overall results can be found at <http://iric.polinilai.edu.my/.../confe.../results-innovation>.

We would like to express our heartfelt thanks and sincere appreciation to all the authors for their contributions to this publication. We also express our gratitude and appreciation to all of the reviewers for their constructive feedback on the papers. Warmest thanks to the members of the organizing committee for their hard work and dedication in ensuring the success of the event.

Congratulations to everyone involved in making this conference a success.

EDITORIAL BOARD

Advisors

Tn. Haji Wan Zulkifly bin Wan Zakaria
(Director of Politeknik Nilai)
Dr. Ahmad Razimi bin Mat Lazim
(Head of Research and Inovation Unit, Politeknik Nilai)

Editor-in-Chief

Dr. Hjh. Nor Hayati Fatmi binti Talib – Politeknik Nilai

Editorial Team

Pn. Nur Hazeleen binti Bashah – Politeknik Nilai
Pn. Syafawati Noorhafizah binti Adnan Adli – Politeknik Nilai
Pn. Fauziah Shaheen binti Sheh Rahman – Politeknik Nilai
Pn. Norfaizah binti Bidin – Politeknik Nilai
Pn. Noriah binti Nawi – Politeknik Nilai
Pn. Fardhila Syahira binti Salmi Nordin – Politeknik Nilai
Dr. Yusni bin Mohamad Yusak – Politeknik Nilai

Proofreaders

Pn. Shammine a/p Dharmalingam – Politeknik Nilai
Pn. Liyana binti Ibrahim – Politeknik Nilai
Pn. Norliyana Bau binti Muhamad Affendi Bau – Politeknik Nilai
En. Muhammad Asyraf bin Abdul Ghani – Politeknik Nilai

SENARAI PANEL PENILAI

Pejabat Timbalan Ketua Pengaraj (Governan), JPPKK

1. Ts. Mohd Asnawi Abd Wahab

PPI, Jabatan Pendidikan Politeknik Dan Kolej Komuniti (JPPKK)

2. Dr. Siti Rosminah Md Derus

Bahagian Kurikulum Jabatan Pendidikan Politeknik dan Kolej Komuniti (JPPKK)

3. Ts. Dr. Raudyah Md Tap
4. Zamsalwani Zamri

Politeknik Nilai (PNS)

5. LAr Dr. Fara Diba Badrul Hisham
6. Dr. Nur Farahin Afiqah Daud
7. Dr. Yusni Mohamad Yusak
8. Dr. Wan Nor Aishah Wan Omar

Universitas Logistik dan Bisnis Internasional (ULBI)

9. Maniah

Faculty of Civil Engineering and Built Environment (UTHM)

10. Syed Burhanuddin Hilmi Syed Mohamad

Universiti Tun Hussein Onn Malaysia (UTHM)

11. Syed Burhanuddin Hilmi Syed Mohamad
12. Mohd Noor Abdullah

Universiti Malaysia Pahang al-Sultan Abdullah

13. PM Dr. Fazeeda Mohamad
14. PM Dr. Puteri Fadzline Muhamad Tamyaz

Universiti Kebangsaan Malaysia (UKM)

15. Umawathy Techanamurthy

Universiti Teknologi MARA Melaka (UiTM)

16. Dr. Ahmad Rosli Mohd Nor

Politeknik Banting (PBS)

17. Nur Raihana Sukri

Politeknik Ibrahim Sultan (PIS)

18. Dr. Hjh. Nor Haniza Mohamad

Politeknik Kuching (PKS)

19. Dr. Jam'aah Suud

Politeknik Melaka (PMK)

20. Kannan Rassiah

Politeknik Metro Johor Bahru (PMJB)

21. Khairul Nizam Mohd Khalid

Politeknik Muadzam Shah (PMS)

22. Dr. Mohammad Ridhwan Nordin
23. Dr. Affizah Mohamad Ghaffar

Politeknik Mukah (PMU)

24. Ts. Dr. Bong Siaw Wee

Politeknik Port Dickson (PPD)

25. Mazlina Mohd Tahir
26. Dr. Mohamad Siri Muslimin

Politeknik Sandakan Sabah (PSS)

27. Dr. Annafatmawaty Ismail

Politeknik Sultan Azlan Shah (PSAS)

28. Nurulaini Hafizah Mohd Hafir

Politeknik Sultan Salahuddin Abdul Aziz Shah (PSA)

29. Dr. Parameswari Shunmugam

Politeknik Tun Syed Nasir Syed Ismail (PTSN)

30. Hasyireen Abdul Halim
31. Khairunnisa A Rahman
32. Nor Hairul Palal

IPG Kampus Pendidikan Islam

33. Aminurrashid Ahmad Dahari

Kolej Komuniti Jelevu

34. Nur Hanim Othman

Kolej Komuniti Kuala Pilah

35. Helen Yong Lee Geok

Kolej Komuniti Kuching

36. Emaria Ahmad

Kolej Komuniti Mas Gading

37. Dr. Hayati Ibrahim

Kolej Komuniti Sungai Siput

38. Ts. Dr. Chow Khoo Keat

STAI Nusantara

39. Dr. Sri Andayani Mahdi Yusuf

ENGINEERING AND TECHNOLOGY

"HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY"

The Study of Land Surface Temperature in Kulim Hi-Tech Using Landsat OLI 8

Zuraini Basarudin^{1*}, Nurul Atiqah Suhaim², Amirul Afiq Azman³, & Mohd Farid Fahmi Abdul Halim⁴

^{1,3,4}Politeknik Tuanku Sultanah Bahiyah, Kulim Hi-Tech Park, 09090 Kulim, Kedah, Malaysia

² Syarikat Jurukur Konsultant, Malaysia

*zuraini.b@ptsb.edu.my

Abstract

Geospatial technology is the integration of remote sensing, Geographic Information Systems (GIS), and the Global Positioning System (GPS) which is very beneficial in studies related to an environment. This research is to study land surface temperature (LST) and land use (LULC) for the years 2014 and 2023 in the Kulim Hi-Tech area using multispectral and multitemporal satellite images. Landsat 8-9 OLI satellite images for the years 2014 and 2023 were obtained from the US Geological Survey (USGS). The Spectral Radiance Model was used to extract LST from Landsat 8-9 OLI. The supervised classification method was used to classify pixels in the Kulim Hi-Tech Area imagery. This method involves the analyst's intervention, who collects data based on their knowledge of the Kulim Hi-Tech area. Subsequently, accuracy assessment and change detection were performed to compare the classification with the ground truth and analyze how an area has changed over the period. The results revealed further validate the relationship between land surface temperature and land use and land cover.

Keywords: Land Use Land Cover, Land Surface Temperature, Geographic Information System, Remote Sensing

1. Introduction

The urbanization process not only involves an increase in population but also causes many changes to the physical environment (Rajan, S. A., & Ibrahim, M. H. 2013). The urban atmosphere has undergone changes due to the influence of anthropogenic activities. These activities alter the Earth's surface from areas with vegetation to impermeable surfaces. Anthropogenic activities include construction, commerce, industry, infrastructure development, institutional development, and others. Additionally, anthropogenic processes are the main driving force in shaping LULC (Barlow et al. 2016; Bruijnzeel 2004; Islam et al. 2017; Rawat, Kumar 2015; Tsegaya et al. 2010) and significantly alter the Earth's surface, resulting in observable changes in LULC patterns over time (Barlow et al. 2018; Dinka 2012). From 2014 to 2023, the Kulim Hi-Tech area has been under development. The rapid changes in urbanization due to development over the years can lead to temperature changes. These anthropogenic factors can also cause changes in land use and land cover. Therefore, the research aims to study land surface temperature (LST) and land use (LULC) for the years 2014 and 2023 in the Kulim Hi-Tech area.

Change detection is defined as the process of identifying differences in the state of an object or phenomenon on the Earth's surface through observations at different times and periods (Ishaka, 2017). The purpose of this study is to classify land use types and detect land use changes that have occurred in the Kulim Hi-Tech area, Kedah for the years 2014 and 2023 using remote sensing application methods. The land use classification process employs the Supervised Classification analysis technique, and post-classification image comparison is also applied in this study to identify patterns of land use change and land surface temperature in the Kulim Hi-Tech area.

Moreover, the arrival of the Northeast Monsoon (MTL) 2023/2024, also known as the rainy season, starting in November 2023 is a major factor in this study. Geographically, Malaysia is located along the equator, which has high temperatures, high humidity, and abundant rainfall. Malaysia receives heavy rainfall throughout the year, ranging between 2,000 mm to 3,000 mm annually (Nor Irza Shakhira, 2015). Malaysia is also influenced by two main types of monsoon winds: the Southwest Monsoon (MBD) and the Northeast Monsoon (MTL), with MTL occurring from November to September. Therefore, this study aims to investigate the relationship between Land Surface Temperature (LST) and Land Use Land Cover (LULC). Additionally, the study has examined temperature changes over the years.

Changes in land use and land cover are among the main factors contributing to temperature changes and the Earth's surface. It can be considered an important component in understanding and modeling the Earth (Lillesand et al., 2004). Anthropogenic refers to all things and activities produced, caused, or influenced by humans because they are created by humans and do not exist naturally. This term is rarely used but is very important for general knowledge. Anthropogenic mostly refers to human activities on the Earth's surface and environmental problems resulting from human actions. An example is the greenhouse effect caused by activities like forest burning to create various sectors such as industry and manufacturing.

Additionally, Malaysia's year-round rainfall influences weather changes. During the MTL season, strong periodic winds from the high-pressure system centered in Siberia transport moist air from the South China Sea towards Peninsular Malaysia, causing strong convection systems. This is very important as it greatly influences the Earth's atmospheric circulation. According to a study (Wan Maisarah et al. 2019), Malaysia receives higher annual rainfall during the MTL, occurring from November to March each year. Malaysia, with its humid tropical climate and temperatures ranging between 24°C to 32°C, experiences significant rainfall throughout the year influenced by monsoon winds and land surface temperatures in the area (Mohd Rizaludin Mahmud, 2015).

Therefore, this study can be an important factor in helping local authorities evaluate and take any measures to control and reduce anthropogenic activities as stated under the Town and Country Planning Act 1976 (Act 172), one of the roles of local planning authorities is to organize, control, and plan the development and use of all land and buildings within their area. Local authorities must also be aware of weather transitions in the surrounding area.

2. Methodology

Study Area

Kulim Hi-Tech is located in the Kulim District, Kedah, Malaysia, at the coordinates 5.4425°N, 100.5630°E. It has now become a developing area with industrial as its main sector. The total area of Kulim Hi Tech is 2033.73 hectares. The Kulim Hi-Tech Park (KHTP) is an industrial park for high-tech enterprises located in the Kulim District, Kedah, Malaysia. It was officially opened in 1996 and holds the distinction of being Malaysia's first high-tech industrial park. It is divided into six dynamic zones, each shaped by its environment and community. These zones intertwine vibrancy and the spirit of innovation which are Industrial Zone, R&D Zone, Residential Zone, Urban Zone, Amenities Zone, Institutional Zone (Portal PBT Kedah, n.d.).

Satellite imagery year 2013 and 2023 was acquired from Landsat Satellite OLI 8. The Landsat 8 satellite carries the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). Landsat 8 orbits the Earth in a near-polar sun-synchronous orbit at an altitude of 705 km (438 mi), inclined at 98.2 degrees, and circles the Earth every 99 minutes. This satellite has a temporal resolution of 16-day. Landsat 8 acquires approximately 740 scenes per day on the Worldwide Reference System-2 (WRS-2) path/row system, with scene overlap ranging from 7 percent at the Equator to a maximum of approximately 85 percent at high latitudes. The coverage area is 185 km \times 180 km.

Table 1: Landsat OLI 8 Information

Band	Resolution	Wavelength (μ m)	Description	Sensor
1	30m	0.433 - 0.453	Coastal / Aerosol	Operational Land Imager (OLI)
2	30m	0.450 - 0.515	Blue	
3	30m	0.525 - 0.600	Green	
4	30m	0.630 - 0.680	Red	
5	30m	0.845 - 0.885	Near Infrared	
6	30m	1.560 - 1.660	Short-wave Infrared	
7	30m	2.100 - 2.300	Short-wave Infrared	
8	15m	0.50 - 0.68	Panchromatic	
9	30m	1.360 - 1.390	Cirrus	
10	100m	10.6 - 11.19	Thermal Infrared	Thermal Infrared Sensor (TIRS)
11	100m	11.5 - 12.51	Thermal Infrared	

Layer Stacking

Layer stacking is a process of combining multiple images into a single image. Therefore, the images should have the same dimensions (number of rows and number of columns). In other words, all images/bands must have the same spatial resolution to perform layer stacking. However, combining images/bands will increase the size of the final stacked image, and consequently, will increase the processing time later when performing analysis. In this scientific research, it will combine 11 images in TIFF format because the data used is from Landsat 8.

Dark Object Subtraction (DOS)

Radiometric correction is performed to reduce or correct errors in the digital numbers of images. This process enhances the interpretability and quality of remote sensing data. Calibration and radiometric correction are crucial when comparing data sets over different time periods. Radiometric errors must be corrected. Corrections are made based on the condition of the image, and not all types of radiometric corrections need to be applied to a single image. Therefore, the Dark-Object Subtraction (DOS) method has been implemented for radiometric correction. After the subset area and band processing, the minimum values for the three images were more than zero. The Dark Object Subtraction (DOS) technique was implemented to ensure the histogram graph starts from zero.

Table 2: Shown the Minimum Values after Layer Stack and Subset Process.

Layer	Imej 2014 Subset	Imej 2023 Susbset
1	9592	9542
2	8562	7472
3	7603	6465
4	6658	6375
5	6900	5413
6	5609	5297
7	2437	2634

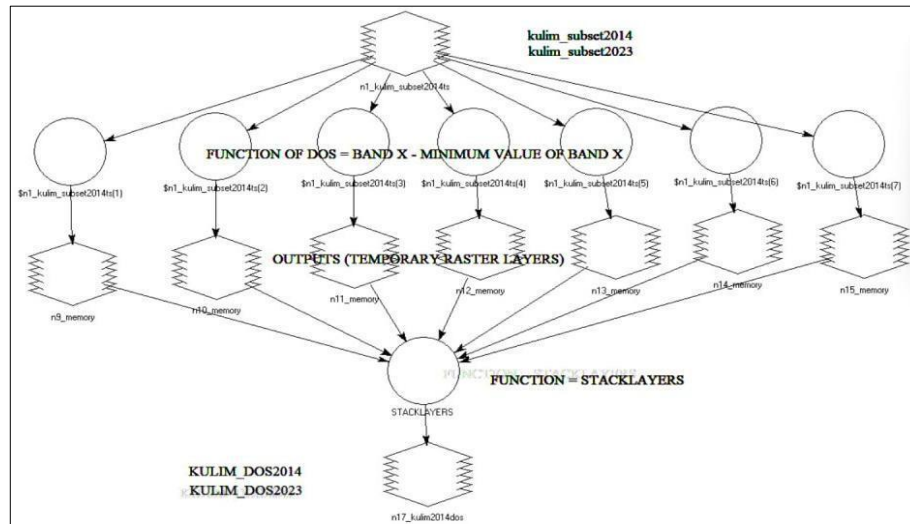


Figure 3: Show the DOS model developed in Erdas Imagine software

LST Extraction

There are few processes in the study to get the LST values

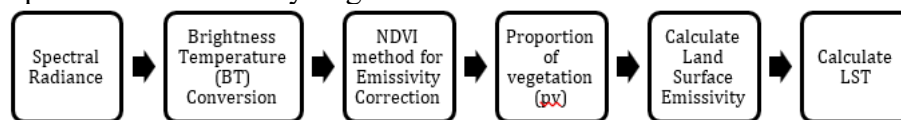


Figure 4: Show the process of LST extraction

The following algorithm was applied for retrieval of LST.

Calculation of TOA (Top of Atmospheric) spectral radiance

$$\text{TOA } (L_{\lambda}) = \text{ML} * \text{Qcal} + \text{AL} - \text{Qi} \quad (1)$$

Where:

ML = Band - specific multiplicative rescaling factor from metadata

Qcal = corresponds to band 10

AL = Band- specific additive rescaling factor from metadata

Qi = Total Correction (Band 10 from Landsat 8)

The conversion of spectral radiance to Brightness Temperature (BT) using thermal constants (Avdan and Jovanovka, 2016).

TOA to Brightness Temperature (BT) conversion:

$$T = \frac{K_2}{\ln \left(\frac{K_1}{L_{\lambda}} + 1 \right)} - 273.15 \quad (2)$$

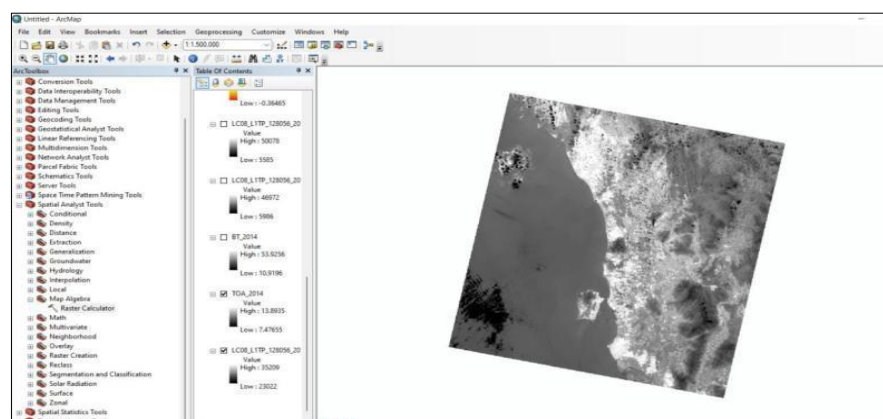


Figure 5: Show the Imagery After Spectral Radiance Calculations Have Been Performed

NDVI Method for Emissivity Correction
Landsat OLI 8 to extract NDVI values.

$$NDVI = \frac{NIR \text{ (band 5)} - Red \text{ (band 4)}}{NIR \text{ (band 5)} + Red \text{ (band 4)}} \quad (3)$$

Proportion of Vegetation (P_v)

P_v is an essential parameter for calculating LSE according to NDVI. Formula used:

$$P_v = \left(\frac{NDVI - NDVI_{Min}}{NDVI_{Max} - NDVI_{Min}} \right)^2 \quad (4)$$

Where:

P_v = proportion of vegetation

NDVI = Normalized Difference Vegetation Index

NDVI_{min} = Minimum value of NDVI

NDVI_{max} = Maximum value NDVI

Land Surface Emissivity (LSE)

Calculation of Land Surface Emissivity (LSE) (ε) Formula:

$$\epsilon = 0.004 P_v + 0.986 \quad (5)$$

Where:

ε = Emissivity Land Surface

P_v = proportion of vegetation

0.986 = correction value

The last step of retrieving the LST or the emissivity-corrected land surface temperature *T_s* is computed as follows:

$$T_s = BT / ((1 + (\lambda * BT/p * I_n(\epsilon))) \quad (6)$$

Where;

BT = highest brightness temperature

λ = Wavelength

ε = Land surface emissivity

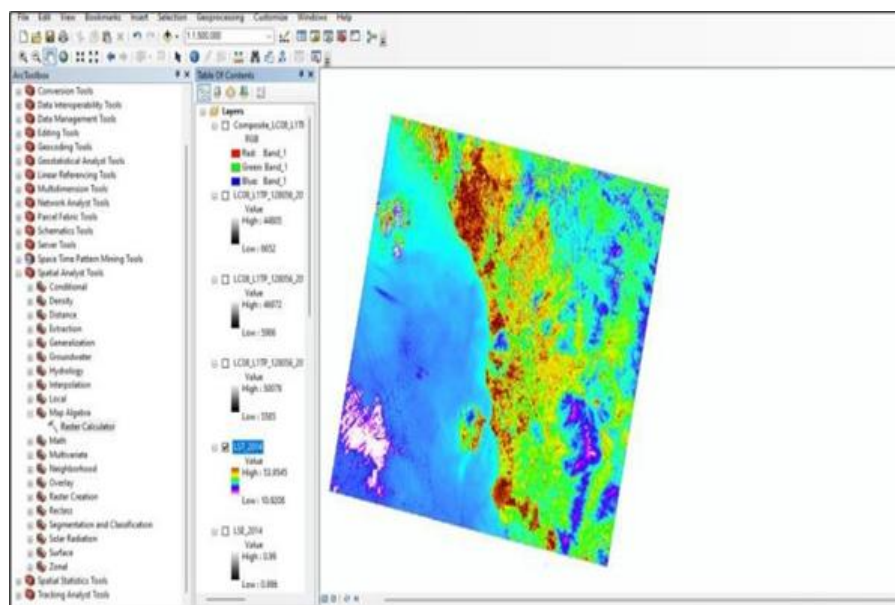


Figure 6: Shows the Result after Calculating LST

Subset Area

The Kulim Hi-Tech image below is the result of merging multiple images into one. As indicated in the Image Metadata, the image consists of 11 bands or layers: 11, with the projection in UTM Zone 47 and the datum in WGS84.

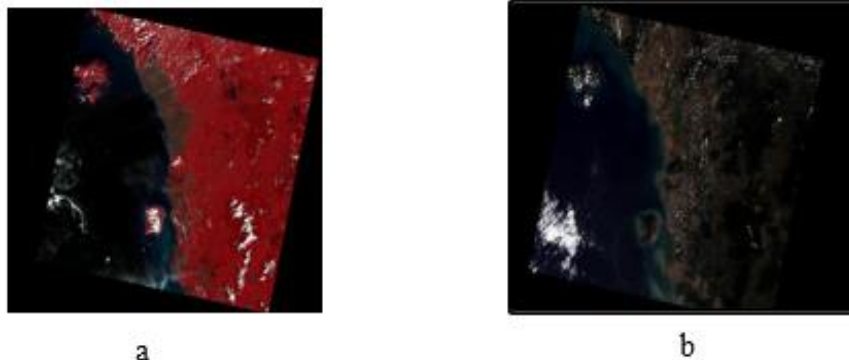


Figure 7: Show the result after Stacking the layers of images from 2014 (a) and 2023 (b)

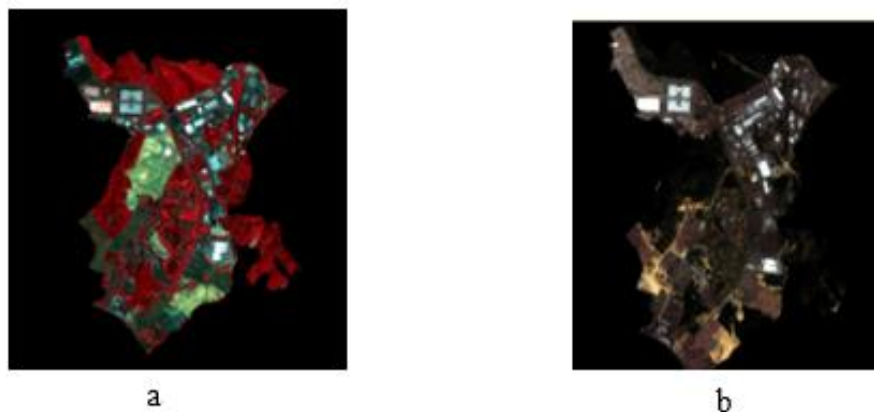


Figure 8: Show the result after Subsetting the image area for the year 2014 (a) and 2023 (b)

Supervised classifications were used in the study to extract the land use data from satellite imageries. Three categories have been classified in the study (i.e: open area, urban area and vegetation). The Maximum likelihood classification method was utilized to classify the study area (Basarudin & Adnan, 2014).

3. Results and Discussion

The LULC Changes

The land use and land cover (LULC) types in Kulim Hi-Tech area consist of urban areas (roads, factories, residential areas, buildings, etc.), vegetation (grass, natural or cultivated plants), and open land. According to the table below, in 2014, the open land area was significantly larger at 787.32 hectares compared to 331.92 hectares in 2023. Additionally, urban areas dominated in 2023 with 1207.35 hectares compared to 511.74 hectares in 2014. Finally, the area covered by vegetation was higher in 2014 at 734.67 hectares, accounting for 36.12%, whereas in 2023, it decreased to 494.46 hectares, or 24.3%. This information highlights the changes in land use over time within the Kulim Hi-Tech area.

Table 3: Shows the Land Use and Cover Changes from 2013 to 2024.

Category	Year 2014 (Hectares)	%	Year 2023 (Hectares)	%	Diff. (Hectares)	% Changes
Open Area	787.32	38.71	331.92	16.32	455.4	40.69 ↓
Urban Area	511.74	25.16	1207.35	59.37	695.6	40.46 ↑
Vegetation	734.67	36.12	494.46	24.31	240.2	19.54 ↓
Total	2033.73	100	2033.73	100	1300.2	100

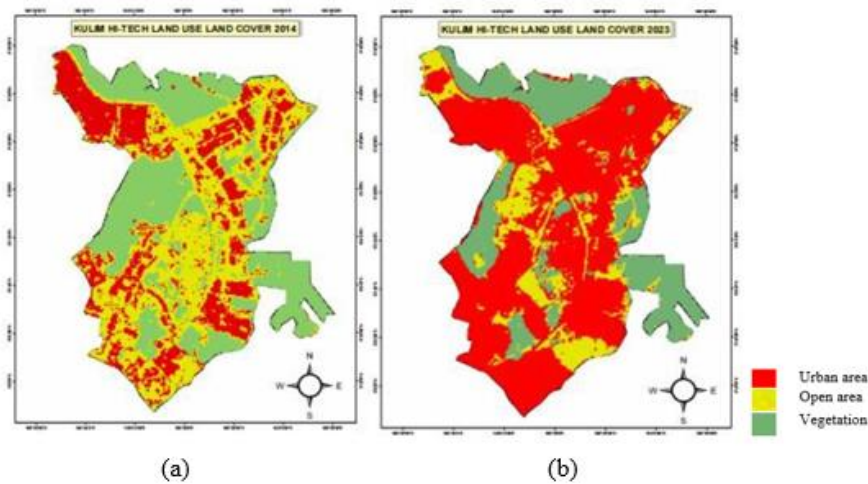


Figure 9: Show Land Use 2014(a) and Land Use (2023)

Changes in Land Surface Temperature (LST)

From 2014 to 2023, the highest LST consistently focuses on urban areas, particularly due to industrial zones. Furthermore, images from 2023 show relatively lower temperatures. This is because the images were captured in November, marking the onset of monsoon winds. The highest temperature range in 2014 was between 32.3°C to 37.8°C, while in 2023, it ranged from 27.9°C to 33.3°C.

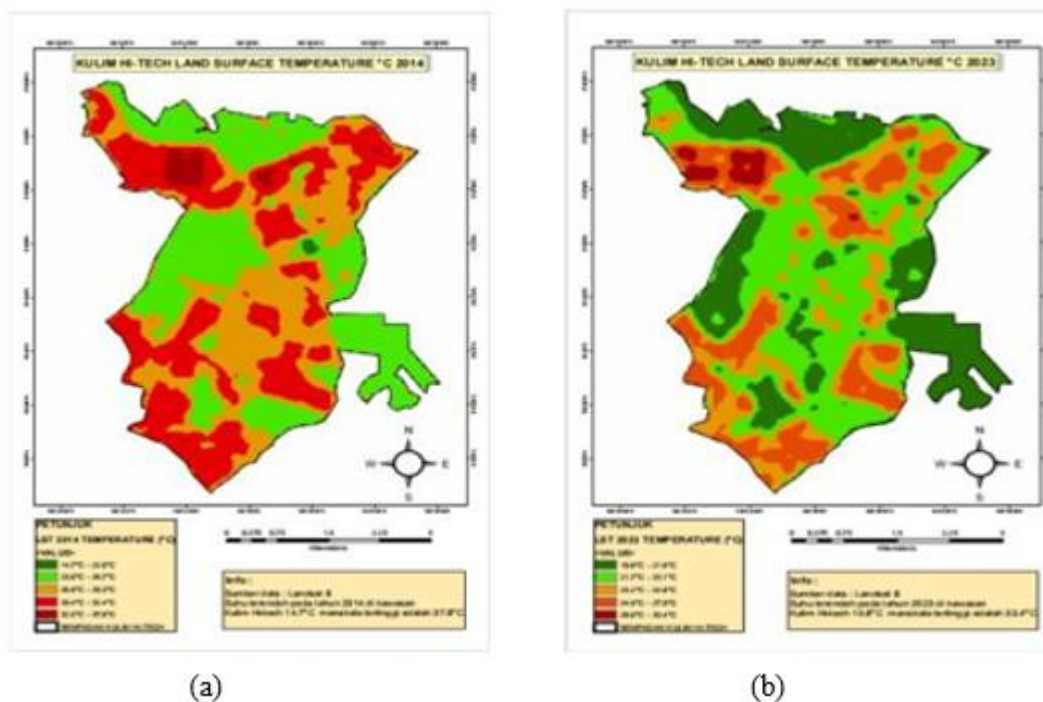


Figure 10 Shows the Land Surface Temperature (LST) year 2014(a) and LST Year 2023 (b).

4. Conclusion

The study results indicate a significant correlation between land surface temperature (LST) and land use/land cover (LULC) in the Kulim Hi-Tech area from 2014 to 2023. It is concluded that most areas in Kulim Hi-Tech experienced temperature changes during this period due to various factors, including anthropogenic influences and changes in monsoon patterns affecting the region. Overall, for this project, the Study on Land Surface Temperature and Land Use/Land Cover Using Geospatial Technology in the Kulim Hi-Tech area has successfully achieved its primary objectives. The study has been effectively analysed and has demonstrated how changes in LULC are linked

to land surface temperature. The workflow processes and research methodologies applied in the project flowchart have had a significant impact, providing new insights and knowledge in the field of land surveying (Geomatics).

Acknowledgment

We would like to express our deepest appreciation to all those who provided us with information and data to complete this research.

References

- Biswal, S. S., & Gorai, A. K. (2020). Change Detection Analysis in Coverage Area of Coal Fire from 2009 to 2019 in Jharia Coalfield using Remote Sensing Data. *International Journal of Remote Sensing*, 41(24), 9545–9564. <https://doi.org/10.1080/01431161.2020.1800128>
- Choy, L. K., & Mohd Noor, N. N. H. (2018). Kajian Perubahan Guna Tanah Menerusi Aplikasi Penderiaan Jauh. *Malaysian Journal of Society and Space*, 14(2), 108–124. <https://doi.org/10.17576/geo-2018-1402-09>
- Jamaluddin, A. F., Fredolin Tangang, F. T., Wan Ibadullah, W. M., Liew, J., Yik, D. J., Salimun, E., Dindang, A., & Abdullah, M. H. (2019). Klimatologi Hujan Diurnal dan Bayu Laut-Darat di Semenanjung Malaysia. *Sains Malaysiana*, 48(3), 509–522. <https://doi.org/10.17576/jsm-2019-4803-03>
- Nadirah Ishak, A., Hidayah, N., Ahmad, T., Singh, M., Singh, J., Elektrik, J., Sistem, D., Kejuruteraan, F., & Bina, A. (2021). Penganalisaan Taburan Hujan Diurnal terhadap Angin Monsun di Malaysia dengan Menggunakan Data Satelit TRMM (The Diurnal Variation of Rain Intensity in Malaysia for Monsoon Region using TRMM Satelit Data). *Jurnal Kejuruteraan*, 33(3). [https://doi.org/10.17576/jkukm-2021-33\(3\)-30](https://doi.org/10.17576/jkukm-2021-33(3)-30)
- Ozdogan, M., Yang, Y., Allez, G., & Cervantes, C. (2010). Remote Sensing of Irrigated Agriculture: Opportunities and Challenges. *Remote Sensing*, 2(9), 2274–2304. <https://doi.org/10.3390/rs2092274>

The Study of Noise Emission Level Along KTM Kajang Railway Track to Surrounding Premises

Karthigeyen Ramachandran^{1*}, Mohd Eizzuddin Mahyeddin² & Mohd Kamaruzaman Musa³

¹Polytechnic Tun Syed Nasir Syed Ismail, Pagoh, Johor, Malaysia

^{2,3}University Tun Hussein Onn Malaysia, Johor, Malaysia

* karthigeyen@ptsn.edu.my

Abstract

This study delves into the pervasive issue of noise pollution, particularly stemming from transportation vehicles like trains, which significantly impacts the quality of life for nearby communities. The aim is to assess the noise levels along the KTM Kajang railway track from two selected sites, SK Convent Kajang and Taman Pinggiran Kajang. The methodology encompasses onsite noise measurements using the Cirrus Optimus model CR:171A Sound Level Meter and GLM 250 VF Professional (Bosch) Laser Distance Meter, extracting the measurements manually using Quest Suite Professional II software, tabulating and analysing the data with Microsoft Excel and lastly comparing with noise guidelines set forth by Occupational Safety and Health (Noise Exposure) Regulations 2019 (DOSH) to identify the hazardous level of the emitted noise. The findings revealed that the noise emitted by trains passing through the KTM Kajang can be categorized as excessive noise when measured from Taman Pinggiran Kajang and outside the classroom of SK Convent Kajang. Recommendations are given to lessen the adverse effects of excessive noise to the surrounding community of KTM Kajang railway track.

Keywords: Noise Pollution, Train Emissions, Community Health

1. Introduction

According to Stansfeld & Matheson (2013), noise is defined as "unwanted sound that is viewed as an environmental stressor and annoyance". The transportation industry is one of the leading proponents of noise mitigation, and the growing traffic volume combined with urbanization implies that the problem would worsen if no measures were taken. Although road traffic is the most significant source of noise pollution in the transportation sector, other sources such as planes and trains also contribute to noise pollution (Micheli & Farné, 2016). Trains are one of the main sources of noise in the transportation system, which has a negative impact on the environment and community well-being. Noise levels emitted by trains are affected by train types, railway lines, train speeds, and driver techniques (Mohd Masirin et al., 2015). Grubliauskas et al. (2014) reported that urban train noise in residential areas is a serious issue that necessitates a variety of organizational and technological solutions. Noise levels fluctuate based on the type of train and distance from the railway track, according to the conclusions of the statistical study.

Train noise is one of the most visible forms of transportation noise, and it may be heard both inside and outside the train. Many railway elements, particularly the wheels, contribute to the noise. The vibrations caused by the minor roughness on the wheel and rail surfaces are the primary cause of railway track traffic noise. Rail car sidewalls, boogie and suspension components, and other moving surfaces all contribute to the sound that is emitted by the wheels and rails. There are two types of train noise: internal and external noise. Human voice, frictions that generate noises in the carriage, sound from the coach's motions, and the operator's voice when giving an announcement are all instances of sounds that could affect the passengers' comfort while the train is in operation (Mohd Masirin et al., 2015).

At low levels, the noise emitted by train can interfere with speech and obscure other noises that may be critical. Despite that, there are benefits as well, such as warning people when a train is approaching or detecting damaged components or other defects through variations in the emitted sound (Trocme et al., 2018). However, increasing train movements, prolonged train operating hours, and construction along transportation routes that are not intended to attenuate noise and vibration can have negative effects on the nearby communities. Controlling noise is an important consideration while building new train lines or redeveloping old lines. As a response, this study focuses on measuring the noise level emitted by KTM Kajang railway track from two selected locations, SK Convent Kajang and Taman Pinggiran Kajang from distance border of 10m and 20m using the Cirrus Optimus model CR:171A Sound Level Meter. This study helps to address the hazardous level of train noise to the nearby communities.

2. Methods

Firstly, two research sites are chosen with two conditions such as, i) feasible to access, and ii) the train noise was the predominant source of noise at that location. The two sites that are highly exposed to the noise emitted by KTM Kajang Railway Track are SK Convent Kajang and Taman Pinggiran Kajang. Two main instruments needed to take measurements from the sites are a Sound Level Meter (SLM) that meets with International Electrotechnical Commissioning (IEC) 61672-1-2002 Class 2 standard and a Laser Distance Model (LDM).

For this study, the Cirrus Optimus model CR:171A and GLM 250 VF Professional (Bosch) are chosen as SLM and LDM respectively. Data is taken from 10m and 20m from the two sites to observe the deviation of maximum sound pressure level in A-weighting (L_{Amax}) when getting further from the railway track. Several measurement precautions are considered during onsite data collection in the locations, according to Department of Environment Malaysia (2019):

- Measurement must be stopped for a while when ambient noise is higher than railway noise
- Measurement made only in dry environment condition
- Sound Level Meter microphone used the windshield to prevent wind speed effect

All the field measurements are extracted manually using Quest Suite Professional II Version 4.3.2298 software. The extracted data are tabulated and presented graphically using Microsoft Excel for Office 365.

3. Data Analysis and Discussions

The comparative column chart for maximum sound pressure level in A-weighting (L_{Amax}) at SK Convent Kajang and Taman Pinggiran Kajang for 10m and 20m are presented in Figure 1 and Figure 2 respectively.

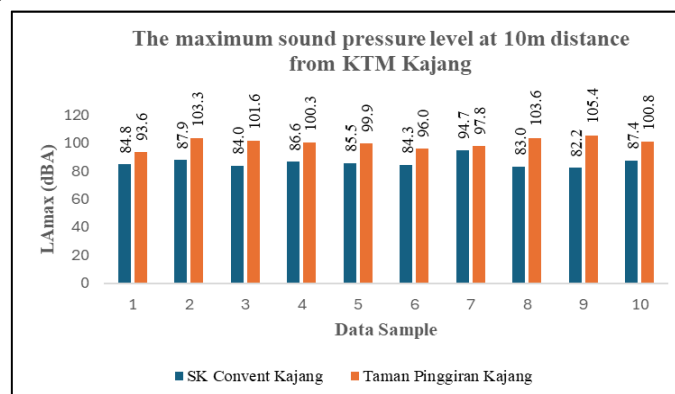


Figure 1: The comparison between L_{Amax} Data Sample at 10m distance

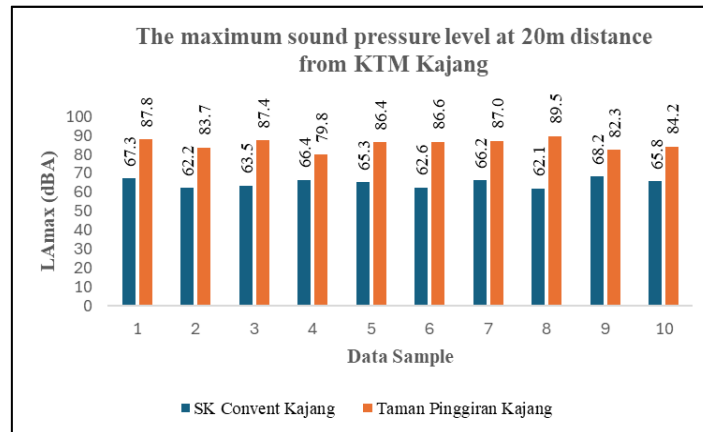


Figure 2: The Comparison between L_{Amax} Data Sample at 20m Distance

Even though the data samples fluctuate over the recording periods, the highest maximum noise, L_{Amax} recorded from the distance of 10m at Taman Pinggiran (105.4dBA) was greater than that of SK Convent Kajang (94.7dBA). However, the reduction of L_{Amax} occurred when measurements taken from 20m and this is shown in Figure 2. The figure shows the highest maximum noise level, L_{Amax} at Taman Pinggiran Kajang is 89.5dBA while for SK Convent Kajang, the value is 68.2dBA.

According to the Occupational Safety and Health (Noise Exposure) Regulations 2019 (DOSH), the noise level exceeding 82dBA is considered as excessive noise. Thus, the noise level emitted by the train measured at Taman Pinggiran Kajang measured at a distance of 10m and 20m can be categorized as excessive noise. For SK Convent Kajang, the noise level measured from 20m distance cannot be categorized as excessive noise. This is because the 20m distance from the railway track is located inside a classroom, with a wall acting as a sound barrier. However, when measured at 10m from the track, which is outside the classroom, the noise level exceeds 82dBA for all 10 samples showing occurrence of excessive noise.

4. Conclusion

This study was attempted to measure the noise emission level by the train passing through the KTM Kajang railway track to the surrounding communities at SK Convent Kajang and Taman Pinggiran Kajang. A Sound Level Meter and Laser Distance Meter is used to take onsite measurements. Quest Suite Professional II is used to extract the measurements manually from the meter. Later, the data are tabulated and analysed in Microsoft Excel. The findings can be summarized as below:

- The noise level that was produced by the railway system varied depending on the distance at which the measurement was taken
- The noise level emitted from KTM Kajang railway services can be categorized as excessive noise to the Taman Pinggiran Kajang location
- The noise level emitted from KTM Kajang railway services can be categorized as excessive noise outside the classroom at SK Convent Kajang

To reduce the negative impacts of excessive noise emitted from KTM Kajang on the surrounding communities, it is recommended to follow a regular schedule to carry out maintenance activity on the mechanical parts of a train or railway track that can emit any noise. A sound barrier (wall) around the railway premise could be constructed to reduce the noise exposure to the surrounding communities. When constructing a new railway line, careful consideration must be given to the track's alignment and the location of populous areas to which it is next to.

Acknowledgement

This paper is an output of the dissertation of the Degree of Master of Science in Railway Engineering. We would like to express our sincere gratitude to all the team members who contributed to the publication of this research paper. We would like to thank all the participants in this study for their time and willingness to share their experiences. Their contributions have been invaluable in helping us to understand the topic and draw meaningful conclusions. Without their encouragement and support, we would not have been able to complete this research.

References

- Department of Environment Malaysia. (2019). The Planning Guidelines for Environmental Noise Limits and Control | Department of Environment. Retrieved December 22, 2019, from Department of Environment Malaysia website: <https://www.doe.gov.my/portalv1/en/information/the-planning-guidelines-for-environmental-noise-limits-and-control/272>
- Grubliauskas, R., Strukecinskiene, B., Raistenskis, J., Strukcinskaite, V., Buckus, R., Janusevicius, T., Pereira, S. (2014). 211. Effects of Urban Rail Noise Level in a Residential Area.
- Micheli, G. J. L., & Farné, S. (2016). Urban Railway Traffic Noise: Looking for the Minimum Cost for the Whole Community. *Applied Acoustics*, 113, 121–131. <https://doi.org/10.1016/j.apacoust.2016.06.018>
- Mohd Masirin, M. I., Johari, N. F., Nordin, N. H., Abdullah, A. H., & Azis, M. I. (2015). A Field Study on Urban Rail Transits in City of Kuala Lumpur: Passenger Views on Train Noise and Vibration. *Applied Mechanics and Materials*. <https://doi.org/10.4028/www.scientific.net/amm.773-774.839>
- Occupational Health and Safety Administration. (1983). Occupational noise exposure; hearing conservation amendment, Occupational Safety and Health Administration, 29 CFR 1910.95. Federal Register. 48(46): 9738-9785.
- Trocme, M., Cahill, S., de Vries, J.G., Farrall, H., Folkesson, L., Fry, G., Hicks, C. & Peymen, J. Habitat Fragmentation due to Transportation Infrastructure. The European Review. Office for Official Publications of the European Communities, Luxembourg, 2002. COST 341

Programme Educational Objectives (PEO) Attainment for Diploma in Electronic Engineering (Communication) at Politeknik Sultan Salahuddin Abdul Aziz Shah

M. Ramli^{1*} & R. M. Zali²

^{1,2}Department of Electrical Engineering, Politeknik Sultan Salahuddin Abdul Aziz Shah, 40150 Shah Alam, Selangor, Malaysia ²Full affiliation of second author, including country

* marlina_ramli@psa.edu.my

Abstract

The success of an educational institution is measured by academic performance and the quality of graduates it produces. All engineering diploma programs adhere to the requirements of the Engineering Technology Accreditation Council (ETAC) on behalf of the Board of Engineers Malaysia (BEM). The Programme Educational Objectives (PEOs) describe the expected achievements of graduates in their career and professional life within three to five years after graduation. Good PEOs are defined by being distinctive, specific, measurable, achievable, result-oriented and time-bound. The Diploma in Electronic Engineering (Communication) is offered by the Department of Electrical Engineering at Polytechnic Sultan Salahuddin Abdul Aziz Shah. The study used dichotomous questions to gather information about graduates' engineering work, professional ethics, entrepreneurial endeavors utilizing technical skills, and career progression. The program aims to produce balanced TVET graduates, set across four PEOs. The Curriculum Division of the Electrical Engineering Department of Polytechnic and Community College Education prepared the survey, targeting graduates from the 2017 and 2018 cohorts. The analysis indicates that all PEOs have achieved their objectives, with target and average values surpassing the expected achievements for both cohorts.

Keywords: Programme Educational Objectives; OBE; TVET Graduates

1. Introduction

The Engineering Technology Accreditation Council (ETAC) is a professional body responsible for all engineering programs in Malaysia. Offering institutions are required to implement the Outcome-Based Education (OBE) system as mandated by ETAC (Board of Engineers Malaysia, 2020). Outcome-Based Education (OBE) is an educational approach focused on achieving specific learning outcomes for students. It involves determining the key concepts, skills, or qualities students should understand, do, or develop, and designing both the curriculum and its structure to achieve these outcomes. OBE involves a shift in curriculum, assessment, and reporting practices towards demonstrating high-order learning and mastery.

Assessment in OBE typically includes three types of outcomes: Course Learning Outcomes (CLOs), which are assessed during the semester; Programme Learning Outcomes (PLOs), assessed at the end of the program; and Programme Educational Objectives (PEOs), evaluated after 3-5 years from graduation. PEOs outline the broader professional and career achievements expected from graduates (Bahagian Kurikulum & Jabatan Pendidikan Politeknik dan Kolej Komuniti, 2021). Programme Educational Objectives (PEOs) are specific goals aligned with the mission and vision of the program, reflecting the interests of stakeholders such as students, alumni, staff, community groups, industry partners and professions (employers) as well as the government (Rashidah Mat Tuselim et al., 2022).

They describe the expected achievements of graduates in their careers and professional life after graduation. Good PEOs are characterized by being distinctive, specific, measurable,

achievable, result-oriented, and time-bound. This means they should clearly outline what graduates are expected to achieve, be specific in their language, be quantifiable so progress can be measured, be realistic in their attainment, focus on outcomes, and have a defined timeframe for achievement. These criteria ensure that PEOs are effective in guiding the program toward its intended outcomes and providing graduates with the necessary skills and attributes for success in their careers.

According to ETAC requirements, Programme Educational Objectives (PEOs) must be published along with the process, and the results should be assessed, with evidence of stakeholder involvement made clear. Following the Department of Polytechnic (2013), Outcome-Based Education (OBE) is an educational process aimed at achieving specific outcomes in terms of individual student learning. Therefore, both curriculum structures and content are designed to achieve these capacities or traits after determining the most important concepts and skills for students to learn and possess. PEOs are a set of specific goals or targets that describe the expected achievements of graduates in their career and professional life a few years after graduation (Mohammed M.U. Faiz & Mubarak S. Almutairi, 2021) and must be measured in all Malaysian educational institutions (Hairi et al., 2019). Programme Educational Objectives (PEO), outline graduates' expected achievements in their career and professional life following graduation (Suhaimi et al., 2022).

Overview of Programme Educational Objectives (PEOs) of Diploma in Electronic Engineering (Communication)

To implement Outcome Based Education (OBE), one of the initial steps is to develop Programme Educational Objectives (PEOs). PEOs are goals that outline what graduates should achieve in their careers a few years after graduation. These objectives serve as guiding principles for curriculum development and assessment, ensuring that educational programs align with students' desired outcomes (Tshai et al., 2014). These goals must align with the academic institution's vision and mission and consider the needs of relevant stakeholders.

The Diploma in Electronic Engineering (Communication), DEP, is a 3-year full-time program comprising 6 semesters of coursework, with one full semester of industrial training included. The program aims to prepare graduates to be competent professionals in their workplace and society during the first few years after graduation. The PEOs of the DEP program are designed to align with the polytechnic's transformation agenda, aiming to produce knowledgeable, responsible individuals who have successful careers and can engage in enterprising activities. This aligns to drive the knowledge and skills-based economy that developed countries require.

The Programme Educational Objectives (PEOs) have been developed in alignment with the vision and mission of the institution, as well as the expectations of stakeholders. These stakeholders include the Ministry of Higher Education (MoHE), lecturers, alumni, and industries involved in the electrical engineering program. The PEOs are designed to meet the needs and requirements of all these stakeholders. To ensure consistency with the vision and mission of the Department of Polytechnic and Community College Education (DPCCE) and Politeknik Sultan Salahuddin Abdul Aziz Shah (PSA), stakeholders participate in the development and review process of the PEOs through various means, such as attending meetings, workshops, completing questionnaire surveys, or engaging in other forums.

The Curriculum Development Committee (CDC), appointed by the DPCCE, is responsible for developing the PEOs and defining the program outcomes, course structure, and syllabus. Once developed, the curriculum is approved by the Polytechnic Curriculum Board (PCB), which is

appointed by the MoHE based on the Education Act 1996 (Act 550). This structured involvement ensures that the program objectives align with institutional goals and stakeholder expectations.

The expected achievements of graduates in their career and professional life are described in the Program Educational Objectives (PEOs) (Pramono et al., 2020), which are clearly stated on the institution's portal, student handbook, posters in all teaching and learning rooms, OBE info website, Learning Management System, and are continuously disseminated to the students during lectures, through student course outlines, and in meetings with academic advisors. The objectives of the program aim to produce balanced TVET graduates, set across four (4) Programme Educational Objectives (PEOs) as indicated in Table 1. These objectives ensure that graduates are well-prepared to meet the demands of their professional and personal lives post-graduation.

Table 1: Programme Educational Objectives (PEO)

PEO	Description
PEO 1	Practicing technician in electrical engineering-related field
PEO2	Contributing to society with professional ethics and responsibilities
PEO3	Engaging in enterprising activities that apply engineering knowledge and technical skills
PEO4	Engaging in activities to enhance knowledge for a successful career advancement

Overview Processes Used to Establish the PEOs

In Malaysia, polytechnics are managed by the Department of Polytechnic and Community College Education (DPCCE), which falls under the Ministry of Higher Education. The DPCCE is responsible for the development of the curriculum for all programs offered by the polytechnics. This process is supervised by the Curriculum Division (CD) of the DPCCE. Figure 1 illustrates the curriculum development process employed by the CD. This structured approach ensures that the curriculum aligns with national educational standards and meets the needs of various stakeholders (Unit Kejuruteraan Elektrik, 2020).

The Programme Educational Objectives (PEOs) and Programme Learning Outcomes (PLOs) were initially created by the Curriculum Division (CD) based on the guidelines provided by the Malaysian Qualification Framework (MQF) and the Engineering Technology Accreditation Council (ETAC). The academic curriculum for each program is developed by the Curriculum Development Committee (CDC), a committee established by the CD. This committee typically includes polytechnic lecturers, experts from other institutions of higher learning (IHLs), and representatives from relevant industries, ensuring a comprehensive and industry-relevant educational framework.

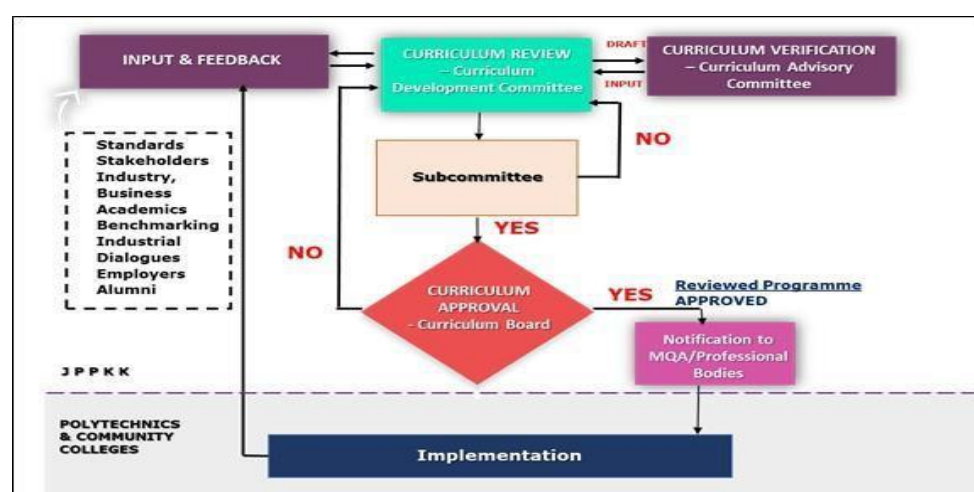


Figure 1: Flowchart of Curriculum Development Process in Polytechnics

The Programme Educational Objectives (PEOs), Programme Learning Outcomes (PLOs), and academic curriculum undergo review and refinement by the Curriculum Advisory Committee (CAC) to ensure their accuracy and relevance (Hadi et al., 2023). This process helps maintain high educational standards and alignment with industry needs, ensuring that the curriculum remains current and effective in preparing students for their professional careers. The Subcommittee of the Polytechnic Curriculum Board (PCB) verifies that the program complies with current standards and policy requirements before PCB approval. The Curriculum Advisory Committee (CAC) members, appointed by the Curriculum Division (CD), comprise experts from institutions of higher learning (IHLs) and representatives from relevant industries. The subcommittee members are selected from senior officers and lecturers of the Polytechnic. The PCB, the highest body established by the Ministry of Higher Education, approves all curricula before implementation at the Polytechnic. The PCB includes top management of the DPCCE, representatives of professional bodies, and academicians appointed from private and public IHLs by the Minister of Higher Education.

The Curriculum Development Committee (CDC) analyzes the PEO input from the Ministry of Education (MOE), industry and other stakeholders and feedback from the Programme

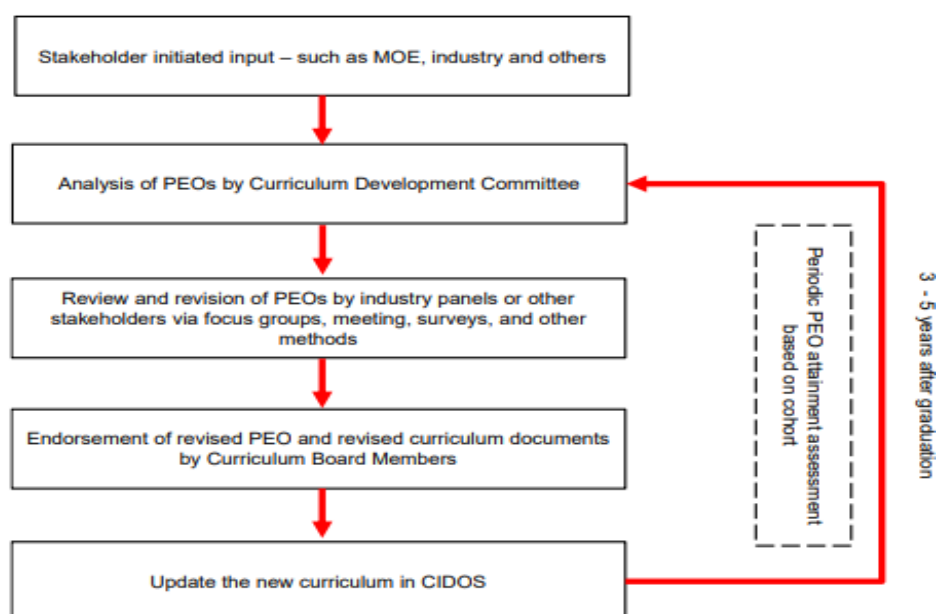


Figure 2: Flowchart of PEO Development and Review

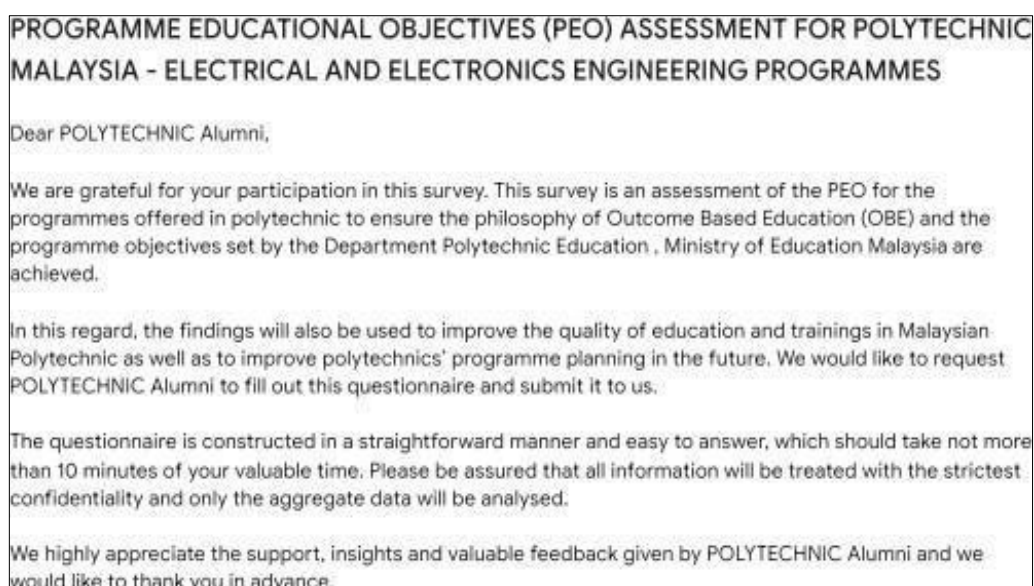
Advisory Committee in the polytechnic and the PEO attainment data to revise the PEOs. This feedback helps identify gaps and improve the PEOs to better align with stakeholders' needs. The revised PEOs are then reviewed by industry and other stakeholders to ensure their relevancy. Guided by the DPCCE vision and mission statements, the CDC uses input from the MOE, the Programme Advisory Committee, other stakeholders, and PEO attainment data to regularly review and update the program's educational objectives. The process established for this review is depicted in Figure 2. The CDC analyzes the PEO inputs and attainment to identify gaps and improve the PEOs, ensuring alignment with stakeholders' needs and the vision and mission of DPCCE. The revised PEOs are submitted to the Program Advisory Committee at the polytechnic level and other stakeholders for review and feedback. Once established, the PEOs must be approved and endorsed by the Polytechnic Curriculum Board (PCB) before being formally adopted by polytechnics. The dissemination of the PEOs is part of the curriculum documents and is made available through the CIDOS portal (Instructional and Digital Learning Division, 2024).

2. Methodology

The survey aims to evaluate the Programme Educational Objectives (PEOs) for the programs offered at the polytechnic, ensuring alignment with the Outcome Based Education (OBE) philosophy and the objectives set by the Department of Polytechnic Education, Ministry of Education Malaysia. To assess the achievement of these PEOs among graduates, a comprehensive online survey has been developed, accessible within a specified time frame. Workshops have been conducted to enhance the surveys and increase the number of respondents. Data analysis from the 2019 pilot test of the PEO survey involved using frequency distribution to display the frequency and percentage of responses. This analysis served as a key performance indicator (KPI) for the achievement of PEOs in 2021. In 2022, updated questionnaires were used in employer and alumni surveys to gather more insights. The reviewers used dichotomous or closed-ended questions to evaluate respondents' work in the engineering field related to PEO1 through PEO4. Additional questionnaires covered topics such as professional ethics, teamwork and communication skills, entrepreneurship, and career advancement.

There are various free questionnaire platforms in line, such as Google Form, SurveyMonkey, Typeform, SoGoSurvey, and so on (Morten Pedersen, 2024). Google Forms has been selected as the most suitable platform for the survey due to its flexibility and the familiarity of respondents with the tool. The survey contains 22 questions, each mapped directly to a specific Programme Educational Objective (PEO). It is proposed that respondents complete the survey within a maximum of 15 minutes. Each question's response provides a quantitative measure of the achievement of a PEO by the respondent.

The method for determining the achievement of a PEO is that if one or more items within a PEO receive a 'Yes' response, the PEO is considered achieved. The survey distribution process involves sending a notification letter to the Head of the Electrical Department from the Curriculum Division to the polytechnic. Collected data is then analyzed using Microsoft Excel software. The data cleaning process is implemented to minimize errors from incomplete data entries. Generally, the PEO study generates descriptive data findings, which are expressed as percentages. The report generated from the data analysis references the performance indicators specified for each PEO by the polytechnics. Based on these findings, recommendations are made to enhance the current PEO statements. Figure 3 in the report illustrates a snapshot of the online survey form and a sample of the results used to demonstrate the performance and achievement of the PEO surveys.



PROGRAMME EDUCATIONAL OBJECTIVES (PEO) ASSESSMENT FOR POLYTECHNIC MALAYSIA - ELECTRICAL AND ELECTRONICS ENGINEERING PROGRAMMES

Dear POLYTECHNIC Alumni,

We are grateful for your participation in this survey. This survey is an assessment of the PEO for the programmes offered in polytechnic to ensure the philosophy of Outcome Based Education (OBE) and the programme objectives set by the Department Polytechnic Education , Ministry of Education Malaysia are achieved.

In this regard, the findings will also be used to improve the quality of education and trainings in Malaysian Polytechnic as well as to improve polytechnics' programme planning in the future. We would like to request POLYTECHNIC Alumni to fill out this questionnaire and submit it to us.

The questionnaire is constructed in a straightforward manner and easy to answer, which should take not more than 10 minutes of your valuable time. Please be assured that all information will be treated with the strictest confidentiality and only the aggregate data will be analysed.

We highly appreciate the support, insights and valuable feedback given by POLYTECHNIC Alumni and we would like to thank you in advance.

Figure 3: Snapshot of the Online Survey Form

The Electrical Engineering Unit, under the Curriculum Division of the Electrical Engineering Department of Polytechnic and Community College Education, is responsible for coordinating the implementation of the PEO Achievement Study in polytechnics. This process began with the development of survey instruments, which were created during a series of workshops attended by the PEO Measurement Committee. This committee is responsible for the study of the Diploma in Electrical Engineering at Polytechnic Malaysia and was appointed by the Curriculum Division.

Following the creation of the instruments, the next step is the selection of respondents by the polytechnic, based on the selection criteria specified in the survey objectives. For the 2017 cohort, this was the first PEO analysis conducted, and it serves as a baseline for future studies since there are no previous studies for comparison. To proceed, the Head of the Program needs to obtain a list of alumni from the Alumni Officer or through an Academic Advisor. The criteria set by the institution determines the number of respondents. The sample size can be calculated using the (Krejcie, 1970) formula for determining population size. This approach ensures a representative sample for the survey, enabling an accurate assessment of the PEO achievement.

3. Finding and Discussion

Before assessing the achievement of the PEOs, performance indicators for each PEO were established during the Department of Electrical Engineering Academic Meeting in 2021. Table 2 shows the PEOs and their corresponding performance indicators. The survey was centralized and conducted by the Curriculum Department. For the cohort of 2017, the survey was administered in 2019, and the data was analyzed in 2021, encompassing a population of 84 graduates. For the cohort 2018, the survey was conducted and analyzed in 2022, covering a population of 226 graduates. A detailed analysis of the survey results was discussed in a series of workshops. These workshops were attended by the PEO assessment committee, which included representatives from 20 polytechnics offering the Electrical Engineering Programme and were appointed by headquarters. During these discussions, adjustments were made to the survey instruments used for the cohorts of 2017 and 2018 to ensure the accuracy and relevance of the data collected.

The Diploma in Electronic Engineering (Communication) is a three-year full-time program that includes six semesters of coursework and one semester of industrial training. To assess the Programme Educational Objectives (PEOs) and ensure alignment with the Outcome-Based Education (OBE) philosophy and objectives set by the Department of Polytechnic Education, Ministry of Education Malaysia, alumni surveys were conducted for the 2017 and 2018 cohorts. The survey responses were analyzed using Microsoft Excel, and the results were compiled based on each PEO's description as indicated in Table 2. These results, which show the percentage of achievement for each PEO, were discussed in workshops with the PEO assessment committee, comprising representatives from 20 polytechnics. The discussions led to adjustments in the survey instruments and recommendations for improving the PEO statements, ensuring continuous alignment with educational goals. Microsoft Excel was used to evaluate all of the survey responses, and the results, which were based on each PEO's description, were compiled.

4. Analysis of PEO

The analysis for PEO 1 aims to assess the percentage of graduates practicing as technicians in electrical engineering-related fields. This is done by analyzing employment information from the survey, focusing exclusively on employed graduates (both employed and self-employed). Data from graduates who are either continuing their studies or are unemployed is excluded from this analysis. Additionally, the working sectors of those graduates employed in the electrical and/or electronic fields are also examined to provide a detailed understanding of their professional

engagement in these areas.

Table 2. Summary of PEOs Indicator and Achievement for Cohort 2017 and 2018

PEO	DESCRIPTION	TARGET	COHORT		STATUS
			2017	2018	
PEO 1	working in the electrical and/or electronic field	40	64.29	56	ACHIEVED
	experience in communication activities		66.67	61	
	worked in a group or team		85.71	81	
	leadership position		76.19	55	
PEO 2	practiced safety and health	30		94	ACHIEVED
	aware of social norms			99	
	member of any professional body or international society or regulatory body			35	
	involved in any community or social activities			58	
PEO 3	involved in any form of business	10	33.33	30	ACHIEVED
	business activity involves electrical/electronic		45.45	21	
PEO 4	achievement in electrical and/or electronic fields including enterprising	30	85.71	88	ACHIEVED
	achievement in another field		14.29		

Based on the collected data presented in Table 2, the achievement of the PEOs for the 2017 and 2018 cohorts of Diploma in Electronic Engineering (Communication) graduates has surpassed the target expectations. Specifically, 64.29% of the 2017 cohort and 56% of the 2018 cohort are employed in electrical and electronic fields. These fields include Sales and Marketing, Engineering, Security (Defence), Consultation, Management Trainee positions, Manufacturing, Services, Information Technology, and Telecommunication. The survey results demonstrate that the program has successfully prepared graduates for employability and high competency in the professional engineering technology field.

The analysis for PEO 2 evaluates the graduates' contributions to society, emphasizing their professional ethics and responsibilities. This analysis includes survey items on experiences in verbal communication (such as serving as a panelist or speaker), written communication, teamwork, leadership roles, membership in professional bodies, practicing safety and health standards, and participation in community activities. For the 2017 cohort, six items were assessed, and this was expanded to seven items for the 2018 cohort by adding a question about awareness of social norms. These seven items now cover experiences in communication activities, teamwork, leadership positions, safety and health practices, social norms awareness, membership in professional or international societies or regulatory bodies, and involvement in community or social activities. The analysis concludes that more than 30% of the graduates achieved the targets set for PEO 2.

The analysis for PEO 3 focuses on the graduates' engagement in enterprising activities that apply their engineering knowledge and technical skills. For the 2017 cohort, this analysis consists of two survey items: involvement in business activities (online/offline) and participation in research and development of product/service/system or technical projects. The survey for the 2018 cohort additionally asks about the form of business (online/offline). Overall, PEO 3 has achieved the targeted goal, which was to have at least 10% of graduates involved in enterprising activities that apply engineering knowledge and technical skills.

The analysis for PEO 4 aims to assess the success achievement of graduates in their careers, particularly in the electrical and/or electronic field, including enterprising activities. This analysis considers various factors such as salary increment, owning a business, promotion to higher posts, further studies, and gaining professional certification. The data indicates that 85.71% of the 2017 cohort and 88% of the 2018 cohort have experienced successful career advancement, based on these criteria. This includes salary increments, business ownership, promotions, further education, and professional certifications in electrical and/or electronic fields, including enterprising. The target for PEO 4 was set at 30%, and the data indicates that this target has been exceeded, surpassing expectations.

5. Triangulation Data Process for Continuous Quality Improvement

The purpose of the triangulation process is to gain feedback to improve the achievement of PEOs, and suggestions to review the PEO statements themselves. The triangulation data process involves collaborating findings from multiple sources or methods to enhance the credibility and reliability of the analysis. In the context of this study, it could entail comparing survey results with data from other sources like interviews, employer feedback, or academic records. This comprehensive approach ensures a more nuanced understanding of the PEO achievements. Whereas, continuous quality improvement involves ongoing efforts to enhance the effectiveness and efficiency of processes. This study involves reviewing survey methodologies, refining survey questions based on feedback, and then the proposal for updating PEOs based on industry standards. By continually assessing and refining methods, the study can ensure that the evaluation process remains relevant and effective.

The commitment of the Department of Electrical Engineering to providing quality education is evident through its active engagement with stakeholders, incorporating their inputs from meetings and surveys to continuously improve the program. The positive findings regarding the Programme Educational Objectives (PEOs) achievement, as perceived by alumni, indicate that the PEOs specified for the program have been successfully achieved. These results are shared in meetings with the academic excellence council of the Electrical Department and the Program Advisory Committee (PAC), which includes the Industrial Panel and Alumni of the DEP program. Feedback, comments, and suggestions gathered from these meetings are utilized for Continuous Quality Improvements (CQI) in the DEP program.

The attainment of PEOs is systematically analyzed to drive continual improvement in the implementation of the ETAC curriculum. To ensure verification, data triangulation is performed in collaboration with the industry advisory panel for the DEP program, as depicted in Figure 4. Two methods are employed to accumulate data: the quantitative technique, involving online surveys, and the qualitative method, consisting of direct discussions. The committee thoroughly compares, incorporates, and understands the results before planning for continuous quality improvement initiatives. This figure outlines how the department utilizes feedback and data from various sources to continuously enhance the quality of the program.

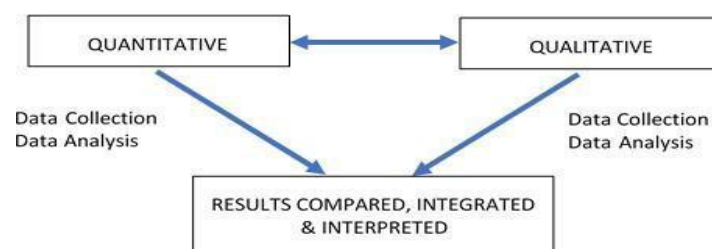


Figure 4. Triangulation Data Process

The PEO performance analysis for the 2017 cohort was presented during the Program Advisory Committee (PAC) meeting held on June 24, 2021. During this meeting, three main feedback points were received. Firstly, it was suggested that the development of survey items be reviewed and refined to ensure balance, particularly in measuring PEO2. Secondly, there was a recommendation to increase the percentage targets, as the existing targets were considered too low, especially for PEO1. It was proposed that the target for PEO1 be increased to 60%, aligning with the average data achieved by graduates, which was 60% and above. Finally, it was decided that all issues and recommendations would be presented and discussed in a department management meeting following the PAC meeting, scheduled for September 8th and 9th, 2021. This meeting aimed to gather ideas and suggestions to enhance the measurement of PEOs.

The assessment for cohort 2018, using the same indicators as cohort 2017, was presented at the PAC meeting held on December 15, 2022. During this meeting, academic representatives from UiTM suggested setting PEO targets that are specifically tailored to each program by the students. This approach would provide more indicative results of program achievements, facilitating further Continuous Quality Improvement (CQI). It was noted that the current instrument applied by DPCCE was too broad and not specific to any program. As a result, recommendations were made to develop PEO analysis questions that are tailored to each program, with the proposal to be forwarded to the Curriculum Division to authorize the program to develop the PEO instrument. The revised PEO indicators will be reviewed by the program committee and implemented for the next assessment in 2024. This proactive approach ensures that PEO assessment methods accurately reflect program achievements and support ongoing improvement efforts.

At the departmental level, actions and planning activities for quality improvement have been discussed and implemented. A Continuous Quality Improvement (CQI) process has been carried out to improve PEO attainment. Some of the actions undertaken include enhancing industry experts' involvement in teaching and learning, facilitating fully face-to-face laboratory work, implementing authentic learning experiences, and encouraging more Corporate Social Responsibility (CSR) activities. These initiatives collectively contribute to enhancing the quality of education and the achievement of PEOs.

An action plan for the PEO attainment assessment process for cohort 2019 will be established, which includes conducting surveys of both alumni and employers. A proper mechanism will be put in place to ensure a sufficient response to the survey is achieved. The involvement of former academic advisors is deemed crucial in ensuring the participation of all graduates in answering the survey questions. To accomplish this, academic advisors will be appointed to the Questionnaire Distribution and Collection Committee within the PEO Technical Committee for surveying graduates of 2018. To facilitate tracking of graduates who have or haven't completed the survey, the involvement of former academic advisors in survey distribution and collection is crucial, ensuring a higher level of awareness and understanding of the educational objectives of the programme.

The established Programme Educational Objectives (PEOs) will be published and publicized to both staff and students through the institution's website, enhancing visibility and understanding of program objectives. To further promote entrepreneurial activities, especially in the field of electrical engineering as outlined in PEO3, an incubator equipped with mobile phone repair facilities was established in early 2023. This initiative aims to encourage students to engage in entrepreneurial activities within the field. Additionally, entrepreneurship-related programs are being intensified to generate interest among students, motivating them to pursue opportunities in this field and become job creators.

6. Conclusion

The Programme Educational Objectives (PEOs) for graduates of the Diploma in Electronic Engineering (Communication) at Politeknik Sultan Salahuddin Abdul Aziz Shah have been thoroughly assessed and evaluated. The data analysis indicates that graduates are successfully achieving the designated PEOs. Continuous Quality Improvement (CQI) can be implemented by identifying areas for enhancement through PEO measurements and analyzing the findings. Input from various stakeholders was integral to the CQI process, contributing to the comprehensive assessment and evaluation of the faculty's PEOs.

References

- Bahagian Kurikulum, & Jabatan Pendidikan Politeknik dan Kolej Komuniti. (2021). *Garis Panduan Pelaksanaan Kajian Pencapaian PEO Edisi 2021*.
- Board of Engineers Malaysia. (2020). *ETAC ETechnician Standard 2020*.
- Hadi, N. A. Ab., Jubilee, K. B., & Wee, B. S. (2023). *An Evaluation of Program Education Objectives for Electrical and Electronic Engineering Programme at Politeknik Mukah* (pp. 233–245). https://doi.org/10.2991/978-94-6463-118-0_25
- Hairi, N., Affandi, H. M., & Nasri, N. M. (2019). Identifying Instruments to Measure Programme Educational Objectives (PEO) Achievement in Malaysia. *Universal Journal of Educational Research*, 7(9A), 135–146. <https://doi.org/10.13189/ujer.2019.071616>
- Instructional and Digital Learning Division, T. D. of P. E. M. of H. E. M. (2024). *Center for eLearning and Teaching (CeLT)*. <https://polycc.cidos.edu.my/>
- Krejcie, R. V., & M. D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, 30, 607–610.
- Mohammed M.U. Faiz & Mubarak S. Almutairi. (2021). Assessment of Student Outcomes of Electrical and Electronics Engineering. *Global Journal of Engineering Education*, 23(3).
- Morten Pedersen. (2024). *The 5 Most Popular Online Survey Tools*. LinkedIn.
- Pramono, B. N. S. R., Mansor, W., Latip, M. F., Mohamad, H., & Abdullah, S. A. C. (2020). Analysis of Graduates Performance Based on Programme Educational Objective Assessment for an Electrical Engineering Degree. *Asian Journal of University Education*, 16(3), 303–309. <https://doi.org/10.24191/ajue.v16i3.10224>
- Rashidah Mat Tuselim, Y., Ramli, A., Che Mamat, R., & Ungku Omar, P. (2022). Evaluation of Programme Educational Objectives for Civil Engineering Technology Programme with Work-Based Learning Approach. In *Teknologi dan Sains Sosial* (Vol. 8, Issue 1).
- Suhaimi, M. S., Nul, L., Juwara, H., & Abdullah, N. (2022). Programmes Educational Objectives (PEO) Achievement for Diploma in Mechanical Engineering at Politeknik Muadzam Shah Full Paper. In *Borneo Engineering & Advanced Multidisciplinary International Journal (BEAM)* (Vol. 1, Issue 2). <https://beam.pmu.edu.my>
- Tshai, K. Y., Ho, J. H., Yap, E. H., & Ng, H. K. (2014). Outcome-based education - The Assessment of Programme Educational Objectives for an Engineering Undergraduate Degree. *Engineering Education*, 9(1), 74–85. <https://doi.org/10.11120/ened.2014.00020>
- Unit Kejuruteraan Elektrik. (2020). *Panduan Kurikulum bagi Program Kejuruteraan Elektrik dan Elektronik*. <https://www.mypolycc.edu.my/index.php/muat-turun/garis-panduan-c/bahagian-kurikulum/send/12-bk/698-panduan-kurikulum-program-ee>

Raspberry Pi Wlan Cast as A Teaching and Learning Aid in Lecture Halls

Mohd Hafiz Haron^{1*}, Muhammad Tarmizi Ab Aziz² & Mohd Firdaus Ibrahim³

^{1,2}Diploma Unit of Electronic Instrumentation, Seberang Jaya Community College, Penang, Malaysia.

³Department of Mechanical Engineering, Seberang Perai Polytechnic, Penang, Malaysia.

* hafiz@kksbj.edu.my

Abstract

In large lecture halls, visibility of the front screen can be a significant issue for many students. This study introduces a device named Raspberry Pi 3, which enhances screen sharing from the presenter to users' personal devices, such as smartphones or laptops, using a wireless network connection. By connecting the Raspberry Pi 3 to the network, the presenter can initiate the screen-sharing process, allowing users to view the presenter's screen display on their devices, no matter their location in the hall. Additionally, the presenter can share files and presentation slides directly with users. Our findings show that this technology greatly improves visibility for students seated far from the front, ensuring they can clearly see the presentation. The study underscores the practicality of Raspberry Pi 3 in educational settings, offering a scalable solution that leverages appropriate programming languages to facilitate large-scale presentations and enhance student engagement.

Keywords: Raspberry Pi 3, Screen Sharing, Large Lecture Halls, Wireless Network, Educational Technology

1. Introduction

Screen display technology allows a device to project the display from one screen to another. Typically, the use of screen display requires Wi-Fi as the intermediary between the user and the presenter. The screen display will show the view from the presenter's screen to the user's screen. This modern technology offers significant benefits to users, but it also has some drawbacks. Usually, the transmitter acts as a server to manage data exchange to the screen display. For a good presenter, quality visuals are crucial for clear communication to the users. Users will request data exchange from the presenter via the server. Once a connection is established, screen selection will be available online. Before making a connection, users need to configure certain settings on their own devices to establish a link between the presenter and the users.

Effective presentation and communication are essential. Presenters need to deliver their presentations on the relevant topics, typically supported by visual aids projected on a large screen. When the screen display is shown to the users using such devices, it enhances the users' ability to view and comprehend the presentation. A common issue arises when the room is too large, and the distance between the users and the screen is too great, resulting in a diminished viewing experience. Sound may not be clear for users listening from a distance. The device has been designed with a high-quality sound system to produce clear audio from every corner of the hall, as the sound is not only emitted from the hall's speakers but also from each user's device speakers.

2. Problem Statement

The considerable distance between users and the screen can cause users to have blurred vision, making it difficult to see the display clearly. This distance may lead users to miss critical information presented. A far-off screen display can also result in users having trouble hearing the presentation clearly, with the distance from the speakers being a primary factor affecting audio clarity. Modern technology does not provide direct audio from the presenter to the users. This issue

can limit the users' ability to hear clearly. Speakers are typically placed at the right and left corners of the hall, making it challenging for users seated at the back to hear the presenter's speech clearly. Connections from viewers' devices might vary. For instance, laboratory computers can connect via Ethernet cables due to their setup in a laboratory topology and direct network access. However, other devices like laptops may require wireless connections to join the network. Additionally, the use of physical drives poses a risk of spreading viruses from the presenter's device to other users' devices during file transfers.

This issue arises when users request presentation materials for reference. A virus is a type of malware that damages computer programs, data files, or the internal hardware's boot sector. The impact of a virus can include deleting or altering infected files. Obtaining materials from the presentation can disrupt users' concentration during the presentation. During the presentation process, users might miss the main points being conveyed. Consequently, users might lose focus on the presentation while trying to catch up on the missed essential points. Presenters are unlikely to wait for users to regain focus or pause to repeat explanations, as this would disrupt other users.

3. Objective

This study has several objectives aimed at achieving priorities and ensuring the process has a solid goal.

- i. To provide a clearer display for users at the back, especially in large lecture halls.
- ii. To enable seamless data sharing, particularly course-related files, without any disruptions.
- iii. To enhance student focus during the learning process, as teaching materials are easily visible and accessible even in crowded lecture halls.

4. Literature Review

In this literature review chapter, we will briefly explain the information obtained that is closely related to the study to be conducted, namely Raspberry Pi WLAN Cast. This chapter will also emphasize the background of existing studies in the market and previous studies involving screen displays. This chapter is also one of the research and investigation activities on topics related to the research questions. This method is necessary to identify methods, identify problems that arise, and ways to overcome or mitigate them. There are various methods or approaches that can be used in the process of collecting information, including making comparisons between old or existing studies. Through this method, the comparison process can identify whether there are deficiencies or strengths in the study and can help improve a study.

Literature review is carried out on the Raspberry Pi WLAN Cast device to ensure that users and presenters can utilize the facility to give and receive screen displays via a wireless network. The scope of this literature review focuses on studying the aspects directly involved in the development of this study. The aspects studied include the advantages of applications, software advantages among users, and applications. Therefore, in conducting the Raspberry Pi WLAN Cast study, it can assist presenters easily share screen displays with users via laptops or smartphones capable of connecting to wireless networks. This is to further solidify the research results to achieve the desired objectives.

Hardware Requirement

Before developing a system, a study on the hardware to be used must be conducted. This is to ensure that the hardware used is suitable for the study to be carried out.



Figure 1: Raspberry Pi 3

The Raspberry Pi is a small single-board computer developed by the Raspberry Pi Foundation to promote basic computer science education at the school level in developed countries. The original model received much more enthusiasm than expected and has been used in various fields such as robotics. When purchasing this product, it does not come with hardware such as a keyboard, mouse, and casing.

Advantages

Despite its credit card-sized dimensions, the Raspberry Pi 3 functions as a normal computer at a lower cost. It can also serve as a low-cost server for lightweight tasks. Utilizing Raspberry Pi as a server can save costs compared to using high-powered servers. The Raspberry Pi 3 comes equipped with basic computer features such as Wi-Fi, 1 Ethernet port, 4 USB ports, and 1 HDMI port. Additionally, it provides 40 pins for connecting additional hardware such as microphones and cameras. The processor used is a Quad-core ARM Cortex-A53 1.2GHz. The GPU used is Broadcom Video Core IV. It has 1GB of RAM clocked at 900MHz. The network hardware includes 10/100 Ethernet, 2.4GHz 802.11n wireless, and Bluetooth 4.1 Low Energy. Storage is via a 16GB microSD card, with a GPIO 40-pin header and ports for HDMI, a 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), and Display Serial Interface (DSI). Raspberry Pi 3 comes with the open-source operating system Raspbian Stretch, based on Debian.

Interface Application

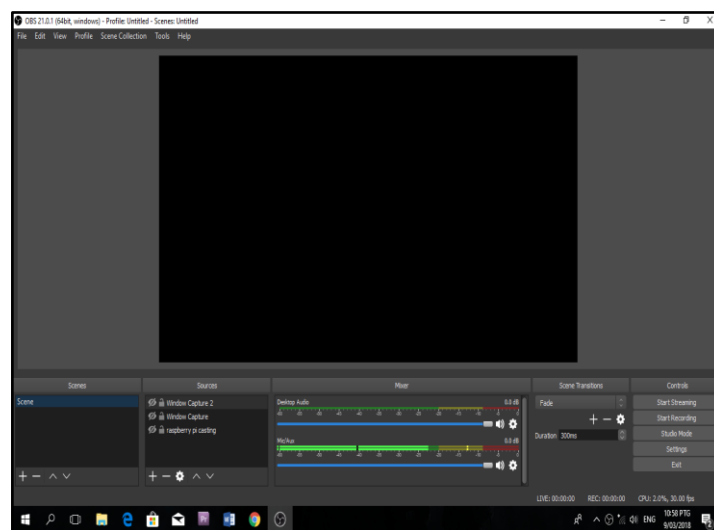


Figure 2: User interface OBS Studio

The user interface provided by OBS Studio software is very easy to understand, with the use of a GUI (Graphical User Interface) containing several functions that can be performed by the software. The functions utilized in this study are streaming and recording.

System Comparison

In the topic of system comparison regarding literature review, there are two aspects to be elaborated on: hardware and software of a system or study being used.

Table 1: Comparison between Previous Studies and Raspberry Pi WLAN Cast

	Google ChromeCast	Apple AirPlay	Raspberry Pi WLAN Cast
Technology	Google Cast SDK mDNS(multi Domain Name System)	Over Wi-Fi and Ad-hoc	Client and Server on Raspberry Pi
Function	Streaming video, screen, and audio wirelessly to devices that support Google Cast.	Streaming video, images, audio, and screen wirelessly to devices that support the AirPlay protocol.	FTP (File Transfer Protocol) Screen and audio streaming, file transmission, and recording of the streaming process.

5. Methodology

In the process of conducting research to produce a new product for the use of lecturers or educators in educational institutions or in the workplace, it requires careful planning and monitoring to ensure that the results obtained will meet the goals and objectives of the implementation. Furthermore, the development of a new product requires careful selection of methodologies that are suitable for the implementation study. Methodology is defined as a process developed by developers to implement a study involving several specific phases, in other words, these phases constitute the System Development Life Cycle based on specific models (Dewitz, 1996).

The role of methodology in a research implementation process is crucial for the production of a product. It is required to analyze data in detail to meet the research objectives and achieve them fully. Methodology must also be a comprehensive set of guidelines containing equipment facility models and specific techniques that need to be followed in carrying out each activity within the System Development Life Cycle example (Mohamad Noorman Masrek et al., 2001). In selecting a suitable methodology for the developed research, it must meet the requirements and specifications of the users, especially.

In addition to being suitable for the produced product, the selection of a methodology must also be aligned with the case study's structure in terms of patterns and policies. If this aspect is not emphasized, there is a risk that the product development process will be hindered or completely paralyzed, and as a result, the resulting study will deviate far from the direction of achieving the mission, goals, and objectives of the research.

Implementation of the Study in General

Table 2: Research Implementation Schedule

Task	Implementation
Scope, Objectives, and Problem Statement Determination	Defining the scope, objectives, and analyzing the problem statement within the case study environment, namely in the lecture halls at Politeknik Seberang Perai, Pulau Pinang.
Data and Information Collection	Data collection sources: 1) Internet 2) Interviews 3) Observations 4) Surveys

Literature Review	Literature review on concepts:
	1) Wi-Fi Technology
	2) File Transfer Technology and Protocols
	3) Screen Display Technology
Design	Physical Sketches
	Logical Sketches
Implementation and Testing	Testing the product in the case study and adjusting based on user feedback from surveys and observations.
Research Findings	Presenting the outcomes, i.e., presenting the product to provide screen displays to all users present in the lecture hall about the content displayed in front.

Research Methodology

The research methodology utilized in this study employs the Agile Method. This method is a combination of iterative process models and focuses on process adaptability and customer satisfaction through rapid software product delivery. The Agile method breaks the product into small incremental builds. These builds are provided in iterations. Each iteration typically lasts from one to three weeks. Each iteration involves cross-functional teams working simultaneously in various areas such as planning, requirements analysis, design, coding, and unit testing.

The Agile model believes that each study should be handled differently, and existing methods should be adapted to meet the study's needs. In Agile, tasks are divided into time boxes (small time frames) to deliver specific features for release. An Iterative Approach is adopted, and working software is delivered after each iteration. Each iteration is an increment in terms of features; the final build holds all the features required by the users.

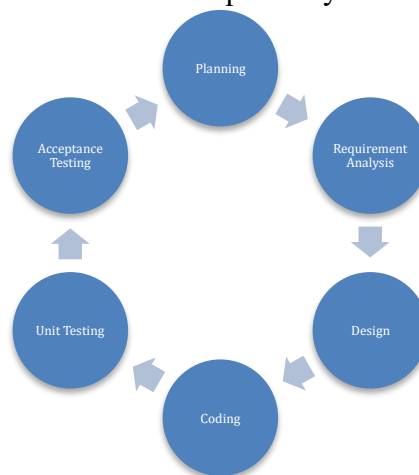


Figure 3: Agile Method Lifecycle Diagram

Planning Phase

The Planning Phase is the most critical phase where the planning and objectives for conducting this study are established. This phase begins with conducting a problem analysis within the study area, namely in the lecture halls of Politeknik Seberang Perai, Pulau Pinang, before creating a product that can provide convenience to users.

Requirement Analysis Phase

In this Requirements Analysis Phase, each requirement will be analyzed first in order to produce this product. Research will be conducted on websites to find the necessary supplies needed to successfully carry out this study. In this phase, every requirement will also be searched for to ensure that the product produced is of high quality and can be used easily and safely.

Design Phase

This phase involves designing the network according to the initial requirements established in the Planning Phase, incorporating additional data collected during the Requirements Analysis. The network design specifications produced are comprehensive detailed designs that meet the lecture hall area at Politeknik Seberang Perai, Pulau Pinang. This phase encompasses both the Physical and Logical Design for the lecture halls at Politeknik Seberang Perai, Pulau Pinang. Microsoft Visio is used to draw the Physical Design, while Packet Tracer 7.0 is used for the Logical Design.

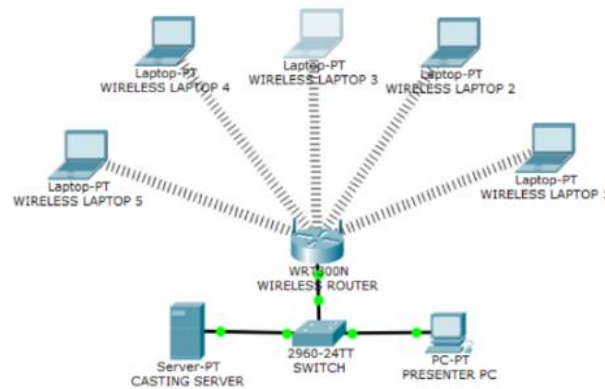


Figure 4: Physical Design Display

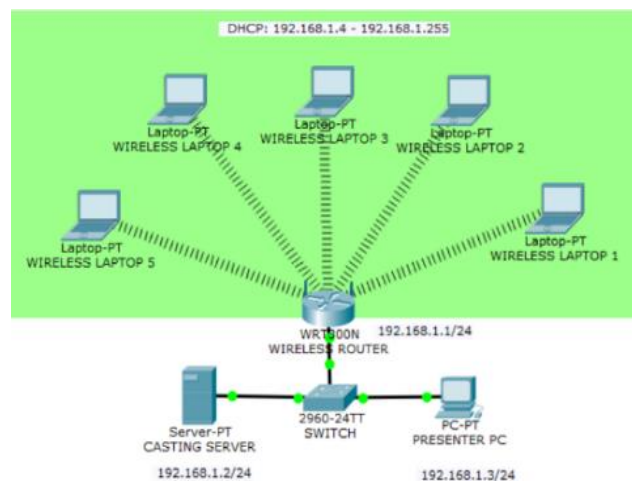


Figure 5: Logical Design Display

Coding

In this step, the use of Raspberry Pi requires several software that needs to be installed on the device. Next, by using software to provide screen displays to users accessing the produced product. In addition, software has been installed to allow the process of file delivery from the lecturer to the audience.

Unit Testing Phase

After completing the Coding Phase, this phase allows for testing of the product being developed. In this phase, the product will be tested to ensure that it functions perfectly without any issues arising before it is used by other users.

Acceptance Testing Phase

The Acceptance Testing Phase will proceed if the Unit Testing Phase runs smoothly and there are no issues arising when the produced product is used. This phase determines whether the product

is ready for use by other users or not. If there are any issues during the Unit Testing Phase, the Acceptance Testing Phase cannot proceed until the issues are resolved as quickly as possible.

Data Collection Techniques

This refers to the process of obtaining information from the environment, which includes internal and external sources through references, reading, and research through various materials, especially reference books, readings, journals, magazines, the Internet, and so on. Among the data collection techniques used are questionnaire surveys, interviews, observations, and reviews.

Questionnaire Surveys

Questionnaire surveys are a data collection technique that uses specific forms or documents to obtain feedback from respondents. This technique is chosen because it is very suitable for use when raw data or facts, namely respondents at Politeknik Seberang Perai, Pulau Pinang, involving students and lecturers. This technique involves the use of forms specifically prepared to collect data. These questionnaires are distributed to respondents who are given the freedom to fill in information based on the questions presented in the questionnaire. This questionnaire survey is conducted during the testing phase to assess the extent of implementation of the screen display product when used in the lecture hall by the target users.

Interviews

The interview technique is the easiest approach for researchers to gather data from respondents who have expertise in a specific field related to the issues that arise in the lecture hall at Politeknik Seberang Perai, Pulau Pinang. The interview technique is used to obtain information through face-to-face interaction. To conduct this technique, the purpose and objectives of the interview need to be determined. In addition, the quantity of information to be collected also needs to be determined. Then, the selection of sources for the desired information is made, which involves selecting respondents. The respondents interviewed are those directly and indirectly involved in the implementation of the screen display product in the lecture hall.

Observation and Review

This data collection technique is crucial because the observation and review process needs to be carried out in the area of the case study to obtain detailed information about the study being conducted. This includes visiting lecture halls or places used for delivering lectures around the Politeknik Seberang Perai, Pulau Pinang area. Every observation and review conducted will be kept as a reference for future use in producing products that provide many benefits to users.

6. Analysis and Design

This section deals with analyzing the research data that has been collected. The overall findings and analysis are presented in the form of tables, charts, and statements to allow key discoveries to be highlighted. This section needs to be organized according to the hierarchy of research questions to demonstrate that all questions have been addressed. The introduction of this section aims to guide the reader towards an understanding of the research findings based on the objectives and problem statements. This chapter will provide an overview of the intended study. Matters that can be elucidated in this section include the response rate and research findings. Research findings enable this process to run smoothly and efficiently. Information and data from respondents provide new ideas for improving this system. The analysis process is carried out according to a plan to obtain and collect data to assist in establishing a new system.

Floor Plan Design

Floor plan is a plan that shows the size of interior spaces, the layout of rooms, floor covering materials, door and window types and codes, the direction of staircases, the swing direction of doors or windows, construction materials shown using standard drawing symbols, floor heights, and contour lines. The floor plan is also a drawing that shows a room that can be viewed from above. Everything in the floor plan appears flat. Architects use floor plans to show the condition and appearance of a room or space or building.

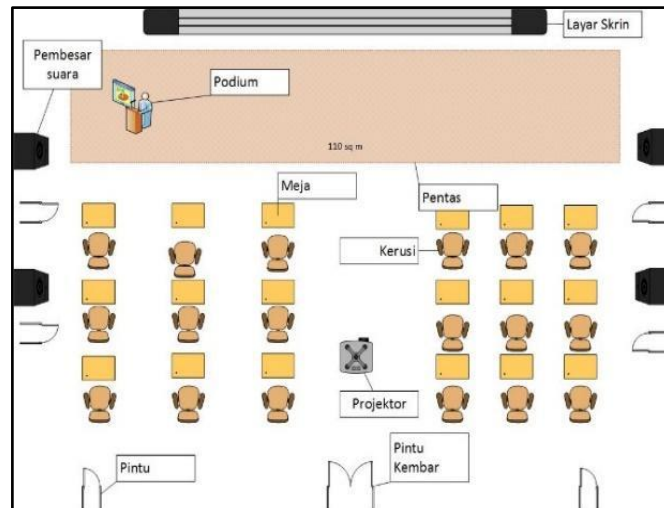


Figure 6: Floor Plan Design in Dewan Sri Mutiara, PSP

Figure 6 shows the floor plan design in Dewan Sri Mutiara, which has been meticulously crafted using Microsoft Visio to illustrate the detailed positioning of components. This floor plan is crucial as it provides a comprehensive overview of the hardware within the hall. The study was conducted within Dewan Sri Mutiara, focusing solely on the area within the hall.

Physical Design Illustration

The physical design entails how the network hardware is actually interconnected with wires and cables. Physical design includes the location and installation of devices and cables. Physical design focuses more on depicting a system or network layout clearly and fundamentally.

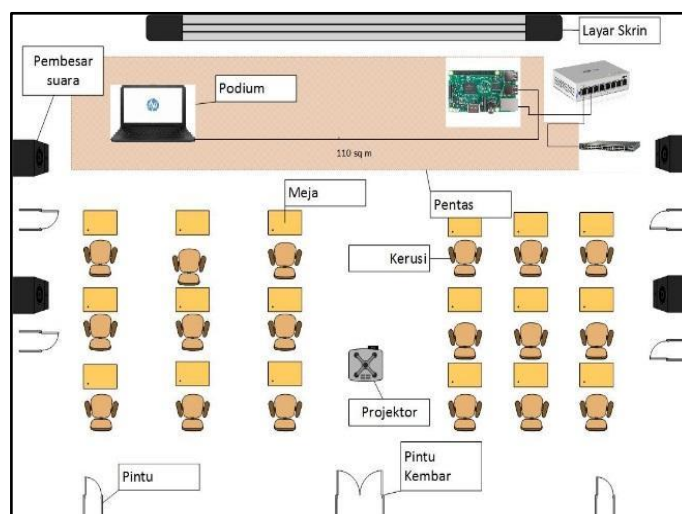


Figure 7: Physical Design Illustration

Figure 7 illustrates the diagram design created to determine the positioning of hardware based on the floor plan. The hardware involved in this study includes a laptop, Raspberry Pi 3, router, and switch. All hardware is located on a stage adjacent to the presenter's laptop.

Logical Diagram

The logical design refers to the logic used to depict a network or how a network is interconnected. A logical design illustrates the placement of each installed hardware component. The logical design is the step where devices on the network are arranged and how devices communicate with each other.

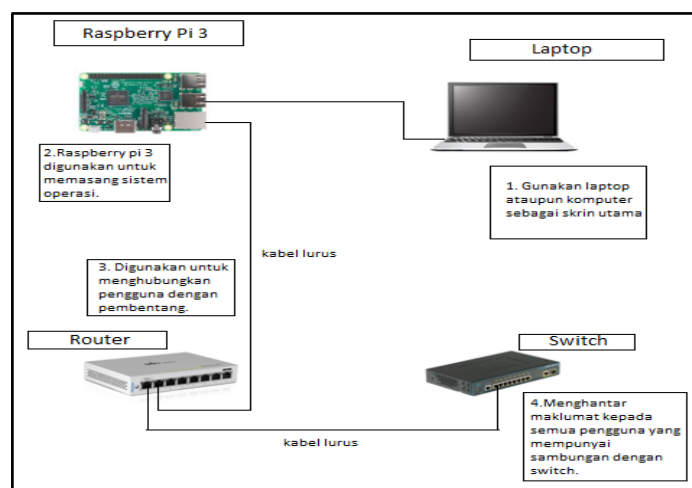


Figure 8: Logical Diagram for the Raspberry Pi WLAN Cast Study.

Figure 8 depicts the logical diagram of the Raspberry Pi WLAN Cast device. The switch establishes a connection to the router, which is then connected directly to the Raspberry Pi 3. After that, using a straight cable, it is connected directly to the laptop and used seamlessly.

7. Findings

The overall findings are presented in tabular form to facilitate the presentation of key findings. Table 3 shows the reported response rates with statements of the number of selected respondents and the response rates obtained from the respondents.

Table 3: Findings

Question	Answer	Percentage (%)
Gender	Male	40%
	Female	60%
Department	JTMK	45%
	JKE	25%
	JKM	10%
	JP	20%
Have you ever felt that the delivery of information from the lecturer to the users during a presentation of knowledge is less effective with current technology in the lecture hall?	Yes	80%
	No	20%
Is the projector screen display used by the lecturer currently quite clear and easy to understand?	Yes	35%
	No	65%
Is the audio delivery in the lecture currently able to provide effective information delivery to the users?	Yes	45%
	No	55%
Have you ever experienced slow downloading of files and information when the lecturer shared information with you for additional information during the lecture?	Yes	75%
	No	25%
Have you ever felt that the equipment you use to receive information from the lecturer is not secure and susceptible to virus attacks?	Yes	85%
	No	15%

Is the arrangement of chairs and tables suitable for users during the presentation process in the hall?	Yes	55%
	No	45%
Does the wireless connectivity you currently use greatly facilitate the communication process between users and presenters during a presentation?	Yes	85%
	No	15%
The focus given is more effective since the use of screen displays.	Yes	75%
	No	25%
Have you ever considered that the size of the hall affects the process of delivering information during presentations?	Yes	70%
	No	30%
Will you make references again after the presentation process with the lecturer in the hall is over?	Yes	60%
	No	40%

Development and Testing

The implementation and testing phase will determine whether the developed system can operate according to requirements, be free from errors, and achieve the set objectives. This phase is also considered a platform for determining the effectiveness of the developed system. The development phase is a continuation of the design phase that has been produced. In this phase, the focus will be on the development and testing of prototypes. In the development part, the designed prototype will be built according to the established criteria. Meanwhile, in the testing part, the prototype will be tested for functionality and user acceptance of the developed system.

Hardware Installation

In this phase, the hardware installation process needs to be carried out to connect all the listed components to build the Raspberry Pi WLAN Casting prototype. The hardware installation process needs to be done carefully to avoid damaging the components on the circuit board.



Figure 9: Raspberry Pi 3 Circuit Board

The Raspberry Pi 3 module circuit board used as a server in this study is shown, installed inside a case to ensure the circuit board is not handled carelessly, which could cause a short circuit. Additionally, the installation of a fan and heatsink is done to control its temperature, ensuring stability and extending the lifespan of this hardware.

Hardware Process

The Wi-Fi connection process begins when users use their devices to connect to the network. Before users can access the network, they must enter the password for this network.

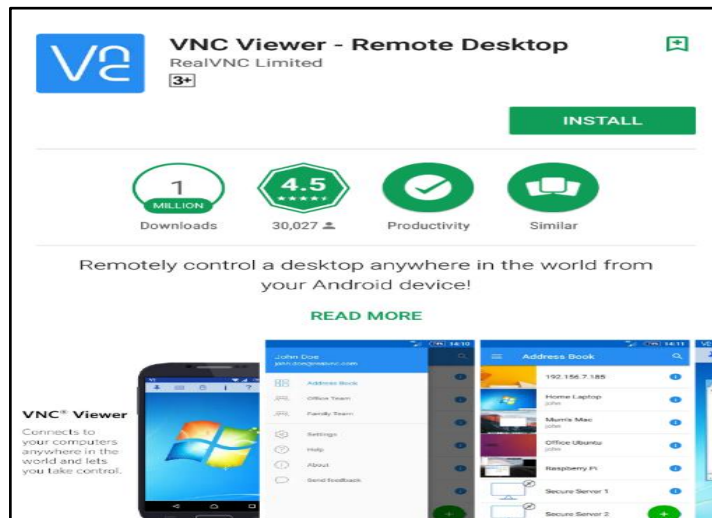


Figure 10: Android Play Store

On smartphones, users can use the VNC Viewer - Remote Desktop software to obtain screen display. Once confirmation is received, users can access the data contained in the shared file but cannot make any changes to the file.

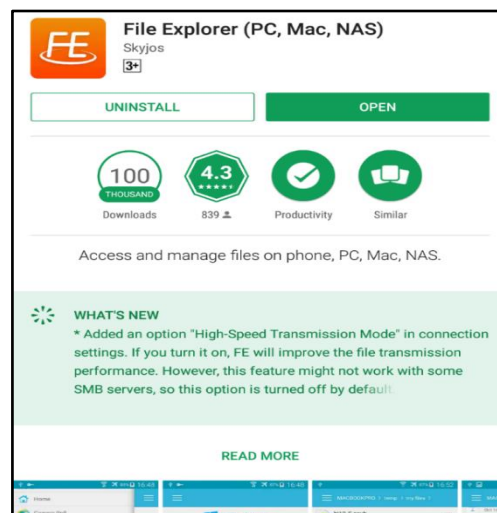


Figure 11: Google Play Store

On smartphone devices, users can access the file transfer server through the File Explorer software (PC, Mac, and NAS).

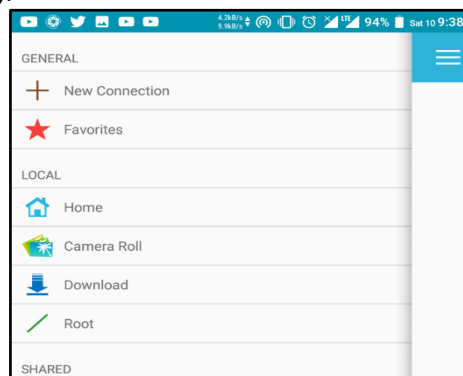


Figure 12: File Explorer

In the software, click on "New Connection" to create a new connection to the server.

7. Recommendation

Advantages of the Study

This study provides a better space than what currently exists. It facilitates both lecturers and audiences during seminars or lectures in the hall. It also makes it easier for some parties to convey information from the lecturer to the audience through this device, which uses wireless connectivity. The advantages of this system are as follows:

- i. Assists the audience in viewing the screen display more closely and clearly through their respective laptops.
- ii. Provides file transfer services through wireless connectivity to facilitate file sharing between the lecturer and audience indirectly in a seminar hall.
- iii. With several security benefits in place, lecturer files will be secure from virus attacks and not easily hacked or stolen by unauthorized parties.
- iv. If there is damage to the sound system in the seminar hall, the lecturer can still convey information to the audience through the built-in sound system in this device

Weakness of the Study

Although the objectives and scope of the study have been achieved, there are several weaknesses that indicate the need for improvement in this system. The weaknesses of this system are as follows:

- i. To ensure the functionality of this study, many software programs are required to implement it.
- ii. For lecturers and audiences, they require specific software to give and receive displays in the hall.
- iii. The scope of the study area used is relatively small because it only utilizes the Local Area Network (LAN).

7. Recommendations

After completing this study, there are several things that need to be done for improvement measures. Several recommendations have been proposed to be added, such as:

- i. Reduce the use of software to develop this study so that the system can function properly.
- ii. This study currently uses the scope of the Local Area Network (LAN); however, in the future, the scope of the Wide Area Network (WAN) will be attempted for the purpose of improving this study.
- iii. This study will be modified so that it can facilitate lecturers in carrying the Raspberry Pi 3 device easily.
- iv. This device is only able to use a USB drive as the main storage source, but in the future, the use of an External Hard Disk will be given more attention.

8. Conclusion

In conclusion, the findings of the study are summarized and discussed comprehensively. The study involves listing the research findings in an appropriate sequence. The research findings discovered are indeed concluded in line with the research questions. Each chapter outlined in this report has greatly contributed to the development of the conducted study. In the introduction chapter, the objectives, problem statements, system scope, user scope, location scope, and research significance are formulated. This is because the introduction section greatly aids in obtaining information for literature review, system journey studies, and information analysis. Previous projects' outcomes have been reviewed for the improvement of the current study. Not to forget, the methodology study has been very helpful in terms of providing a detailed and effective research process sequence.

By using the methodology approach, the development of this study can be continued in a more organized and strategic manner. The developed Raspberry Pi WLAN Cast has achieved its objectives and fulfilled the goals expected by the users. This is because every objective that needed to be considered during this study has been achieved when conducting the research to obtain results. The development of this system can provide convenience to lecturers and audiences to give and receive information more clearly and effectively. It is hoped that this study can contribute to technology advancement for the benefit of the broader community in improving the quality of life in the future. Furthermore, the findings obtained in conducting this study can also provide meaningful experiences and be utilized as efficiently as possible to enhance management efficiency in the development of any research. Recommendations are presented to further improve the quality of a system. Strengths and weaknesses are also presented in the conclusion chapter along with recommendations to ensure that the promised study can be completed successfully.

Acknowledgment

A heartfelt thank you to the students of PSP for their assistance in data collection for the research. Special appreciation goes to our esteemed faculty members for their invaluable support and encouragement throughout the implementation of this study. A special mention to Dr. Mohd Nazrin bin Md Isa for his expertise and guidance in managing the Raspberry Pi devices.

References

- A Raspberry Pi. (2013). Retrieved June 12, 2022, from <https://www.raspberrypi.org/forums/viewtopic.php?f=63&t=51436>
- AirPlay. (2018). Retrieved June 21, 2022, from <https://en.wikipedia.org/wiki/AirPlay>
- Build a Raspberry Pi NAS. (2017). Retrieved March 12, 2023, from <https://pimylifeup.com/raspberry-pi-nas/>
- Chromecast. (2018). Retrieved May 21, 2023, from <https://en.wikipedia.org/wiki/Chromecast>
- D. (2016). Contents. Retrieved May 12, 2023, from <https://www.digitalocean.com/community/tutorials/how-to-install-and-configure-vnc-on-ubuntu-14-04>
- Miracast. (2018). Retrieved March 21, 2023, from <https://en.wikipedia.org/wiki/Miracast>
- Team, S. (n.d.). Raspberry Pi 3 Model B. Retrieved March 21, 2023, from http://wiki.seeed.cc/Raspberry_Pi_3_Model_B/
- Vidmar, R. J. (1992, August). On the use of atmospheric plasmas as electromagnetic reflectors. *IEEE Transactions on Plasma Science*, 21(3), 876-880. <http://www.halcyon.com/pub/journals/21ps03-vidmar>
- Tightvncserver - show the same screen on hdmi and vncclient. (2013). Retrieved June 12, 2020, from <https://raspberrypi.stackexchange.com/questions/9590/tightvncserver-show-the-same-screen-on-hdmi-and-vncclient>

Remote Lab: An Enhancement in Technical and Vocational Education Training (TVET)

Vaina Malar Panneer Selvan^{1*} & Uma Devi Nadarajah²

^{1,2} Mechanical Engineering Department, Politeknik Banting Selangor, Malaysia

*vaina@polibanting.edu.my

Abstract

In the dynamic landscape of technical and vocational education training (TVET), the integration of remote laboratories stands as a transformative advancement, addressing challenges in traditional hands-on training methods. This scoping review explores the multifaceted dimensions of remote labs, offering virtual access to practical experiences and simulations, thereby reshaping the educational paradigm. This scoping review aims to comprehensively examine the impact of remote labs on TVET. It seeks to analyse existing literature to discern the effectiveness, challenges, and potential advancements in integrating remote labs, providing insights for educators, policymakers, and researchers. To achieve the research objective, a systematic literature review will be conducted using the Scopus database. Keyword searches will focus on topics related to "remote labs," "IoT in education," and "technical and vocational education." The inclusion criteria will prioritize studies published within the last five years to ensure relevance and currency. The review will summarize recent studies exploring the integration of Internet of Things (IoT) in remote labs for technical and vocational education, highlighting technological advancements and pedagogical implications. A critical analysis of the literature will identify prevalent issues and challenges associated with the implementation of remote labs, such as technical limitations, accessibility concerns, and pedagogical considerations. The scoping review will provide insights into potential avenues for future research and offer recommendations to address identified challenges, fostering continuous improvement and innovation in remote lab integration for TVET. In conclusion, this scoping review emphasizes the transformative role of remote labs in enhancing TVET. The findings underscore the need for addressing challenges and optimizing the integration of remote labs, with recommendations for future research focusing on refining pedagogical strategies, improving technological infrastructure, and ensuring inclusivity in remote learning environments.

Keywords: Remote lab, Internet of Things (IoT), TVET

1. Introduction

In the rapidly evolving landscape of technical and vocational education, the integration of innovative technologies has become imperative to meet the demands of an increasingly interconnected and dynamic world. One such transformative advancement is the introduction of remote laboratories, offering a change in basic assumptions in the traditional methods of hands-on training. This scoping review aims to explore and clarify the various dimensions of remote labs as a groundbreaking enhancement in technical and vocational education training.

Historically, vocational, and technical education has been synonymous with practical, hands-on learning experiences, enabling students to bridge the gap between theoretical knowledge and real-world applications (Lameras & Moumoutzis, 2021). However, conventional approaches face challenges in adapting to the modern educational needs, including geographical constraints, resource limitations, and the ever-growing pace of technological change. Remote labs emerge as a promising solution, providing students with virtual access to practical experiments, simulations, and equipment through web-based platforms (Jara et al., 2009).

The significance of remote labs lies in their ability to transcend the constraints of time and space, offering an inclusive and flexible learning environment (Yusoff et al., 2021). This is particularly relevant in vocational and technical education, where access to specialized equipment and facilities can be a bottleneck (Hecker et al., 2021). Remote labs not only democratize access but also cater to diverse learning styles, accommodating students in various locations, irrespective of their proximity to traditional educational institutions (Balakrishnan, 2017).

Moreover, the incorporation of remote labs aligns seamlessly with the evolving nature of industries, where digitization and automation play pivotal roles (Khan et al., 2022). By exposing students to virtual experimentation and problem-solving scenarios, this technological enhancement prepares them for the demands of a rapidly changing workforce landscape. As we delve into the intricacies of remote labs, this scoping review will scrutinize the efficacy, challenges, and potential avenues for further development in integrating this technology into vocational and technical education programs.

In summary, this paper aims to provide a comprehensive overview of the role of remote labs in enhancing technical and vocational education training. Through an examination of existing literature, we seek to discern the impact of remote labs on learning outcomes, skill acquisition, and the overall educational experience, paving the way for informed insights and recommendations in the realm of modern education.

2. Research Objectives

The primary objective of this scoping review is to thoroughly investigate the role and impact of remote laboratories in vocational and technical education. This study aims to elucidate the multifaceted dimensions of remote labs, focusing on their integration, effectiveness, and the challenges they present. By analysing existing literature, the review seeks to provide a comprehensive understanding of how remote labs can transform vocational and technical training.

One of the core objectives is to explore the integration of Internet of Things (IoT) technologies in remote labs, highlighting the technological advancements and their pedagogical implications. The review will examine recent studies to understand how IoT enhances the functionality and accessibility of remote labs, providing students with immersive, real-time experiences that bridge the gap between theory and practice.

Additionally, the review aims to identify the prevalent issues and challenges associated with implementing remote labs. This includes technical limitations such as internet connectivity and hardware requirements, accessibility concerns, and the pedagogical considerations necessary for effectively incorporating these technologies into educational curricula. Understanding these challenges is crucial for developing strategies to overcome them and ensure the successful adoption of remote labs.

Finally, the review seeks to offer insights into potential future research avenues and provide practical recommendations for educators, policymakers, and researchers. This includes suggestions for improving technological infrastructure, refining pedagogical strategies, and ensuring inclusive access to remote labs. By addressing these areas, the review aims to foster continuous improvement and innovation in the integration of remote labs into vocational and technical education, enhancing the quality and effectiveness of training for students.

3. Methods

To achieve the research objectives of this scoping review, a systematic approach is employed, utilizing the Scopus database as the primary source for literature collection. This scoping review systematically maps the landscape of remote labs in technical and vocational training through a comprehensive examination of the Scopus database. A strategic search is employed, utilizing precise keywords such as "remote labs," "IoT in education," "technical and vocational education," and related terms, as well as Boolean operators to ensure extensive coverage of pertinent literature. Inclusion and exclusion criteria are meticulously defined to isolate studies directly addressing remote lab considerations. The inclusion criteria prioritize peer-reviewed articles published within the last five years to ensure the relevance and currency of the findings. The selection process involves an initial screening of titles and abstracts to identify studies that align with the research scope. Subsequently, full-text articles are reviewed to confirm their suitability for inclusion.

Data extraction is systematically conducted, focusing on key aspects such as study objectives, methodologies, findings, and implications. This enables a thorough analysis of how remote labs are being integrated into vocational and technical education, particularly through IoT applications. Through a rigorous screening and selection process, key themes and insights are distilled from the corpus of literature. The review synthesizes findings to highlight the integration of remote labs in vocational and technical education and points towards future research directions. By employing a rigorous screening and selection process, key themes and insights are distilled from the corpus of literature. The review synthesizes findings to highlight the integration of remote labs in vocational and technical education, particularly through IoT applications, and points towards future research directions.

4. Scopes

The review summarizes recent studies on integrating the Internet of Things (IoT) in remote labs for technical and vocational education, highlighting technological advancements and pedagogical implications. It critically analyses the literature to identify issues and challenges in implementing remote labs, such as technical limitations, accessibility concerns, and pedagogical considerations. The scoping review provides insights into potential avenues for future research and offers recommendations to address identified challenges, fostering continuous improvement and innovation in remote lab integration for vocational and technical education. By focusing on continuous improvement and innovation in remote lab integration, the review aims to enhance the effectiveness and inclusivity of technical and vocational education.

IoT in Remote Lab

The global impact of COVID-19 has catalyzed a critical reassessment of educational practices, particularly in higher education worldwide, including Moroccan universities. Faced with unprecedented challenges, educators and policymakers have pivoted towards innovative pedagogical approaches. Moroccan institutions like the Laboratory of Engineering Sciences and Energy Management (LASIME) at the Superior School of Technology of Agadir have responded with solutions such as the LABERSIME platform. This cloud-based system integrates embedded technology to facilitate cost-effective and efficient real laboratory experiments, aiming to enhance self-learning motivation (Abekiri et al., 2023).

In the context of sustainable engineering education, Project-Based Learning (PjBL) during the pandemic demonstrated comparable student performance between remote and traditional modalities, with projects aligned with Sustainable Development Goals (SDGs) emphasizing health, decent work, and sustainable communities (Hayashi et al., 2023). In exact sciences, the implementation of an IoT system utilizing the Red Pitaya STEMLab board effectively supported

remote manipulations in analog electronics, promoting enhanced self-learning outcomes (Taj et al., 2021).

Professional education has also embraced innovation, exemplified by IoT-based functional architectures for remote mechanical physics labs that offer flexible experimentation and data collection opportunities (Ordonez Urbano et al., 2023). Additionally, remote laboratories focusing on sensor-based experiments using IoT platforms have prepared learners for real-world applications in industrial automation by facilitating flexible learning environments (Ramya et al., 2020).

Beyond these advancements, the evolving landscape of engineering education, shaped by the fourth industrial revolution, emphasizes the integration of Cyber-Physical Systems, IoT, and Smart Manufacturing. Golob and Bratina (2018) advocate for leveraging communication and web-based technologies to develop efficient remote control system labs, while Romagnoli et al. (2020) propose a multi-layer model to organize technical information and forecast future trends in remote-access labs.

In summary, these initiatives underscore the transformative potential of digital technologies, IoT innovations, and Industry 4.0 frameworks in revolutionizing STEM education. They not only address immediate educational challenges but also offer scalable solutions for remote learning and meet diverse educational needs in the face of global crises and beyond.

Issues and challenges in in Remote Lab for Technical and Vocational Education

Here, we explore a diverse range of research and case studies highlighting the evolution and impact of technology-enhanced learning in engineering education. Research at the Swiss Federal Institute of Technology in Lausanne (EPFL) focuses on personal and collaborative learning within Technology Enhanced Learning. This research underscores the interplay between engineering education practice and professional practice, demonstrating how faculty members' real-world experience influences the success of new learning methods. The impact of Web 2.0 is particularly emphasized, supporting project-based collaborative learning through innovative social software as Personal Learning Environments. The study also presents a vision for addressing engineering education challenges using user-driven recommendation mechanisms based on trust models (Gillet, 2010).

Laboratory experiences, whether hands-on, virtual, or remote, are identified as crucial in engineering education, each offering unique advantages and drawbacks. A global overview reveals the educational effectiveness of each type. A case study from Tecnológico de Monterrey illustrates that virtual labs can complement or replace hands-on labs due to their low costs and ease of replication, promoting active learning and skill development. Essential elements for successful teaching and learning, such as presence, belief, and collaboration, guide the design of various lab types for experimental teaching in engineering (Hernández-de-Menéndez et al., 2019).

Amid digital and energy transitions, educational innovation remains crucial, especially in engineering. A standardized training platform supported by five European universities integrates remote laboratory experiences, each focusing on a different renewable energy source. Led by the University of Huelva, this network offers a homogenized platform for training in renewable energy, effectively combining theory and practice in the digital era (Martínez et al., 2023).

The increasing prevalence of remote labs, which allow students to conduct online experiments with real-world equipment, presents challenges for student engagement. A case study of two engineering courses reveals that remote labs requiring self-regulation and scheduling are

effective when combined with active learning pedagogy. Structured open-ended assignments, lab preparation, teamwork, progress meetings, and reflection reports enhance engagement. Support before and during experiments and clear guidance on lab setup further strengthen student involvement (Van den Beemt et al., 2023).

Engineering disciplines, particularly in Industrial Automation, Process Automation, and Mechatronics, face challenges from the fourth industrial revolution, introducing new technologies like Cyber-Physical Systems, IoT, and Smart Manufacturing. This study explores how communication and web-based technologies can create efficient remote and distributed control system labs. Examples include using web-based SCADA technology for user interfaces and developing fault detection and isolation applications. An improved platform for web-based remote control system experiments is proposed, demonstrating its quick assembly as an IoT system suitable for control education (Golob & Bratina, 2018b).

The critical role of laboratories in engineering education is well-recognized, but institutions face challenges in maintaining high-quality lab facilities. Remote labs are increasingly seen as viable alternatives or supplements to traditional hands-on labs, offering the significant advantage of distributed access, enabling cross-institutional sharing of facilities. However, organizational and logistical issues related to such sharing have been underexplored. An analysis of a national-scale lab sharing initiative highlights factors affecting engagement in lab sharing and discusses implications for ongoing support (Lowe, 2013).

Distance learning for labs presents challenges in student collaboration and device virtualization. A real-time collaborative educational framework developed for senior-level computer engineering courses addresses these challenges, showing that social dynamics in lab work change significantly with remote labs, and a well-designed social component is necessary for effective team-based learning (Saniie et al., 2015).

Technologies like mobile phones, social media, and AI have transformed education, with digital connectivity as a foundation. Current networks support visual and auditory data transmission for distance learning, but remote physical interaction remains a gap. The 5G network, with its superior latency and reliability, promises to enable remote interaction with physical objects, revolutionizing Education 4.0. A prototype remote lab leveraging 5G technology showcases these opportunities (Kizilkaya et al., 2021).

The COVID-19 pandemic posed significant challenges for remote lab courses, especially those requiring hardware. A course on information display technologies, adapted for remote learning, successfully combined online instruction with hands-on experiments, enhancing student learning and course comprehension (Kam et al., 2021). A survey at TU Dortmund University explored the shift to online education among mechanical engineering students and faculty. The study found that while the transition was initially challenging, both students and teachers quickly adapted. The flipped classroom concept proved effective, with preferred methods including pre-recorded lectures, interactive Q&A sessions, and self-assessment quizzes. The survey also addressed the challenge of offering online lab experiences, suggesting solutions like virtual, remote, and digital-live labs, culminating in best practice guidelines for online engineering courses (Grodzki et al., 2021).

Remote laboratories offer innovative solutions for delivering hands-on experiences to online engineering students. Alkhatib et al. (2023) introduced a cost-effective method where students build virtual systems step-by-step and connect to real-time on-campus labs for remote

experimentation. This approach, leveraging technologies like Virtual Networking Computing (VNC), Video Conferencing (VC), and Object-Oriented Programming (OOP), effectively substitutes traditional labs and supports active learning remotely. Prada et al. (2015) emphasize the importance of flexibility and scalability in remote labs. They propose a three-tier architecture (physical system layer, server layer, and client layer) to address these challenges. Using web standards such as HTML5, AJAX, and CSS3, their remote lab for automatic control demonstrates high educational value and seamless user interaction.

Trunova et al. (2023b) highlight the critical role of remote labs in crisis situations, such as the ongoing war in Ukraine. They propose the "My Digital Electrical Engineering" (MDEE) laboratory to ensure continuity and quality of technical education without requiring physical relocation. This approach enables students to safely continue their education remotely. Ensuring safety and validation is crucial for remote labs. Henke et al. (2015) discuss methods to protect physical systems from incorrect control algorithms and malicious activities. They emphasize verifying sensor and actuator constellations to guarantee safety and propose efficient validation methods for student designs.

The Covid-19 pandemic highlighted the need for effective remote learning solutions. Tjahyadi et al. (2023) propose Digital Twin technology, which creates a virtual replica of physical systems interconnected via the internet. This approach preserves physical interaction and enhances flexibility, allowing users to remotely manipulate real systems and observe their virtual counterparts, bridging the gap between theory and practice.

Future works and Recommendation in Remote Lab for Technical and Vocational Education

The COVID-19 pandemic has catalyzed a global shift toward online education, accentuating the role of remote laboratories in vocational and technical training. This synthesis aims to examine the empirical evidence and practical applications of remote labs, emphasizing their effectiveness, flexibility, and potential to improve student learning outcomes.

Technological and communication advancements have facilitated the development of virtual and remote labs, offering new opportunities for both on-campus and distance learners. These innovations address some limitations of traditional hands-on labs by providing more efficient and cost-effective solutions. At the Polydisciplinary Faculty of Beni Mellal in Morocco, Taj et al. (2021b) assessed the impact of hands-on, simulation, and online remote labs on student performance in a DC motor laboratory practice. Their study found high levels of student satisfaction, measured by parameters such as usefulness, usability, motivation, and understanding.

Remote laboratories are crucial for Internet-enabled education, particularly in STEM fields, due to their effectiveness, flexibility, and cost efficiency. Wang et al. (2015) developed a novel solution for real-time experiment live video streaming using the HTTP Live Streaming (HLS) protocol and FFMPEG software. This approach addressed common network firewall issues, allowing users to view live experiment videos on any portable device without encountering firewall problems, thereby enhancing future remote laboratory development.

Experimentation is integral to engineering education, balancing theoretical knowledge with practical experience. Traditional labs, however, are costly due to the expenses associated with equipment, space, and human resources. Romagnoli et al. (2020b) employed a systematic review and mini-Delphi method to develop a multi-layer model for networked remote-access labs. This model provides a comprehensive structure for organizing technical information and defining the state of the art and future prospects of remote lab solutions.

Incorporating Industry Revolution 4.0 (IR4.0) into educational curricula has become increasingly important. At UOW Malaysia KDU University College, Jiehan et al. (2022) implemented a capstone project involving a remote lab based on engineering module learning outcomes. The lab featured a robotic arm controlled via the Blynk interface and observed through a website with a low-cost camera chip. This project showcased the potential of IR4.0 technologies to engage students and enhance their learning experiences, providing detailed methodologies for future use.

Online teaching and learning have become a daily reality, and various tools are being evaluated for their effectiveness. Nafalski et al. (2017) assessed a fully online course delivered from Australia to Polish students at Lublin University of Technology. The evaluation revealed positive feedback, with over 70% of students agreeing that online and face-to-face modes produced similar learning outcomes. The technical aspects, such as Internet connection parameters and the use of Skype for text messaging, voice, video, and recorded content, were crucial for delivering quality online education.

The integration of remote laboratories has proven highly beneficial in vocational and technical education, offering cost-effective, flexible, and efficient alternatives to traditional hands-on labs. Empirical studies validate the effectiveness of remote labs in enhancing student learning outcomes across various disciplines, particularly in the context of the COVID-19 pandemic and ongoing digital transformation. These findings highlight the potential of remote labs to revolutionize vocational and technical education by providing scalable solutions to diverse educational needs.

Zhang and Li (2019) explored the integration of Virtual and Remote Labs (VRLs) in engineering and scientific education, focusing on student satisfaction and their intention to continue using VRLs. Their study, involving 240 students over a 16-week period using a VRL developed with Unity3D PRO, found that students experienced a moderate level of flow, with female students reporting higher flow experiences than their male counterparts. Significant correlations were identified between flow experience, perceived usefulness, confirmation, satisfaction, and continuance intention, suggesting key areas for enhancing VRL integration in education.

The rapid shift to remote learning during the COVID-19 pandemic presented challenges for lab-based courses. Debacq et al. (2021) detailed the implementation of remote food engineering labs at a French university as an alternative to traditional face-to-face labs for Master's students. The adaptation of key lab operations into remote formats, using virtual tours and pre-collected data analysis, provided valuable insights into hybrid teaching approaches. Despite limitations from rushed implementation and lack of direct access to pilot plants, the remote labs demonstrated the potential of digital resources to enhance educational methods.

Boltsi et al. (2024b) highlighted the multidimensional relationship between learning and teaching technologies, emphasizing the importance of digital tools in transforming information into knowledge, especially in STEM education. Their study, aligned with the Education 4.0 framework, underscored the need for modern curricula to incorporate smart sensors, AI, and Robotics, and to digitize university campuses using IoT, ICT, and 5G technologies. The extensive survey categorized contemporary digital tools and technologies, linking them to lab types, learning outcomes, and the Education 4.0 framework's requirements.

The demands of Industry 4.0 are reshaping engineering education, requiring students to develop IT competencies to meet emerging technological challenges. Terkowsky et al. (2019) analyzed a remote laboratory at a German university to assess its potential in preparing students for "Working 4.0" competencies. Their research demonstrated that remote labs could reflect the complexity of Industry 4.0 but also highlighted the need for a broader perspective in educational development to align with industry demands.

Cross Reality (XR) spaces, which integrate immersive, augmented, mixed, and virtual realities with physical reality, offer a comprehensive educational experience. May (2020) discussed the integration of various realities in lab education, using a three-dimensional matrix to categorize online laboratories. The study evaluated a remote lab in mechanical engineering education for an international student body, highlighting positive effects on students' learning experiences and identifying current needs and future potentials at the intersection of engineering education, internationalization, and digitalization.

In conclusion, the integration of remote laboratories in vocational and technical education has proven to be highly beneficial, providing flexible, accessible, and effective learning experiences. However, continuous improvement in technological implementation and pedagogical approaches is necessary to fully maximize the advantages of remote lab environments.

5. Conclusion and Discussion

In conclusion, this scoping review underscores the transformative potential of remote laboratories in enhancing technical and vocational education. Remote labs offer a solution to traditional training challenges by providing virtual access to practical experiences, thus transcending geographical and resource limitations. Integrating Internet of Things (IoT) technologies within these labs enhances technological capabilities and aligns educational practices with the demands of Industry 4.0.

The review highlights several key findings: recent studies demonstrate the effectiveness of IoT-enabled remote labs in facilitating hands-on learning and improving educational outcomes. However, significant challenges persist, including technical limitations, accessibility issues, and the need for robust pedagogical frameworks to support remote lab implementation. Addressing these challenges is crucial to maximizing the benefits of remote labs. Future research should focus on developing innovative solutions to overcome these barriers. This includes enhancing technological infrastructure, creating inclusive and accessible learning environments, and refining pedagogical strategies to effectively integrate remote labs into vocational and technical education curricula. Moreover, continuous evaluation and adaptation are necessary to ensure that remote labs meet the evolving needs of students and industries.

By fostering collaboration among educators, policymakers, and researchers, the integration of remote labs can be optimized, leading to improved educational practices and outcomes. This review provides a foundation for future work, offering insights and recommendations that can guide the ongoing development and implementation of remote laboratories in vocational and technical education.

References

Abekiri, N., Rachdy, A., Ajaamoum, M., Nassiri, B., Elmahni, L., & Oubail, Y. (2023a). Platform for Hands-on Remote Labs Based on the ESP32 and NOD-red. *Scientific African*, 19. <https://doi.org/10.1016/j.sciaf.2022.e01502>

- Alkhatib, M., Qu, Y., Cai, R., Unglaub, R. A. G., & Ritter, R. (2023). Real Time Virtual Laboratory Solution Prototype and Evaluation for Online Engineering Degree Programs. *IEEE Access*, 11, 130508–130516. <https://doi.org/10.1109/ACCESS.2023.3334262>
- Al-Obaidi, M. Q., & Derbel, N. (2023a). Design of IoT Based Remote Renewable Energy Laboratory. *International Journal of Emerging Technologies in Learning*, 18(12), 75–87. <https://doi.org/10.3991/ijet.v18i12.38659>
- Al-Zoubi, A., Dmour, M., & Aldmour, R. (2022). Blockchain as a Learning Management System for Laboratories 4.0. *International Journal of Online and Biomedical Engineering*, 18(12), 16–34. <https://doi.org/10.3991/ijoe.v18i12.33515>
- Balakrishnan, V. (2017). Book2U and Students' Learning Styles: The Effect of Learning Styles on Intention to Use a social media-enabled tool. *Universal Access in the Information Society*, 16(2). <https://doi.org/10.1007/s10209-016-0460-5>
- Boltsi, A., Kalovrektis, K., Xenakis, A., Chatzimisios, P., & Chaikalis, C. (2024a). Digital Tools, Technologies and Learning Methodologies for Education 4.0 Frameworks: A STEM Oriented Survey. *IEEE Access*, 1. <https://doi.org/10.1109/ACCESS.2024.3355282>
- Chandra, J. A. P., & Samuel, R. D. (2010). E-learning in engineering education: Design of a collaborative advanced remote access laboratory. *International Journal of Distance Education Technologies*, 8(2), 14–27. <https://doi.org/10.4018/jdet.2010040102>
- Debacq, M., Almeida, G., Lachin, K., Lameloise, M.-L., Lee, J., Pagliaro, S., Romdhana, H., & Roux, S. (2021). Delivering Remote Food Engineering Labs in COVID-19 time. *Education for Chemical Engineers*, 34, 9–20. <https://doi.org/10.1016/j.ece.2020.10.002>
- Gillet, D. (2010). Tackling Engineering Education Research Challenges: Web 2.0 Social Software for Personal Learning. *International Journal of Engineering Education*, 26(5), 1134–1143. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-78649351686&partnerID=40&md5=6e30367c6deebe8a3c9bb8ae307f9d78>
- Golob, M., & Bratina, B. (2018a). Web-based Control and Process Automation Education and Industry 4.0. *International Journal of Engineering Education*, 34(4), 1199–1211. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85049776016&partnerID=40&md5=13b2db9fd4a648e52c9c5a7846c40f1e>
- Grodotski, J., Upadhya, S., & Tekkaya, A. E. (2021). Engineering Education Amid a Global Pandemic. *Advances in Industrial and Manufacturing Engineering*, 3. <https://doi.org/10.1016/j.aime.2021.100058>
- Hayashi, V. T., Arakaki, R., Almeida, F. V. D., & Ruggiero, W. V. (2023). The Development of Sustainable Engineering with PjBL during the COVID-19 Pandemic †. *International Journal of Environmental Research and Public Health*, 20(5). <https://doi.org/10.3390/ijerph20054400>
- Hecker, L., Irish, J., Rounseville, S., Knox, A., Kato, K., & Gokhale, V. (2021). *Novel Screening Methods to Identify Nox4 Inhibitors*. https://doi.org/10.1164/ajrccm-conference.2021.203.1_meetingabstracts.a4447
- Henke, K., Vietzke, T., Wuttke, H.-D., & Ostendorff, S. (2015). Safety in interactive hybrid online labs. *International Journal of Online Engineering*, 11(3), 56–61. <https://doi.org/10.3991/ijoe.v11i3.4557>
- Hernández-de-Menéndez, M., Vallejo Guevara, A., & Morales-Menendez, R. (2019). Virtual reality laboratories: a review of experiences. *International Journal on Interactive Design and Manufacturing*, 13(3), 947–966. <https://doi.org/10.1007/s12008-019-00558-7>
- Jacko, P., Bereš, M., Kováčová, I., Molnár, J., Vince, T., Dziak, J., Fecko, B., Gans, Š., & Kováč, D. (2022). Remote IoT Education Laboratory for Microcontrollers Based on the STM32 Chips. *Sensors*, 22(4). <https://doi.org/10.3390/s22041440>
- Jara, C. A., Candelas, F. A., & Torres, F. (2009). Internet virtual and remote-control interface for robotics education. In *Developments in Higher Education*.

- Jiehan, T., Yee, T. C., Zadhy, H., Diallo, A. M., Vickraman, M., & Royan, N. R. R. (2022). Integrating IR4.0 Technology in Engineering Education: Robotic Arm Remote Lab. *Journal of Engineering Education Transformations*, 36(1), 83–94. <https://doi.org/10.16920/jeet/2022/v36i1/22140>
- Kam, K. A., Kumar, V., Lamport, Z. A., & Kymissis, I. (2021). A laboratory course on information display technologies for remote learning. *Journal of the Society for Information Display*, 29(11), 852–858. <https://doi.org/10.1002/jsid.1000>
- Khan, M. G., Ul Huda, N., & Uz Zaman, U. K. (2022). Smart Warehouse Management System: Architecture, Real-Time Implementation and Prototype Design. *Machines*, 10(2). <https://doi.org/10.3390/machines10020150>
- Kizilkaya, B., Zhao, G., Sambo, Y. A., Li, L., & Imran, M. A. (2021). 5G-Enabled Education 4.0: Enabling Technologies, Challenges, and Solutions. *IEEE Access*, 9, 166962–166969. <https://doi.org/10.1109/ACCESS.2021.3136361>
- Lameras, P., & Moumoutzis, N. (2021). Towards the development of a digital competency framework for digital teaching and learning. *IEEE Global Engineering Education Conference, EDUCON, 2021-April*. <https://doi.org/10.1109/EDUCON46332.2021.9454027>
- Lasica, I. E., Katzis, K., Meletiou-Mavrotheris, M., & Dimopoulos, C. (2016). Research challenges in future laboratory-based STEM education. *Bulletin of the Technical Committee on Learning Technology*, 18(1), 2–5. <https://www.scopus.com/inward/record.uri?eid=2-s2.085024476629&partnerID=40&md5=31aa70f5c8e3513c41279bc0d71f4072>
- Liccardo, A., Arpaia, P., Bonavolonta, F., Caputo, E., De Pandi, F., Gallicchio, V., Gloria, A., & Moriello, R. S. L. (2021). An Augmented Reality Approach to Remote Controlling Measurement Instruments for Educational Purposes during Pandemic Restrictions. *IEEE Transactions on Instrumentation and Measurement*, 70. <https://doi.org/10.1109/TIM.2021.3101314>
- Lowe, D. (2013). Integrating reservations and queuing in remote laboratory scheduling. *IEEE Transactions on Learning Technologies*, 6(1), 73–84. <https://doi.org/10.1109/TLT.2013.5>
- Martínez, M., Segura, F., & Andújar, J. M. (2023). The Challenge of Digital Transition in Engineering. A Solution Made from a European Collaborative Network of Remote Laboratories Based on Renewable Energies Technology. *Applied System Innovation*, 6(2). <https://doi.org/10.3390/asi6020052>
- May, D. (2020). Online laboratories for supporting international student collaboration in merging realities. *International Journal of Online and Biomedical Engineering*, 16(3), 4–26. <https://doi.org/10.3991/IJOE.V16I03.12849>
- Nafalski, A., Considine, H., Zawko, T., & Nedic, Z. (2017). On-line teaching and learning: Australia-Poland. *Global Journal of Engineering Education*, 19(2), 118–123. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85023642846&partnerID=40&md5=7bc0cd588e69c3449f7bd265f7a5c88f>
- Odeh, S., Alves, J., Alves, G. R., Gustavsson, I., Anabtawi, M., Arafeh, L., Jazi, M., & Arekat, M. R. (2015). A Two-Stage Assessment of the Remote Engineering Lab VISIR at Al-Quds University in Palestine. *Revista Iberoamericana de Tecnologías Del Aprendizaje*, 10(3), 175–185. <https://doi.org/10.1109/RITA.2015.2452752>
- Odeh, S., Anabtawi, M., Alves, G. R., Gustavsson, I., & Arafeh, L. (2015). Assessing the remote engineering lab VISIR at Al-Quds University in palestine. *International Journal of Online Engineering*, 11(1), 35–38. <https://doi.org/10.3991/ijoe.v11i1.4219>
- Ordóñez Urbano, C. F., Muñoz, J. A., Fierro, L. P., Marulanda, J. F. F., & Vargas-Canas, R. (2023). Remote Laboratories for Physics Education: A Proposal Toward Interactive Learning for

- Engineering Students. *Revista Iberoamericana de Tecnologías Del Aprendizaje*, 18(3), 305–312. <https://doi.org/10.1109/RITA.2023.3303100>
- Pang, D., Cui, S., & Yang, G. (2022). Remote Laboratory as an Educational Tool in Robotics Experimental Course. *International Journal of Emerging Technologies in Learning*, 17(21), 230–245. <https://doi.org/10.3991/ijet.v17i21.33791>
- Prada, M. A., Fuertes, J. J., Alonso, S., García, S., & Domínguez, M. (2015). Challenges and solutions in remote laboratories. Application to a remote laboratory of an electro-pneumatic classification cell. *Computers and Education*, 85, 180–190. <https://doi.org/10.1016/j.compedu.2015.03.004>
- Prakash, K. R., Santhosh, M. S., Purushothama, G. K., & Ramya, M. V. (2021). An approach to convert conventional laboratories into IoT-enabled laboratories. *International Journal of Web-Based Learning and Teaching Technologies*, 16(5), 108–120. <https://doi.org/10.4018/IJWLTT.20210901.oa6>
- Ramya, M. V., Purushothama, G. K., & Prakash, K. R. (2020). Design and implementation of IoT based remote laboratory for sensor experiments. *International Journal of Interactive Mobile Technologies*, 14(9), 227–238. <https://doi.org/10.3991/ijim.v14i09.13991>
- Reid, D. P., Burrridge, J., Lowe, D. B., & Drysdale, T. D. (2022). Open-source remote laboratory experiments for controls engineering education. *International Journal of Mechanical Engineering Education*, 50(4), 828–848. <https://doi.org/10.1177/03064190221081451>
- Robles-Gómez, A., Tobarra, L., Pastor-Vargas, R., Hernández, R., & Cano, J. (2020). Emulating and evaluating virtual remote laboratories for cybersecurity. *Sensors (Switzerland)*, 20(11). <https://doi.org/10.3390/s20113011>
- Romagnoli, G., Esposito, G., Rizzi, A., Zammori, F., Bertolini, M., & Uckelmann, D. (2020a). Lab networks in engineering education: A proposed structure for organizing information. *International Journal of Online and Biomedical Engineering*, 16(5), 41–70. <https://doi.org/10.3991/IJOE.V16I05.11891>
- Romagnoli, G., Esposito, G., Rizzi, A., Zammori, F., Bertolini, M., & Uckelmann, D. (2020b). Lab networks in engineering education: A proposed structure for organizing information. *International Journal of Online and Biomedical Engineering*, 16(5), 41–70. <https://doi.org/10.3991/IJOE.V16I05.11891>
- Saniie, J., Oruklu, E., Hanley, R., Anand, V., & Anjali, T. (2015). Transforming computer engineering laboratory courses for distance learning and collaboration. *International Journal of Engineering Education*, 31(1), 106–120. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84921709617&partnerID=40&md5=af62b5c9589c561e2de4342865148467>
- Schiano Lo Moriello, R., Liccardo, A., Bonavolonta, F., Caputo, E., Gloria, A., & De Alteriis, G. (2022). On the Suitability of Augmented Reality for Safe Experiments on Radioactive Materials in Physics Educational Applications. *IEEE Access*, 10, 54185–54196. <https://doi.org/10.1109/ACCESS.2022.3175869>
- Sekaran, J. F., & Hildas, R. (2023). Implementation of an Industrial Automation Remote Lab (IARL) and validation using a deep learning approach during the COVID pandemic. *Computer Applications in Engineering Education*, 31(6), 1593–1607. <https://doi.org/10.1002/cae.22663>
- Stan, C. M. (2023). Development Of a Sustainable Power Electronics Laboratory with Remote Access and Control Via the Internet. *Environmental Engineering and Management Journal*, 22(7), 1315–1328. <https://doi.org/10.30638/eemj.2023.109>
- Taj, A. M., Fabregas, E., Abouhilal, A., Taifi, N., & Malaoui, A. (2021). Comparative Study of Traditional, Simulated and Real Online Remote Laboratory: Student' Perceptions in Technical Training of Electronics. *International Journal of Online and Biomedical Engineering*, 17(5), 33–48. <https://doi.org/10.3991/ijoe.v17i05.21949>

- Taj, A. M., Fabregas, E., Abouhilal, A., Taifi, N., & Malaoui, A. (2021b). Comparative Study of Traditional, Simulated and Real Online Remote Laboratory: Student' Perceptions in Technical Training of Electronics. *International Journal of Online and Biomedical Engineering*, 17(5), 33–48. <https://doi.org/10.3991/ijoe.v17i05.21949>
- Terkowsky, C., Frye, S., & May, D. (2019). Online engineering education for manufacturing technology: Is a remote experiment a suitable tool to teach competences for “Working 4.0”? *European Journal of Education*, 54(4), 577–590. <https://doi.org/10.1111/ejed.12368>
- Tjahyadi, H., Prasetya, K., & Murwantara, I. M. (2023). Digital Twin Based Laboratory for Control Engineering Education. *International Journal of Information and Education Technology*, 13(4), 704–711. <https://doi.org/10.18178/ijiet.2023.13.4.1856>
- Trunova, I., Arhun, S., Hnatov, A., Apse-Apsitis, P., Kunicina, N., & Myhal, V. (2023a). Sustainable Approach Development for Education of Electrical Engineers in Long-Term Online Education Conditions. *Sustainability (Switzerland)*, 15(18). <https://doi.org/10.3390/su151813289>
- Trunova, I., Arhun, S., Hnatov, A., Apse-Apsitis, P., Kunicina, N., & Myhal, V. (2023b). Sustainable Approach Development for Education of Electrical Engineers in Long-Term Online Education Conditions. *Sustainability (Switzerland)*, 15(18). <https://doi.org/10.3390/su151813289>
- Valencia de Almeida, F., Hayashi, V. T., Arakaki, R., Midorikawa, E., Canovas, S. D. M., Cugnasca, P. S., & Corrêa, P. L. P. (2022). Teaching Digital Electronics during the COVID-19 Pandemic via a Remote Lab. *Sensors*, 22(18). <https://doi.org/10.3390/s22186944>
- Van den Beemt, A., Groothuijsen, S., Ozkan, L., & Hendrix, W. (2023). Remote labs in higher engineering education: engaging students with active learning pedagogy. *Journal of Computing in Higher Education*, 35(2), 320–340. <https://doi.org/10.1007/s12528-022-09331-4>
- Wang, N., Chen, X., Song, G., & Parsaei, H. (2015). A novel real-time video transmission approach for remote laboratory development. *International Journal of Online Engineering*, 11(1), 4–9. <https://doi.org/10.3991/ijoe.v11i1.3167>
- Wanyama, T. (2017). Using industry 4.0 technologies to support teaching and learning. *International Journal of Engineering Education*, 33(2), 693–702. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85019748668&partnerID=40&md5=574036c4008199b1e1f488f0046b79a4>
- Wilkerson, M., Maldonado, V., Sivaraman, S., Rao, R. R., & Elsaadany, M. (2022). Incorporating immersive learning into biomedical engineering laboratories using virtual reality. *Journal of Biological Engineering*, 16(1). <https://doi.org/10.1186/s13036-022-00300-0>
- Wuttke, H.-D., Parkhomenko, A., Tulenkov, A., Tabunshchyk, G., Parkhomenko, A., & Henke, K. (2019). The remote experimentation as the practical-oriented basis of inclusive engineering education. *International Journal of Online and Biomedical Engineering*, 15(5), 4–17. <https://doi.org/10.3991/ijoe.v15i05.9752>
- Yusoff, Z. M., Zulaikha Hanafiah, N. I., Abidin, A. F. Z., Kadir, K. A., Harun, M. H., Rifin, R., Hasan, K. K., & Hasan, A. F. (2021). Electronic educational quiz board for block diagram learning in control principle subject through android application. *International Journal of Engineering Trends and Technology*, 69(1). <https://doi.org/10.14445/22315381/IJETT-V69I1P215>
- Zhang, M., & Li, Y. (2019). Students' continuance intention to experience virtual and remote labs in engineering and scientific education. *International Journal of Emerging Technologies in Learning*, 14(17), 1–16. <https://doi.org/10.3991/ijet.v14i17.10799>

PLC Based Automatic Mini Conveyor Control System Trainer Prototype Design Development

Bakiss Hiyana Abu Bakar^{1*}, Mokhtar Bin Hashim² & Sharmiza Kamaruddin³

^{1,2,&3}Electrical Engineering Department, Politeknik Sultan Haji Ahmad Shah, Kuantan, Pahang, Malaysia

*bakiss@polisas.edu.my

Abstract

Proficiency in an automatic conveyor control systems and Programmable Logic Controller (PLC) programming are essential for students, especially in Electrical Engineering. This expertise is extensively taught in higher education institutions, including Polytechnics in Malaysia, which focuses on technical and vocational education (TVET). Recognizing the importance of hands-on experience among students, universities emphasize practical exposure to PLC controllers in automation systems. To enhance student's understanding, concerted efforts are made to develop mini conveyor trainer kits with integrated monitoring systems for student performance assessment, offering an interactive learning experience. Various research projects design PLC-based Automatic Mini Conveyor Control System as an educational tool, both in hardware and simulation methods. However, some Polytechnics are still lacking adequate training facilities that meet the syllabus requirement for effectively demonstrating PLC applications in conveyor control systems. To bridge this gap, this research focuses on designing a 24VDC supply PLC-based Automatic Mini Conveyor Control System Prototype as an educational tool that emphasises hands-on experience. This design enables students to implement PLC program designs directly using CX-Programmer software, enhancing their interest and comprehension in PLC and automation courses. The design will utilize an OMRON PLC as the primary control device, driving the mini conveyor with a DC motor. Additional components include inductive and capacitive proximity sensors and reed switch as inputs and a pneumatic cylinder as the output for the sorting system. Overall, the fully automated mini conveyor system is successfully designed for educational purposes, facilitating practical implementation in the learning process and delivering satisfactory outcomes.

Keywords: Automatic Mini Conveyor System Trainer, Programmable Logic Controller (PLC), Conveyor Control System

1. Introduction

Automation in industries aims to enable machines to operate without direct human intervention, streamlining processes and reducing the need for manual labour. This technology, utilizing electronic, mechanical, and computer-based systems, executes tasks autonomously, enhancing efficiency and productivity. Programmable Logic Controllers (PLCs) according to Capiel (1982) is an electronic system that operates digitally and designed for use in industrial environments. PLC plays a crucial role in industrial automation, managing various functions such as logic operations, sequencing, and timing. PLCs are extensively utilized in conveyor belt automation, requiring appropriate design and programming for seamless operation.

Programmable Logic Controller (PLC) is an automatic control device that has become an important part of industrial processes (Pawar et al., 2016) that is widely used in various industrial sectors. However, there are still many graduates who are not ready to work due to the competency gap between industry needs and student's competencies. Since the proficiency in PLC is vital for students, particularly in the field of Electrical Engineering, it is extensively taught in educational institutions, including Polytechnics in Malaysia, with a focus on Technical and Vocational

Education and Training (TVET). Recognizing the importance of hands-on experience, universities prioritize practical exposure to PLC controllers in automation.

As mentioned by (Federley et al., 2010), mini conveyor systems provide a tangible platform for students to learn about Programmable Logic Controllers (PLCs) and automation. They simulate real world manufacturing environments, allowing students to understand practical applications of PLC programming. The need for added value to existing trainers needs to be done to achieve the objectives targeted by the lecturers according to the syllabus that has been set. Unfortunately, some institutions lack adequate training facilities to effectively demonstrate PLC applications in conveyor control systems.

Previously, many training media for PLC learning in the form of software applications had been developed among researchers. Research focusing on the development of PLC training media software with Augmented Reality (AR) for learning PLC wiring done by (Kim & Kim, 2013; Lee & Kim, 2011). Another research done by (Năvrănescu et al., 2015) also presents PLC training media in an e-learning method where it combines real hardware with video and simulation concepts. Software applications used as training media are practical and effective for learning PLC programming. However, they are insufficient for training students in components wiring and troubleshooting the PLC system. These training media primarily focus on programming and do not emphasize troubleshooting skills.

According to (Noviyanto & Sudira, 2020), students should possess specific work competencies to effectively perform technical tasks. These competencies include:

- i. Installation (Wiring) PLC input output devices
- ii. Proficiency in PLC Programming
- iii. Troubleshooting of PLC based system

To enhance students' understanding and hands-on skills, efforts are being made by developing mini conveyor trainer kits with integrated monitoring systems, providing a tangible and interactive learning experience (Asuncion, n.d.; Ball & Busick, n.d.; Lukito et al., 2020; Noviyanto & Sudira, 2020; Putri & Mowaviq, 2021). These kits, designed for educational purposes, employ PLC technology to control the miniaturized conveyors, offering students practical insights into industrial automation. This educational approach aims to simulate real-world industrial processes, allowing students to gain practical knowledge in conveyor control using a PLC. However, the development of PLC training media above still has limitations and not integrated directly into the Polytechnic Syllabus.

Programming and control studies related to conveyors and PLCs are commonly integrated into university curricula, allowing students to gain practical knowledge in conveyor control. The subject DEJ40033 Programmable Logic Controller (PLC) & Automations are a compulsory course for all fourth-semester students pursuing a Diploma in Electrical Engineering (DEE) and elective subject for others programs within the Department of Electrical Engineering across the Polytechnic Malaysia. This subject emphasizes theoretical and practical aspects, guiding students in acquiring fundamental skills. Students gain essential knowledge in designing PLC programming using specialized tools. Additionally, the curriculum delves into the practical application of sensors and actuators within automation systems, emphasizing the integration of PLC technology (Posdzi & Omar, 2023).

This research paper discusses a PLC based training media design to meet the course objectives. These strategies aim to equip students with the necessary expertise, fostering

proficiency in the foundational aspects of PLC and Automations. The design and development of a PLC-based mini conveyor for educational purposes in Polytechnic Malaysia aim to create teaching aids, providing educators with tools to convey PLC concepts effectively. The development of teaching kits includes the integration of inductive and capacitive proximity sensors as inputs and pneumatic cylinders as actuators for the sorting system in the mini conveyor (Posdzi & Omar, 2023; Pratama et al., 2021; Putri & Mowaviq, 2021; Tepe C, Aslan AS, 2023). By the course's conclusion, students are expected to demonstrate competence in these key areas, providing a solid foundation for their future endeavours in the field.

2. Problem Statement

This research on design development of PLC based automatic mini conveyor control system based on the causes of problems that arise as follows:

- i. There is a lack of adequate training facilities for effectively demonstrating PLC applications in conveyor control systems since Polytechnic has recognized the significance of hands-on experience to emphasize practical exposure to PLC controllers in the field of automation.
- ii. Furthermore, the existing conveyor trainers are not equipped with actuators that can effectively demonstrate PLC applications in conveyor control systems such as pneumatic cylinders that may enhance their interest and comprehension in the subject DEJ40033 PLC & Automations.

Inspired by this reason, the design of a PLC based automatic mini conveyor control system trainer in Polytechnic Malaysia is evident in the research conducted on creating teaching aids and learning tools.

3. Research Objectives

Students often struggle to apply theoretical PLC knowledge to real-world industrial scenarios. To bridge this gap, educational institutions develop PLC-based conveyor prototypes to offer hands-on experience. These prototypes, equipped with PLCs like the OMRON model, mimic industrial setups, and enhance students' understanding of automation processes. Integrating sensors such as proximity sensors, ensures efficient operation by detecting loads on the conveyor.

This research aims to design an effective teaching medium to assist educators convey PLC concepts to students (Pratama et al., 2021). Students using PLC training media should have prior knowledge in basic electricity and electronics, programming fundamentals, sensor and actuator functionalities, and PLC operation. Additionally, they should be capable of using the CX-Programmer application program. The objectives of the research are as follows.

- i. To design and develop a PLC-based mini conveyor control system trainer prototype that integrates sensor components, pneumatic actuators, DC motor and an OMRON PLC for system control.
- ii. To develop instructional materials and exercises that enable students to practice essential competencies, such as component identification, PLC programming, PLC wiring and troubleshooting that meet the DEJ40033 PLC and Automation syllabus requirement.

4. Methodology

The research method in this study is divided into several stages based on conceptual frameworks that guided this study. This study followed the input, process and output (IPO) model.

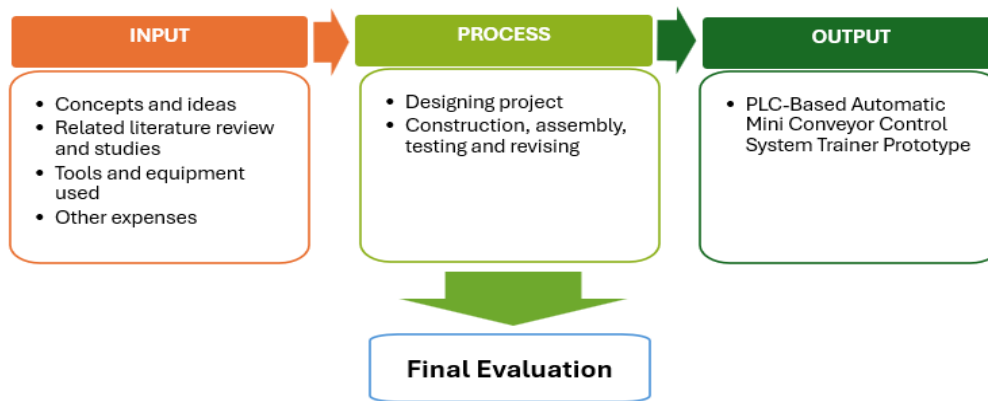


Figure 1: Conceptual Model

The INPUTS for this study include concepts and ideas aligned with the syllabus requirements, relevant literature and studies, tools and equipment used in the project construction, and the expenses incurred during fabrication. The PROCESS involves designing the project, acquiring necessary materials, constructing and assembling the prototype, and conducting testing and revisions to address any technical issues. The OUTPUT is a finished and functional PLC-Based Automatic Mini Conveyor Control System Trainer Prototype. Upon completion, the project underwent various tests before its final evaluation to assess its acceptability and performance.

The research methodology based on conceptual methods are divided into three phases.

- Phase I is literature study. It focuses on studying conveyor mechanisms, sensor functionality, DC motor and pneumatic cylinder. The goal is to identify the suitable design and components that align with the DEJ40033 PLC & Automations syllabus in Polytechnic and CP1E OMRON PLC controller.
- Phase II is the design stage. It involves designing the PLC based automatic conveyor system. At this stage, output includes the wiring diagram, hardware design and system instrumentation.
- Phase III is the prototyping stage. It covers the manufacturing of hardware, developments of programs and system instrumentation. At this stage, it aims to produce a conveyor system prototype, followed by process corrections and the creation of scientific articles related to the research.

Syllabus Review and Mapping

Further literature from previous research compared the design of educational trainers that can meet with Polytechnic Syllabus for PLC. After an extensive review, this research proposed a new design for PLC-based automatic mini conveyor system trainer design prototype. This design meets over 80% of the DEJ40033 PLC and Automations Syllabus, as highlighted in Figure 2. The design basically covers all chapters and specifically enhances student understanding in chapter 2, 4 and 6, providing practical knowledge in conveyor control using a PLC.

The developed product underwent validation to evaluate its initial design. In this stage, validation was conducted by lecturers, who are experts in media and materials for PLC learning, from the Electrical Engineering education study program at Polytechnic Sultan Haji Ahmad Shah (POLISAS). They assessed the PLC-based learning media to determine its suitability for the PLC-based automatic mini conveyor. Following the validation and subsequent design improvements, material and media experts conducted trials to determine the product's feasibility.

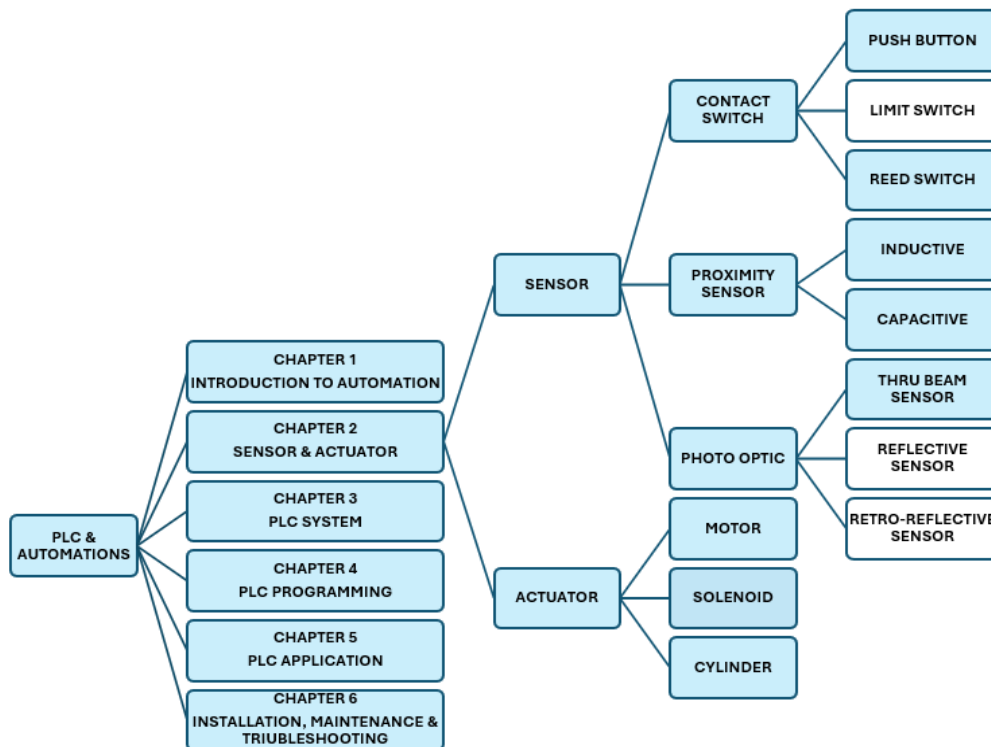


Figure 2: Syllabus Review and Mapping Meet the Trainer Design

5. Result and Discussion

In this section, we discuss the result of each research's step under the design and fabrication process. After further review and study, several analyses produce related to the training media design, i.e.:

- i. Students who use PLC training media must have learned about basic electricity and electronics, basic programming, sensors, actuators and PLC. Students are also able to operate CX-Programmers.
- ii. PLC training media intended to meet the competencies needed by technicians in the industry. This PLC training media must intend to fulfil the basic competencies in the Polytechnic Curriculum.

PLC-based automatic mini conveyor system trainer design prototype develops in accordance with these specifications. In general, PLC based training media block diagrams are shown in Figure 3.

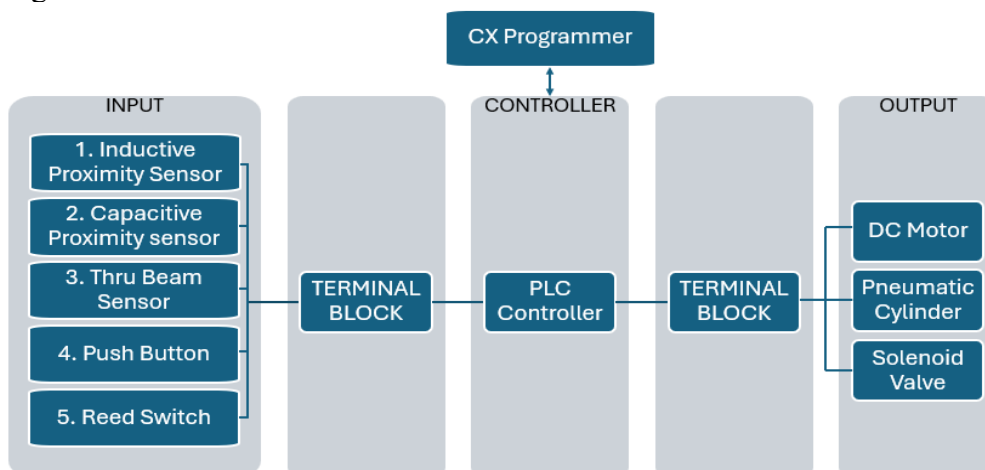


Figure 3: System Design Block Diagram

PLC-based mini conveyor system comprises four main components: input devices, the PLC controller, output devices, and the CX Programmer for programming. The input devices include a thru beam sensor, inductive proximity sensor and capacitive proximity sensor, push button and reed switch. The output devices consist of relays, 24V DC motor and pneumatic cylinder. A terminal block is utilized to organize cable connections between the input and output terminal on the PLC. The terminal setup allows students to learn wiring connections between inputs and outputs using banana cables.

The hardware specifications for a PLC-based mini conveyor innovation trainer are outlined in the Table 1 below, ensuring alignment with industry practices and enhancing hands-on learning experiences.

Table 1: Component List

No	Group	Component	Quantity
1	Controller	Omron CP1E	1
2	Input	Inductive Proximity Sensor	1
		Capacitive Proximity Sensor	1
		Thru Beam Sensor	1
		Push Button Switch	3
		Reed Switch	4
3	Output	Solenoid Valve	2
		Pneumatic Cylinder	2
		Air Regulator	1
		24DC Motor	1

The prototype was developed according to research stages. The PLC-based automatic mini conveyor system trainer prototype was built to the specified dimensions. Figure 4 and Figure 5 illustrate the input and output components integrated into the PLC training media. Each I/O component in this media is equipped with auxiliary terminals for wiring practice. The frame of the training media is constructed from steel and aluminium.

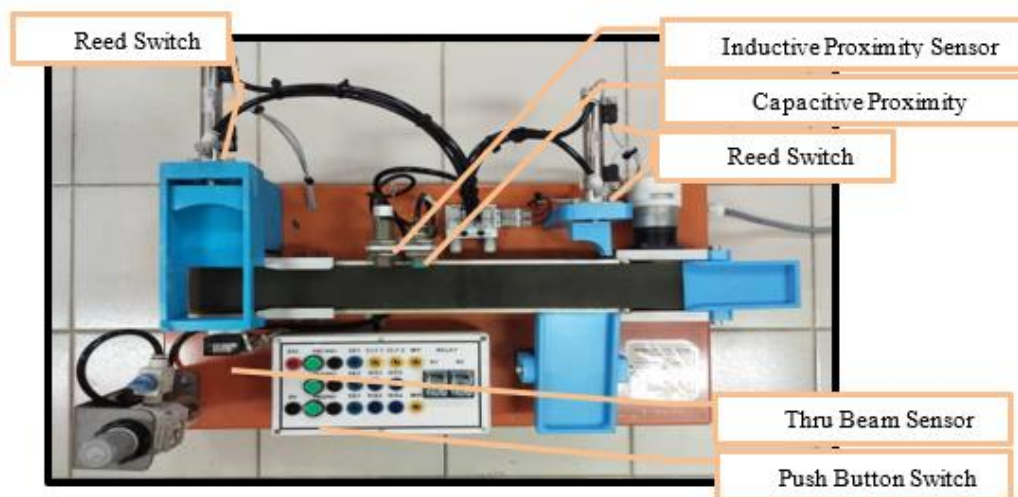


Figure 4: Input components in PLC-Based Automatic Mini Conveyor Control System Trainer Prototype

The CP1E OMRON PLC serves as the primary control device as shown in Figure 6, propelling the mini conveyor through a DC motor. This fully automated mini conveyor system design has provided a tangible platform for students to learn about Programmable Logic Controllers (PLCs) and automation according to the syllabus that has been set. They simulate real world manufacturing environments, allowing students to understand practical applications of PLC programming. The added value of the PLC-based automatic mini conveyor trainer has been successful for educational purposes, delivering satisfactory results and enhancing practical learning experiences.



Figure 5: Output components in PLC-Based Automatic Mini Conveyor Control System Trainer Prototype



Figure 6: PLC-Based Automatic Mini Conveyor Control System Trainer Final Prototype

6. Conclusion

This research aimed to develop mini-PLC-based conveyor teaching kits for Electrical Engineering Diploma students at Polytechnic Malaysia. The study successfully created a PLC-based automatic mini conveyor control system educational trainer prototype. This system integrates sensor components, a pneumatic actuator, and a CP1E OMRON PLC as the main control unit to drive the mini conveyor via a DC motor. The training media enables students to practice essential competencies, such as identifying components, creating PLC ladder diagram programs using CX-Programmer software, and performing PLC wiring and troubleshooting. It meets syllabus requirements and addresses industry needs, particularly for tasks suitable for semi-professional graduates. Future enhancements could include more advanced systems, like automatic sorting mechanisms and pick-and-place packaging machines. Further research is recommended due to the significant potential for improvement.

Acknowledgment

The author would like to thank Polytechnic Sultan Haji Ahmad Shah (POLISAS) for continuous support in realizing this research. Special thanks also for Head of Department of Electrical Engineering and all group members for the full support and commitment in completing this research. This research paper is an output of continuous improvement for teaching and learning process for subject DEJ40033 PLC & Automations in Polytechnic Malaysia.

References

- Asuncion, R. (n.d.). Low Cost 2 Station Industrial Automation Trainer. <https://ssrn.com/abstract=3471693>
- Ball, A. K., & Busick, J. S. (n.d.). A Low-Cost Conveyor System for Teaching Automation to Engineering Technology Students.
- Federley, S., Jussila, J., Mattila, J., Horelli, J., & Väänänen, M. (2010). Using simulation models to improve the planning-delivery chain. *5th International Conference on Electrical and Control Technologies*, ECT 2010, July, 59–62.
- Kim, Y. S., & Kim, H. M. (2013). Design of a new virtual interaction-based PLC training using virtual sensors and actuators: System and its application. *International Journal of Distributed Sensor Networks*, 2013(7). <https://doi.org/10.1155/2013/505920>
- Lee, J.-O., & Kim, Y. S. (2011). An AR-based Wiring Practice for PLC Training. *Journal of International Council on Electrical Engineering*, 1(4), 425–429. <https://doi.org/10.5370/jicee.2011.1.4.425>
- Lukito, E. S., Negeri, U., Yogyakarta, Y., Id, I. F. A., & Walipranoto, P. (2020). Development of Learning Media (Programmable Logic Controller) as a Case Study of Sorting Machine Applications on Electronics Engineering Education Study Program Faculty of Engineering Universitas Negeri Yogyakarta F Arifin.
- Năvrănescu, V., Chirilă, A. I., Deaconu, A. S., & Deaconu, I. D. (2015). Educational platform for working with programmable logic controllers. *2015 9th International Symposium on Advanced Topics in Electrical Engineering*, ATEE 2015, 215–220. <https://doi.org/10.1109/ATEE.2015.7133767>
- Noviyanto, E., & Sudira, P. (2020). Design of Industrial Oriented PLC Training Media for Vocational School.
- Pawar, R., Bhasme, N. R., & Student, M. E. (2016). Application of PLCs for Automation of Processes in Industries. Rahul Pawar. *Int. Journal of Engineering Research and Applications*, 6(6), 53–59. www.ijera.com
- Posdzi, N., & Omar, P. U. (2023). " Programmable Logic Controller (PLC): Programming & Applications " i (Issue August).
- Pratama, H., Azman, M. N. A., Zakaria, N. A., & Khairudin, M. (2021). Development of programmable logic controller teaching aids on electrical motor installation course among vocational school students in Aceh, Indonesia. November, 117–127. <https://doi.org/10.31643/2021.19>
- Putri, T. W. O., & Mowaviq, M. (2021). Prototype of automatic conveyor system using programmable logic controller for educational purpose. *IOP Conference Series: Materials Science and Engineering*, 1173, 12037. <https://doi.org/10.1088/1757-899X/1173/1/012037>
- Tepe C, Aslan AS, E. İ. (2023). Conveyor belt experiment setup for programmable logic controller education. *International Journal of Electrical Engineering & Education*, Volume 60(3), 258–272

The Impact of Intersection Design on Traffic Volume and Road Service Level

Zuraidah Hashim^{1*}, Adilen @ Lucia Suil² & Khairul Nizam Mat Amin³
^{1,2,3}Civil Eng. Department, Politeknik Sultan Hj. Ahmad Shah, Kuantan, Pahang, Malaysia
*zuraidahhashim@polisas.edu.my

Abstract

The development of a city towards a developed country is a contributor to the increase in traffic flow. The design of the intersection designed on Jalan Bukit Ubi has an impact on the service level of the road. This study is to determine the impact of changes in the intersection design at Jalan Bukit Ubi on the volume of traffic and the level of service on the road. The method used to determine the objective of the study is the Traffic Volume Study and the Level of Service (LOS) method. The result of the Traffic volume study is that the volume of vehicles obtained after changing the intersection design for peak hours is a reduction of almost 50% from the original volume. The study shows the findings from the determination of the Level of Service after changes to the design of the intersection at Jalan Bukit Ubi is at Level of Service, A which is at the value of the saturation degree of the intersection 0.27 where the LOS value before was level F with a degree of saturation of 1.12. This research shows that road planning and design play an important role in ensuring a better traffic management system and have a huge impact in ensuring the smoothness of the traffic system in a city.

Keywords: Level of Service, Traffic Volume Study, Intersection, Peak Hour, Saturation Degree.

1. Pengenalan

Reka bentuk persimpangan memainkan peranan penting dalam pengurusan trafik bandar, yang secara langsung mempengaruhi isipadu aliran trafik, dan tahap perkhidmatan secara keseluruhan. Reka bentuk persimpangan yang cekap dan pintar boleh mengurangkan kesesakan dan kelewatan serta meningkatkan keselamatan jalan raya (Arshad Jamal et. al, 2020). Kajian ini bertujuan untuk menilai bagaimana reka bentuk persimpangan yang berbeza memberi impak kepada isipadu aliran trafik dan tahap perkhidmatan jalan, memfokuskan pada kedua-dua persimpangan lampu isyarat dan persimpangan tidak searas iaitu di Jalan Bukit Ubi, Pahang.

Kajian ini merangkumi analisis data bagi menentukan isipadu aliran trafik dan tahap perkhidmatan sebelum dan selepas perubahan reka bentuk di persimpangan lampu isyarat Jalan Bukit ubi. Reka bentuk persimpangan kajian sebelum perubahan adalah searas dan selepas adalah pertambahan reka bentuk persimpangan tidak searas. Reka bentuk di tempat kajian sebelum ini hanya persimpangan lampu isyarat dimana merujuk Jieyu Fan et.al, 2023, tempoh masa lampu isyarat, menyumbang kepada aliran trafik yang tinggi. Kelewatan dan masa menunggu yang panjang adalah berpunca daripada kapasiti jalan yang tidak mencukupi, kekurangan tempat letak kenderaan dan kemudahan pejalan kaki (Emy Paulose et. al, 2022).

Persimpangan berlampu isyarat menyebabkan kelewatan disebabkan kenderaan menunggu giliran dan menjadikan peningkatan masa perjalanan (Raihanah & Md Yushalify, 2023). Rajah 1 menunjukkan lokasi kajian dan jalan sekitar persimpangan searas berlampu isyarat dan tidak searas Jalan Bukit Ubi merangkumi Jalan Haji Junid, Jalan Lim Hoe Lek, Jalan Indera Mahkota dan Jalan dari pusat bandar. Kajian terhadap perubahan reka bentuk persimpangan dengan pertambahan persimpangan tidak searas adalah merujuk kepada Raihanah & Md Yushalify (2023), dimana persimpangan tidak searas boleh menampung isipadu trafik yang lebih tinggi tanpa pengurangan yang ketara pada tahap perkhidmatan jalan. Rekabentuk persimpangan jenis ini memberikan aliran

trafik yang tidak terganggu terutamanya bagi kawasan bandar.



Rajah 1: Lokasi Kajian di Persimpangan Jalan Bukit Ubi

Tahap kebolehhidmatan jalan boleh ditentukan melalui Jadual 1 dan Jadual 2, dimana melibatkan isipadu dan kapasiti.

Jadual 1: Kriteria Tahap Kebolehhidmatan bagi Persimpangan Tanpa Lampu Isyarat & Lampu Isyarat

Kapasiti Rizab (pcph)	Tahap kebolehhidmatan	Kawalan Kelewatan setiap lane	Jangkaan Kelewatan ke Jalan bukan keutamaan
400	A	≤ 10.0	Sedikit / tiada kelewatan
300 - 399	B	$>10.0 - 20.00$	Kelewatan Trafik Singkat
200 - 299	C	$>20.00 - 35.00$	Purata Kelewatan Trafik
100 - 199	D	$>35.00 - 55.00$	Kelewatan Trafik yang Lama
0 - 99	E	$>55.00 - 80.00$	Kelewatan Trafik yang Sangat Lama
*	F	>80.00	*

Sumber: Arahan Teknik (Jalan 11/87): A Guide to the Design of at Grade Intersection, ATJ 13/87 (Pindaan 2017): A Guide to the Design of Traffic Signal

Jadual 2: Kriteria Tahap Kebolehhidmatan berdasarkan Nisbah Darjah Ketepuan Persimpangan

Nisbah Darjah Ketepuan	Tahap kebolehhidmatan	Jangkaan Kelewatan ke Jalan bukan keutamaan
< 0.30	A	Sangat Berkesan
< 0.43	B	Berkesan
< 0.83	C	Sederhana
< 0.83	D	Kurang Berkesan
< 1.00	E	Tidak Berkesan
> 1.00	F	Sangat Tidak Berkesan

Sumber: Malaysia Highway Manual Capacity, 2006

2. Metodologi

Bagi menentukan kesan reka bentuk persimpangan terhadap aliran trafik dan tahap kebolehhidmatan, kajian ini menggunakan kajian isipadu trafik dalam menentukan tahap kebolehhidmatan persimpangan Jalan Bukit Ubi. Kajian isipadu trafik kajian dilakukan pada waktu puncak bagi menyediakan data penting yang memastikan pelan pembangunan infrastruktur yang dilakukan boleh memenuhi tempoh keperluan yang tinggi dan cekap bagi sesuatu bandar. Analisis data dari kajian isipadu trafik membantu dalam menentukan tahap kebolehhidmatan yang disediakan oleh persimpangan Jalan Bukit Ubi.

Kajian Isipadu Trafik

Kajian dilaksanakan pada semua jalan yang menyumbang kepada aliran trafik persimpangan Jalan Bukit Ubi iaitu Jalan Hj. Junid (A), Jalan Bukit Ubi dari Indera Mahkota (B), Jalan Lim Hoe Lik (C) dan Jalan Bukit Ubi dari pusat Bandar (D) selama 8 minggu. Namun begitu data tertinggi Sahaja yang diambil untuk dianalisis pada waktu puncak iaitu pada waktu pagi dan petang. Dapatan aliran kenderaan mengambilkira kelas kenderaan dan direkodkan di dalam jadual bagi setiap 5 minit sehingga satu jam.

Tahap kebolehhidmatan

Bagi menentukan tahap kebolehhidmatan, kadar aliran kenderaan penumpang dibandingkan dengan kapasiti dua hala iaitu 3200 ukp/j (HCM 2000). Penentuan nilai tahap kebolehhidmatan adalah merujuk Malaysia Highway Capacity Manual, 2006 (MHCM 2006) dimana melaksanakan inventori persimpangan, kajian isipadu lalu lintas, merekodkan jumlah lalu lintas pada waktu puncak yang tertinggi, menentukan faktor waktu puncak bagi setiap arah, perkadaran peratus isipadu untuk belok kanan dan belok kiri.

Proses diteruskan sehingga menentukan kadar aliran bagi setiap laluan merujuk MHCM. Penentuan ketepuan persimpangan dan tahap perkhidmatan dikira bagi kedua-dua waktu puncak pagi dan petang. Kadar aliran tepu yang ideal bagi keadaan jalan di Malaysia ialah 1930 ukp/jam/Lorong. Hasil dari nisbah isipadu per kapasiti ditentukan merujuk Jadual 2. Selepas semua analisa terhadap aliran trafik ditentukan kapasiti kumpulan laluan bagi persimpangan, kawalan kelewatan dan tahap perkhidmatan berdasarkan masa isyarat operasi.

3. Analisis Data dan Perbincangan

Dapatan Kajian Isipadu Trafik

Dapatan dari Jadual 3 menunjukkan analisis keseluruhan aliran kenderaan bagi semua kelas kenderaan iaitu kereta, motorsikal, van, lori, lori berat dan bas merangkumi Jalan Lim Hoe Lek, Jalan Hj. Junid dan Jalan Bukit Ubi dari kedua-dua arah iaitu Indera mahkota dan pusat bandar. Data ini merangkumi dapatan sebelum perubahan rekabentuk persimpangan dan selepas perubahan rekabentuk persimpangan dengan pertambahan persimpangan tidak searas.

Jadual 3: Isipadu kenderaan pada Waktu Puncak

Waktu Puncak	Sebelum Perubahan Reka bentuk Persimpangan	Selepas Perubahan Reka bentuk Persimpangan
Pagi	3352	1676
Petang	3629	1815

Didapati selepas perubahan reka bentuk persimpangan dilakukan iaitu dengan menambah reka bentuk persimpangan tidak searas di Jalan Bukit Ubi peratus pengurangan isipadu trafik berkurang sebanyak hampir 50 % bagi kedua-dua waktu puncak.

Dapatan Tahap Kebolehhidmatan

Penentuan tahap kebolehhidmatan bagi jalan yang telah dikategorikan sebagai jalan utama negeri atau jalan perbandaran bagi semua jalan yang terlibat di dalam kajian. Jadual 4 dan Jadual 5 menunjukkan analisis penentuan tahap kebolehhidmatan bagi persimpangan Jalan Bukit Ubi sebelum dan selepas perubahan rekabentuk persimpangan iaitu dari persimpangan berisyarat searas ditambah dengan persimpangan tidak searas dari laluan utama Jalan Bukit Ubi.

Jadual 4: Dapatan Tahap Kebolehhkhidmatan Sebelum Perubahan Reka Bentuk Persimpangan

Jalan	Kategori	Major						Minor					
Gerakan	Dari ke berpusing	A	B	C	C	B	A	B	A	D	D	C	B
		LT	Thru	RT	LT	Thru	RT	LT	C	Thru	RT	LT	THRU
Trafik	Isipadu	DHV (vph)	212	643	212	110	1012	110	180	149	172	289	270
		PHF	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
		v (vph)	236	714	236	122	1124	122	200	166	191	321	304
Kapasiti	Asas	BC (pcu/h/lane)	2000										
	Faktor Perubahan	Lebar	0.920										
		Lorong, f_w	0.847										
		Komposisi kenderaan, f_c	1.000										
		Gred, f_g	1.000										
		Jenis	1.000										
		Kawasan, f_a	1.000										
		LT/RT, f_{LT}/f_{RT}	0.76	1.0	0.84	0.76	1.0	0.84	0.76	1.0	0.84	0.76	1.0
Analisis	s (vph)		1652	2173	1825	1652	2173	1825	1652	2173	1825	1652	2173
	Nisbah v/s		0.14	0.33	0.13	0.07	0.52	0.07	0.12	0.08	0.1	0.19	0.14
	Fasa Isyarat Trafik		1-4	1	1-4	2	1-4	3	1-4	4			
	Kapasiti Fasa Kritikal		0.33			0.52			0.1			0.17	
Darjah Ketepuan Persimpangan		1.12											
Kesimpulan dan Cadangan Tahap Kebolehhkhidmatan		F											

Jadual 5: Dapatan Tahap Kebolehhkhidmatan Selepas Perubahan Reka Bentuk Persimpangan

Jalan	Kategori		Major						Minor					
Gerakan		Dari ke berpusing	D			B			A			C		
			A LT	B Thru	C RT	C LT	D Thru	A RT	B LT	C Thru	D RT	D LT	A THRU	B RT
Trafik	Isipadu	DHV (vph)	172	294	-	300	1012	-	180	149	172	289	270	274
		PHF	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
		v (vph)	191	327	0	333	1124	0	200	166	191	321	300	304
Kapasiti	Asas	BC (pcu/h/lane)	2000											
	Faktor Perubahan	Lebar Lorong, f_w	0.920											
		Komposisi kenderaan, f_c	0.847											
		Gred, f_g	1.000											
		Jenis Kawasan, f_s	1.000											
		LT/RT, $f_{LT}/$ f_{RT}	0.76	1.0	0.84	0.76	1.0	0.84	0.76	1.0	0.84	0.76	1.0	0.84
		s (vph)	1602	2107	1770	1602	2173	1825	1652	2173	1825	1652	2173	1825
		Analisis	Nisbah v/s	0.12	0.16	0.00	0.21	0.52	0.00	0.12	0.08	0.1	0.19	0.14
Kapasiti Fasa Kritikal	0.00			0.00			0.10			0.17				
Darjah Ketepuan Persimpangan	0.27													
Kesimpulan dan Cadangan Tahap Kebolehhidmatan			A											

Impak perubahan rekabentuk persimpangan ini telah memberikan tahap perkhidmatan jalan yang lebih baik dimana dari nilai F dengan darjah ketepuan 1.12 iaitu tidak berkesan kepada tahap perkhidmatan A dengan darjah ketepuan 0.27 iaitu sangat berkesan, dimana aliran trafik hanya terdapat sedikit kelewatan atau bebas.

4. Kesimpulan

Kesimpulan yang dapat dibuat hasil dapatan kajian yang dilakukan adalah impak daripada perubahan rekabentuk persimpangan yang dilakukan daripada rekabentuk asal iaitu persimpangan searas berlampu isyarat, ditambah dengan reka bentuk persimpangan tidak searas bagi laluan utama Jalan Bukit Ubi didapati aliran trafik berkurangan kepada 50% daripada aliran sebelumnya. Tahap kebolekhidmatan jalan juga telah menjadi lebih baik iaitu dari tahap F dengan darjah ketepuan 1.12 dimana hampir tiada pergerakan kepada pergerakan yang bebas iaitu tahap A dengan darjah ketepuan 0.27 bagi persimpangan kajian.

5. Kepentingan Kajian

Kajian ini sangat penting untuk diteruskan di masa hadapan untuk melihat adakah tahap perkhidmatan ini masih akan kekal di tahap yang berkesan bagi Jalan Bukit Ubi dimana pengguna jalan raya yang menggunakan laluan ini semakin meningkat hari demi hari. Unjuran pengiraan dalam 42 tahun juga telah dilakukan dalam kajian ini untuk melihat jangka masa jalan ini dapat memberikan servis yang terbaik kepada penggunanya. Berdasarkan analisis yang dibuat didapati tahap kebolekhidmatan telah menurun kepada tahap E dimana nilai darjah ketepuannya adalah 0.84. Namun begitu kajian yang lebih terperinci boleh dilaksanakan bagi memastikan pembangunan bandar tidak memberi impak kepada kesesakan dan keselesaan pengguna jalan raya.

Penghargaan

Kajian ini dilaksanakan adalah untuk membantu pihak – pihak yang terlibat dalam perancangan bandar dan rekabentuk jalan untuk memastikan perancangan yang dilaksanakan dapat memberikan impak yang baik kepada pengguna jalan raya sama ada dari aspek kebolekhidmatan, trafik yang lancar dan selamat serta meningkatkan pengurusan bandar secara terancang. Diharap kajian ini dapat memberi impak dan membantu pihak yang berkaitan dalam memastikan kemaslahatan pengguna jalan raya di kawasan bandar.

Rujukan

- Arahan Teknik (Jalan) 11/87. A Guide to the Design of at- Grade Intersection. Cawangan Jalan JKR Malaysia.
- Arahan Teknik (Jalan) 13/87 (Pindaan 2017). A Guide to the Design of Traffic Signal. Jabatan Kerja Raya Malaysia.
- Arshad Jamal, M. Tauhidur Rahman, Hassan M. Al Ahmadi, Irfan Ullah & M. Zahid (2020). Intelligent Intersection Control for Delay Optimization: Using Meta-Heuristic Search Algorithms. *Sustainability* ,12(5),1896.
- Emy Paulose, Anjali Gnair, Anthony Thomas, Fathima Thomas, Fathima Rashidha M, & Goutham Viswanathan (2022). Delay Analysis of Signalized Intersection under Heterogeneous Traffic Condition. *International Research Journal of Engineering and Technology (IRJET)*, 9(6), 1834 - 1837.
- Jieyu Fan, Arsalan Najafi, Jokhio Sarang & Tian Li (2023). Analyzing and Optimizing the Emission Impact of Intersection Signal Control in Mixed Traffic. *Sustainability* ,15,16118.
- Malaysia Highway Capacity Manual (2006). Highway Planning Unit. Ministry of Works Malaysia.
- Qinrui Tang & Alexander Sohr (2020). Exit Lane Allocation with the Lane-Based Signal Optimization Method at Isolated Intersections. *Canadian Journal of Civil Engineering*, 47(12), 1345 - 1358.
- Raihanah Adawiyah Shahrudin & Md Yushalify Misro (2023). Controlling Traffic Congestion in Urbanised City: A Framework Using Agent-Based Modelling and Simulation Approach. *International Journal of Geo- Information*, 12, 226.

Power Consumption Analysis of Centrifugal Force Apparatus TM 600

Arman Md Said^{1*} & Ahmad Fariz Fauzi²

^{1,2}Politeknik Melaka, Malaysia

*arman_said@polimelaka.edu.my

Abstract

The centrifugal force apparatus TM 600 is one of the oldest laboratory machines that has been used since 1999 at Politeknik Melaka (PMK). The function of this machine is to investigate the physical laws of such circular motion such as revolution per minute (RPM). Based on its technical data, maximum power usage is 0.04kW. To verify this machine is still reliable to use, a power consumption analysis has been performed using a socket type Power Analyzer based on the value of current (A) per RPM and value of power (W) per RPM. Both studies were detailed based on 50 grams mass and 100 grams mass with the same radial distance of 125mm from the centre of rotation. All the data shows a clear correlation between increasing speed and rising power consumption. The difference in masses also can significantly reduce power consumption. At the same time, the value of power factor during operation is around 0.4 - 0.5 shows that the induction motor operates within a light load. The findings of the study found that the nominal power is still less than 0.04 kW shows that the centrifugal force apparatus TM600 is still in the best operational condition, but future studies must be done focussing on the possible high load and its power consumption for this machine.

Keywords: Centrifugal Force, Power Consumption, Power Factor

1. Introduction

When a body rotates about any axis other than one at its centre of mass, it exerts an outward radial force called centrifugal force upon the axis or any arm or cord from the axis which restrains it from moving in a straight (tangential) line (Erik Oberg, 1992). It is the familiar outward acting force that is induced in rotating systems. The basic concepts used in mechanics are space, time, mass and force (Jr, 1990). A technically important special case relating to the movement of bodies is that of movement on a circular path which involves motion on a curved path with constant path radius of curvature or path radius r . The angular velocity of a rotating body is now defined as a vector quantity having a direction along the instantaneous axis of rotation (Joseph Edward Shigley, 1995).

The angular velocity in rad/s is calculated from the speed n in rpm. $\omega = 2\pi n/60 = 0.1047 n$. A body on a circular path is thus subject to acceleration even at constant velocity (speed) with the acceleration being directed towards the centre of the circle. The production of such acceleration requires external force acting in the direction of acceleration towards the centre of the circle. Applying Newton's second law forms the basis for most of the analysis in dynamic. For a particle of mass m subjected to a resultant force F , the law may be stated as $F = ma$ (Meriam, 1993). When a body rotates about any axis other than one at its centre of mass, it exerts an outward radial force called centrifugal force upon the axis or any arm or cord from the axis which restrains it from moving in a straight (tangential) line (Erik Oberg, 1992). It is the familiar outward acting force that is induced in rotating systems. The basic concepts used in mechanics are space, time, mass and force (Jr, 1990).

A technically important special case relating to the movement of bodies is that of movement on a circular path which involves motion on a curved path with constant path radius of curvature or path radius r . The angular velocity of a rotating body is now defined as a vector

quantity ω having a direction along the instantaneous axis of rotation (Joseph Edward Shigley, 1995). The angular velocity in rad/s is calculated from the speed n in rpm. $\omega = 2\pi n/60 = 0.1047 n$. A body on a circular path is thus subject to acceleration even at constant velocity (speed) with the acceleration being directed towards the centre of the circle. The production of such acceleration requires external force acting in the direction of acceleration towards the centre of the circle.

Applying Newton's second law forms the basis for most of the analysis in dynamic. For a particle of mass m subjected to a resultant force F , the law may be stated as $F = ma$ (Meriam, 1993). The only external force acting here is the so-called centrifugal force is F . With angular velocity ω the centrifugal force is $F = mr\omega^2$. It can be seen that the centrifugal force increases linearly with mass m and path radius r . The angular velocity ω is such that four times the force is required to keep the body on its circular path if the speed is doubled. The unit of force, called a newton (N), is derived from $F=ma$. Thus, 1 newton is equal to a force required to give 1 kilogram of mass an acceleration of 1 m/s^2 ($N = \text{kg} \cdot \text{m/s}^2$ (R.C. Hibbeler, 2008). The greater force and more mass you need to accelerate it. The force (F) acting on an object is equal to the mass (m) of an object time its acceleration (a) (Ya'acob, 2017).



Figure 1: Power Analyzer



Figure 2: Centrifugal Force Apparatus TM600

The movement of a body on a circular path is encountered in all fields of technology. Circular motion and its effect in the form of the centrifugal force produced is observed on all rotating machines. The centrifugal force apparatus TM 600 (Figure 2) permits experimental investigation of the physical laws of such circular motion, for example the relationship between the radius, mass and speed of the body. The acceleration of the body will be directly proportional to the resultant force and inversely proportional to the mass of the body (Hibbeler, 2011). On centrifuges centrifugal force is used to separate materials of differing densities. On turbines the blades are subjected to centrifugal force.

In car tyres the centrifugal unbalance forces produce vibration. Depending on application, centrifugal forces are either desirable, e.g., on a centrifugal clutch or they have an undesirable effect as is the case with the unbalance forces of a turbine rotor. Thanks to its simple, compact, clear-cut design, the unit is suitable not only for demonstrating the effects involved, but also for use by trainees. A body has a mass but a size that can be neglected (Pytel, 2010). A power analyser is an instrument that measures the rate of power flow in Centrifugal Force Apparatus TM 600. Power factor is unity which reduce the formula used to $P = V \times I$ (Mehta, 2011).

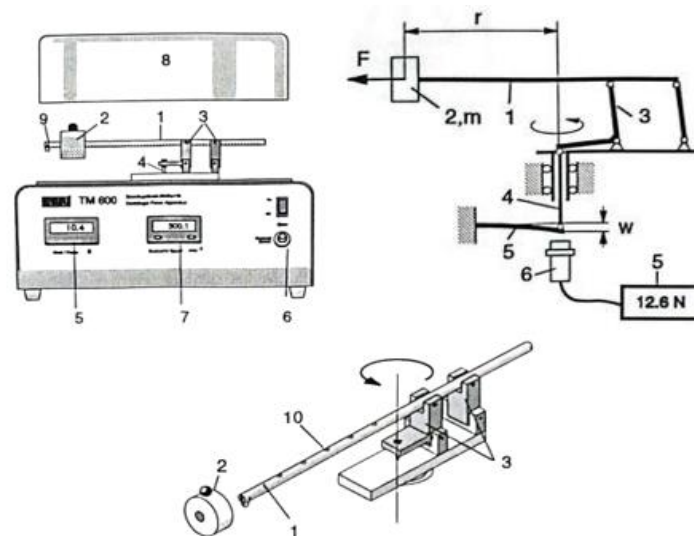


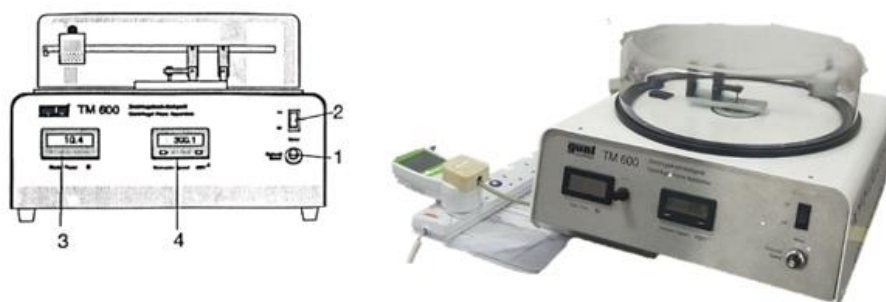
Figure 3: Unit description and function

The main part of the unit is an arm (1) which rotates about a vertical axis. Bodies (2) of varying mass, m with radius, r are attached to the arm. For measuring the centrifugal force F exerted by the body of mass, m (2), the arm is supported such that it can move in radial direction by two guides. The centrifugal force is transmitted by way of a crank lever (3) and a thrust rod (4) located in the axis of rotation to a clamped bending bar (5). The deformation, w of the bar, which is proportional to the centrifugal force, is measured using a displacement measuring system (6) and the centrifugal force is displayed directly in N via a digital instrument (5). Various engaging holes (10) enable the bodies (2) to be attached with the desired radius. The speed of the arm (1) can be infinitely adjusted with the speed-controlled drive motor.

The speed is set using a 10-turn potentiometer (6) and indicated by way of a digital revolution counter (7) in rpm. A transparent guard (8) covers the rotating parts whilst measurement is in progress. A safety catch (9) on the arm ensures that a body cannot fly off if not properly engaged. Make sure that the locking pin (1) of the body is properly engaged in the hole in the arm and that safety catch (2) is correctly positioned. Body could otherwise come loose and fly off. The following mass or radius combinations are recommended for smooth running at high speeds. The system is then more or less completely balanced. The factor of safety method of design is a reliable, time-proven method when properly used, sound and safe designs are obtained using it (R.Mischke, 1989).

2. Methods

Perform Measurement



Procedures:

1. Set speed potentiometer (1) to zero first and then switch on motor (2).

2. Approach desired speed with speed potentiometer (1).
3. Socket type Power Analyzer (Figure 1) is used to monitor the current value of the current voltage.
4. Note down the real time value of current (A) and speed (4) indicated.
5. To investigate the dependence on speed and current, we select two different bodies $m = 50$ grams and $m = 100$ grams with fix radius = 125mm.

Experiment and Data Collection

This study was conducted to measure the real time value of current (mA) per revolution per minute (RPM) and the real time value of power per revolution per minute (RPM). Both studies were detailed based on 50 grams mass and 100 grams mass with fixed radial distance of 125mm from the centre of rotation (COR).

Experiment for 50 grams mass at COR = 125mm

Table 1: Experiment for 50 grams mass at COR = 125mm

10-turn potentiometer	Speed (RPM)	Current (A)	Power (W)
0	0	0.085	8
1	61.9	0.095	10
2	115.3	0.105	11
3	152.5	0.11	12
4	184	0.11	12
5	232	0.115	12.5
6	281.8	0.12	12.5
7	335.8	0.125	13.5
8	396.4	0.13	14
9	464.6	0.14	14.5
10	534.6	0.145	15

Experiment for 100 grams mass at COR = 125mm

Table 2: Experiment for 100 grams mass at COR = 125mm

10-turn potentiometer	Speed (RPM)	Current (A)	Power (W)
0	0	0.085	8
1	61.9	0.095	10
2	115.9	0.1	10.5
3	153.1	0.105	11
4	184.4	0.105	11.5
5	231.3	0.11	12.5
6	282.3	0.115	13.5
7	336.4	0.125	14
8	343.8	0.135	15
9	464.3	0.15	16.5
10	534.4	0.16	17

3. Analysis

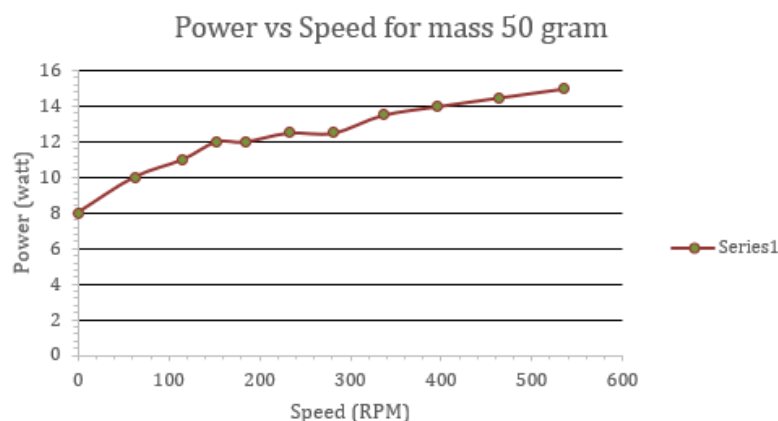


Figure 4: Power versus Speed for mass 50g

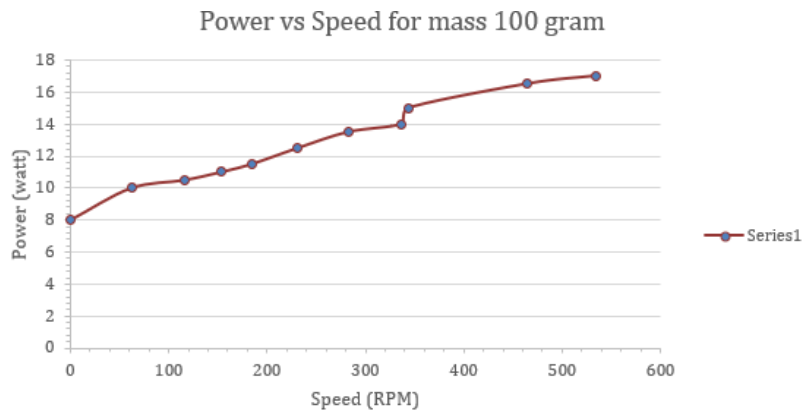


Figure 5: Power versus Speed for mass 100g

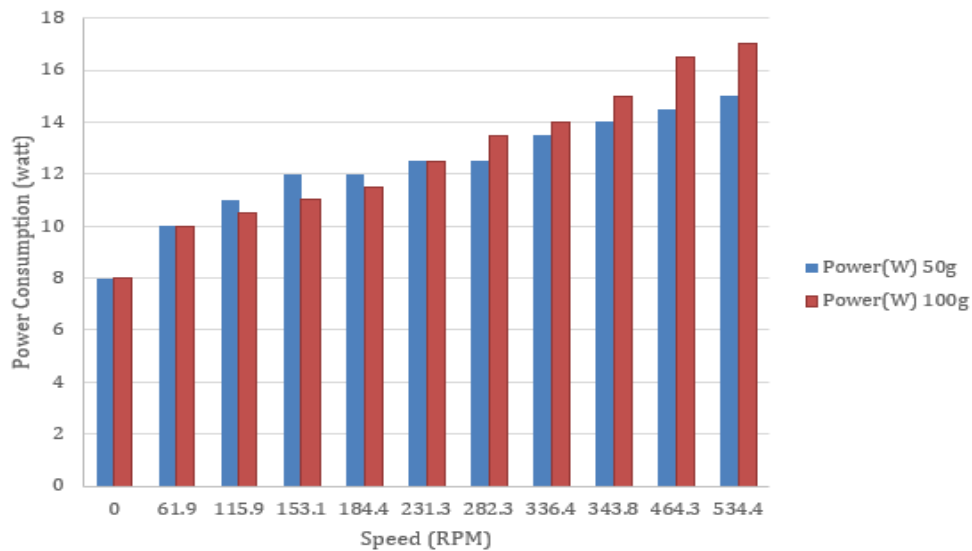


Figure 6: Power Consumption Comparison between 50g mass and 100g mass

4. Data Analysis and Discussion

Calculate current from power and voltage from data collection from Graph Power Consumption comparison between 50g mass and 100g. Here P is power in watts, V is voltage in volts and I is current in amps.

The equation can be rearranged using algebra $P = IV$

Technical data collected from Figure 6.

Power: 230V, mass 50 gram =12-watt, $m=50g/0.05kg$, $r = 125mm/0.125m$, $n = 153.1 \text{ rpm}$

By using $I = P/V = 12 \text{ watt} / 230V = 0.052 \text{ A}$, by using $F = mr\omega^2$, $\omega = 2\pi n/60 = 0.1047n$

$F = (0.05) (0.125) [(0.1047) (153.1)]^2 = 1.61 \text{ kgm/s}^2 \text{ or N}$

Power: 230V, mass 100 gram = 17-watt, $m=100g/0.1kg$, $r = 125mm/0.125m$, $n = 534.4 \text{ rpm}$,

By using $I = P/V = 17 \text{ watt} / 230V = 0.074 \text{ A}$ by using $F = mr\omega^2$, $\omega = 2\pi n/60 = 0.1047n$

$F = (0.1) (0.125) [(0.1047) (534.4)]^2 = 39.13 \text{ kgm/s}^2 \text{ or N}$

Calculating the cost of electricity usage = rate (0.21800) x Energy

Energy = Power x Time

Appliance	Daily (Hour)	Power(kw)	kw x Hour	22 cent/kwh
TM 600	2	0.012 (12w)	0.024	0.528
TM 600	2	0.017 (17w)	0.034	0.748

The calculation results show that when a smaller mass and radius are used in this experiment, it produces a lower value of electric current and power and saves energy consumption. The results of the calculation show the value of power factor during operation is around 0.4-0.5

and shows that the induction motor operates within a light load. The findings of the study found that the nominal power is still less than 0.04 kW. The findings also prove that Centrifugal Force Apparatus TM 600 is still relevant and in good condition for students to use in carrying out practical work.

5. Implications and Direction for Future Research

Although this study is only limited to one equipment and material at the Makmal Kajidaya Bahan, Politeknik Melaka, it is very helpful in identifying the use of the power of this equipment and can prove that this Centrifugal Force Apparatus TM 600 can still be used for teaching and learning, especially practical work. The results of the findings and calculation of force and electric current, show that the Centrifugal Force Apparatus TM 600 is still in good condition. Studies that can be done focussing on the possible high load and its power consumption for this machine and the effect of power factors on electrical energy for others equipment at the Makmal Kajidaya Bahan, Politeknik Melaka.

Acknowledgement

First of all, we would like to express our gratitude to Almighty Allah for enabling us to complete this research on "Power Consumption Analysis of Centrifugal Force Apparatus TM 600". We are also grateful to our friends who contributed ideas and perspectives that enriched this research. To our parents, their constant encouragement, patience and understanding have been the pillars of our success. Thank you everyone for shaping this research and enhancing our learning experience.

References

- Erik Oberg, F. D. (1992). *Machinery's Handbook*. New York: Industrial Press Inc.
- Hibbeler, R. (2011). *"Statics and Mechanics of Materials, Third Edition in SI units"*. Prentice Hall.
- Joseph Edward Shigley, J. J. (1995). *Theory of Machines and Mechanisms*. Singapore: McGraw-Hill International Editions.
- Jr, F. P. (1990). *Vector Mechanics for Engineers*. Singapore: McGraw-Hill, Inc.
- Mehta, V. (2011). *Principles of Electrical Engineering*. New Delhi, India: Schand & Co Ltd.
- Meriam, J. (1993). *Engineering Mechanics Dynamics*. WILEY.
- Pytel, A. (2010). *Engineering Mechanics Static; Third Edition, SI*. Canada: Nelson Education Ltd.
- R.C.Hibbeler. (2008). *Engineering Mechanics Statics Twelfth Edition*. Singapore: Pearson.
- R.Mischke, J. E. (1989). *Mechanical Engineering Design Fifth Edition*. Singapore: McGraw-Hill International Editions.
- Ya'acob, M. B. (2017). *Engineering Mechanics*. Politeknik Nilai: Politeknik Nilai

Comparative Analysis of Charcoal and Banana Stem Fiber Filters in Fat, Oil, And Grease Traps: A Chemical Parameter Evaluation

Nor Aziah Fatma Abdul Ayah @ Abdul Aziz^{1*}, Mohd Azriman Mat Ali² & Rahayu Mhd Adnan³

^{1,2&3}Politeknik Sultan Mizan Zainal Abidin, 23000 Dungun, Terengganu, Malaysia.

*aziah.fatma@psmza.edu.my; aziahfatma@gmail.com

Abstract

The accumulation of fat, oil, and grease (FOG) in wastewater systems can lead to significant problems, including pipe blockages and environmental pollution. This study investigates the effectiveness of using charcoal and banana stem fiber as filter materials in fat, oil, and grease traps to improve the treatment of oily wastewater. This study aims to conduct a comparative analysis of the efficacy of charcoal and banana stem fiber filters in removing fat, oil, and grease by chemical parameters evaluation such as chemical oxygen demand (COD), biological oxygen demand (BOD), dissolved oxygen (DO), total suspended solids (TSS), and ammoniacal nitrogen (AN) from wastewater. Charcoal and banana stem fiber were evaluated for their ability to remove fat, oil, and grease from wastewater samples, and the results were compared to those of other commonly used filter media. The findings suggest that charcoal and banana stem fiber are effective in reducing the levels of fat, oil, and grease in wastewater, making them viable options for use in fat, oil, and grease traps.

Keywords: Charcoal, Banana Stem Fiber, Fat, Oil, Grease, Wastewater Treatment

1. Introduction

The ability to effectively remove fats, oils, and grease (FOG) from wastewater is a critical concern in both household and commercial settings. Decentralized wastewater systems, which include septic tanks and grease traps, play a crucial role in the primary treatment of these pollutants (D'Amato & Liehr, 2007). Researchers have explored various approaches to improving these systems' performance, including using innovative materials as filters. Two promising materials that have gained attention are charcoal and banana stem fiber. (Beck et al., 2021) Charcoal, a highly porous and absorbent material, has demonstrated the ability to remove contaminants from water effectively (Eyvaz et al., 2017). Similarly, banana stem fiber, a renewable and biodegradable resource, has shown potential as a filtration medium due to its high surface area and adsorption capacity (Kusumawardani et al., 2021). Combining these materials in a layered filter system may provide enhanced removal of fats, oils, and grease, leading to improved efficiency of decentralized wastewater treatment systems.

In the quest to address the persistent challenge of managing fat, oil, and grease (FOG) in wastewater, researchers have explored a diverse array of filter materials, each with their own unique characteristics and performance profiles. This study aims to conduct a comparative analysis of the efficacy of charcoal and banana stem fiber filters in removing these pollutants, focusing on their chemical parameters. (Sadikin et al., 2015; Fikri et al., 2021). Charcoal, a highly porous and versatile material, has long been recognized for its exceptional adsorptive properties, making it a promising candidate for oil and grease removal (Fikri et al., 2021). The intricate network of pores within the charcoal structure provides a large surface area, facilitating the capture and retention of organic compounds. The adsorption process is driven by the van der Waals forces, which create a weak attraction between the pollutant molecules and the charcoal surface, leading to the effective removal of oil and grease. In contrast, banana stem fiber, a renewable and eco-friendly material, has garnered attention for its potential in wastewater treatment. The fibrous structure of the banana

stem can act as a physical barrier, trapping larger particulates of oil and grease, while its inherent chemical properties may also contribute to the adsorption of these pollutants.

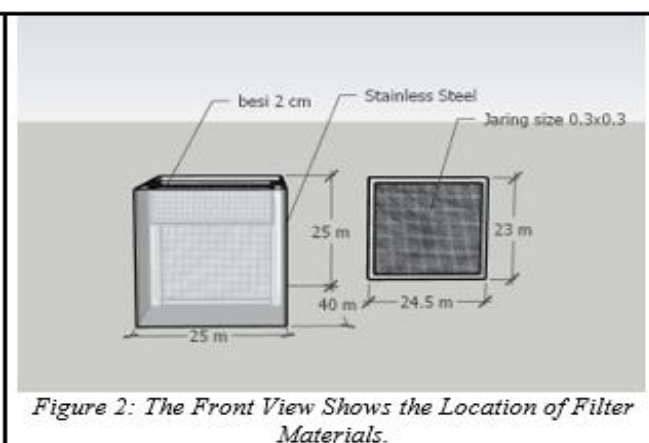
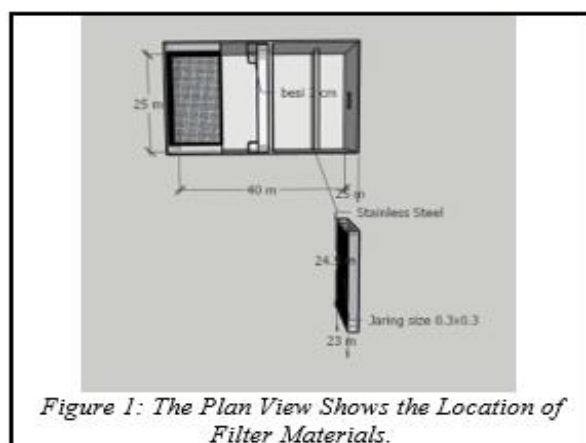
The findings of previous studies (Fikri et al., 2021) have demonstrated the effectiveness of charcoal-based filters in reducing oil and grease levels in wastewater, outperforming traditional grease traps. Similarly, the use of chitosan-filled filters made from empty fruit bunches, a material akin to banana stem fiber, has shown promise in removing total suspended solids and oil and grease, albeit with a lower efficiency (Sadikin et al., 2015).

This study aims to build upon these findings, conducting a comparative analysis of the performance of charcoal and banana stem fiber filters in reducing the levels of fat, oil, and grease in wastewater. The chemical parameters, such as Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Total Suspended Solids (TSS), and Ammoniacal Nitrogen (AN) before and after of the filters, will be examined to gain a comprehensive understanding of their respective removal mechanisms and effectiveness. By exploring the comparative advantages of these two filter materials, this research seeks to provide valuable insights for developing more efficient and sustainable wastewater treatment solutions, contributing to the broader goal of environmental protection and resource conservation.

2. Methods

The methodology for this study will involve the following steps:

1. (Palacios, 2015) Preparation of mesh filter materials: - Charcoal will be obtained from a commercial source and crushed into a fine powder. - Banana stem fibers will be harvested, dried, and pulverized into a fine, porous medium.
2. Lab-scale filtration experiments: - The influent wastewater (sample) containing known fat, oil, and grease concentrations will be prepared. - The wastewater will be passed through a mesh filter column placed in it with charcoal and banana stem fiber, respectively, under constant flow rates and pressure conditions.
3. Evaluation of performance: - The filtrate from the filter column will be analyzed for residual fat, oil, and grease concentrations using standard analytical techniques such as evaluation of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Total Suspended Solids (TSS), and Ammoniacal Nitrogen (AN).
4. Comparative Analysis - The comparative analysis of the efficacy of charcoal and banana stem fiber filter testing in entering FOG trap, existing FOG trap, and existing FOG trap with a mesh filter materials improvement.



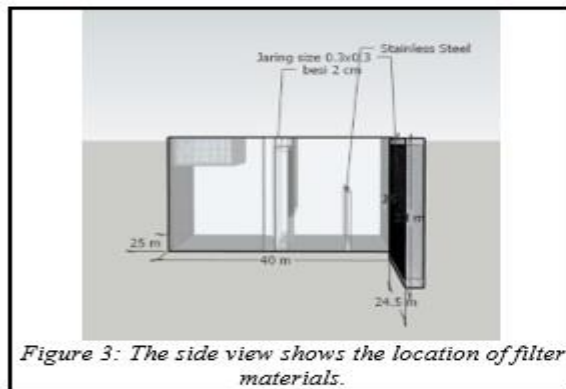


Figure 3: The side view shows the location of filter materials.

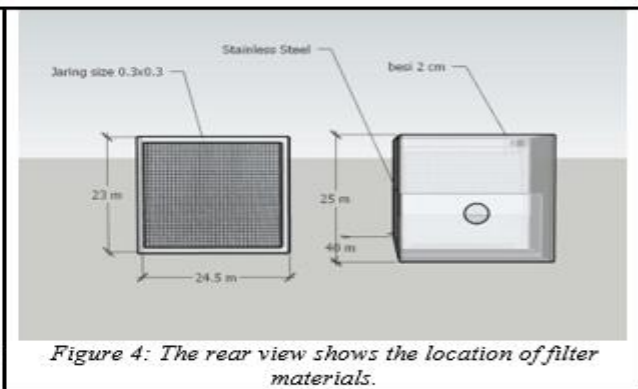


Figure 4: The rear view shows the location of filter materials.

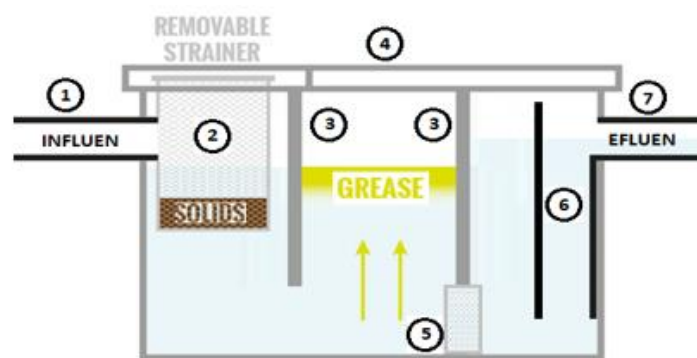


Figure 5: The Basic Component of FOG Trap with A Mesh Filter Materials Improvement.

Table 1: Description of the Basic Components of FOG Trap

Number	Description
1	The influent pipe to FOG trap
2	Stainless steel removable strainer
3	Stainless steel baffle partition wall
4	Stainless steel type FOG trap cover
5	The mesh filter materials (charcoal and banana stem fibre)
6	Outlet chamber
7	The effluent to the sewer/drain system

Figure 5 and Table 1 show the basic components of a basic component of FOG trap with a mesh filter materials improvement. Typically, wastewater from sinks, cooking areas, and washing places is directed into the oil trap through influent pipes. Food residues in this wastewater will be caught by a removable filter, allowing water and oil to flow to the middle section past the first baffle wall. Since oil is lighter than water, it floats on top while water sits at the bottom. The water level in the FOG trap always follows the influent pipe level in the outlet chamber.

Each time wastewater enters the FOG trap through an influent pipe, water flows through the lower part of the baffle wall. A mesh filter material is placed at the bottom of the second baffle wall to absorb excess oil and separate oil and water depending on the natural behavior of these substances due to their differing densities. Excess wastewater will exit through the effluent pipe to the sewage system or open channel. Food residues caught in the removable strainer need to be removed and cleaned daily. Oil accumulated at the top of the oil trap will solidify and needs periodic cleaning. The mesh filter material needs replacement after effluent samples indicating no significant differences compared to influent samples.

3. Results and Discussion

Wastewater residues such as oil and grease, and excess food discharged directly into the drainage system, can cause pollution issues like water pollution. Hasmiza (2009) states that oil and grease

trap systems must be present in every cafe, and the systems developed should be able to address pollution issues effectively and have good maintenance.

Table 2: The data of Chemical Oxygen Demand (COD)

Sample	Chemical Oxygen Demand (COD) (mg/L)		
	Sample 1	Sample 2	Average
Influent Entering to FOG trap	250.00	327.00	288.50
Effluent from Existing FOG trap	137.00	199.00	168.00
Effluent from Existing FOG trap with a mesh filter materials improvement.	94.00	146.00	120.00

The data presented in Table 2 provides valuable insights into the efficacy of a Fats, Oils, and Grease (FOG) trap in wastewater treatment. The Chemical Oxygen Demand (COD) measurements indicate the organic content of the wastewater, which is a crucial parameter in assessing the effectiveness of wastewater treatment processes (Faria et al., 2016). The data shows that the influent entering the FOG trap had a COD of 288.50 mg/L, indicating a significant organic load. After passing through the existing FOG trap, the COD was reduced to 168.00 mg/L, a 41.6% decrease (Faria et al., 2016). This reduction suggests that the existing FOG trap was able to remove a portion of the fats, oils, and grease from the wastewater. However, the data also reveals that further improvements can be made. When the existing FOG trap was modified with the addition of a mesh filter material, the COD of the effluent was reduced to 120.00 mg/L, a 28.6% decrease from the effluent of the existing FOG trap (Faria et al., 2016; Srimoon & Potipat, 2021; Fikri et al., 2021). This suggests that the addition of the mesh filter material enhanced the removal of fats, oils, and grease, leading to a more efficient wastewater treatment process (Fikri et al., 2021; Faria et al., 2016; Srimoon & Potipat, 2021).

Table 3: The data of Biochemical Oxygen Demand (BOD)

Sample	Biochemical Oxygen Demand (BOD) (mg/L)		
	Sample 1	Sample 2	Average
Influent Entering to FOG trap	9.80	7.14	8.47
Effluent from Existing FOG trap	5.17	3.49	4.33
Effluent from Existing FOG trap with a mesh filter materials improvement.	4.26	2.11	3.19

As shown in Table 3, the average Biochemical Oxygen Demand (BOD) of the influent entering the FOG trap was 8.47 mg/L. For the effluent from the existing FOG trap, the average BOD was 4.33 mg/L, indicating a 48.9% reduction in BOD. Further, the average BOD of the effluent from the existing FOG trap with a mesh filter improvement was 3.19 mg/L, a 62.4% reduction compared to the influent (Fikri et al., 2021; Faria et al., 2016). The results suggest that the FOG trap was effective in reducing the BOD of the wastewater, and the mesh filter improvement enhanced the efficiency of the system (Fikri et al., 2021). As noted in previous studies, the reduction in oil and grease levels can have significant environmental benefits by preventing the formation of surface layers that block sunlight and disrupt photosynthesis in aquatic ecosystems (Fikri et al., 2021; Faria et al., 2016).

Table 4: The data of Dissolve Oxygen (DO)

Sample	Dissolve Oxygen (DO) (mg/L)		
	Sample 1	Sample 2	Average
Influent Entering to FOG trap	1.60	1.40	1.50
Effluent from Existing FOG trap	3.90	3.80	3.85
Effluent from Existing FOG trap with a mesh filter materials improvement.	5.00	5.00	5.00

The present study aimed to investigate the impact of a mesh filter material improvement on the dissolved oxygen (DO) levels in the effluent from an existing fat, oil, and grease (FOG) trap. The data provided indicates that the effluent from the existing FOG trap had an average dissolved oxygen level of 3.85 mg/L, which is lower than the desired level for proper wastewater treatment.

The introduction of a mesh filter material improvement to the existing FOG trap resulted in a significant increase in the average dissolved oxygen level, reaching 5.00 mg/L (Fikri et al., 2021). This improvement can be attributed to the enhanced removal of fats, oils, and grease from the wastewater, as suggested by previous studies (Fikri et al., 2021; Faria et al., 2016). Fats, oils, and grease (FOG) can hinder the natural processes of wastewater treatment by limiting the availability of dissolved oxygen (Faria et al., 2016). The accumulation of these substances on the surface of water bodies can also block sunlight, impeding the photosynthesis of aquatic plants and further reducing dissolved oxygen levels (Tang et al., 2018).

Table 5: The data of Total Suspended Solids (TSS)

Sample	Total Suspended Solids (TSS) (mg/L)		
	Sample 1	Sample 2	Average
Influent Entering to FOG trap	13 560	14 786	14 173
Effluent from Existing FOG trap	12 246	11 436	11 841
Effluent from Existing FOG trap with a mesh filter materials improvement.	4 000	3 510	3 755

The data presented in Table 5 provides valuable insights into the performance of a grease trap system in removing Total Suspended Solids (TSS) from wastewater. According to the table, the average Total Suspended Solids (TSS) concentration in the influent entering the grease trap was 14,173 mg/L. After passing through the existing grease trap, the effluent concentration was reduced to an average of 11,841 mg/L, indicating a removal efficiency of approximately 16.4% (Srimoon & Potipat, 2021; Fikri et al., 2021). Further improvements were made by installing a mesh filter material in the grease trap, which resulted in a significant reduction in the Total Suspended Solids concentration in the effluent. The average effluent concentration with the mesh filter improvement was 3,755 mg/L, corresponding to a removal efficiency of approximately 73.5%.

These findings are consistent with the literature, which suggests that grease traps can be effective in reducing the levels of contaminants such as oil, grease, and total coliform, but may have limited effectiveness in removing total suspended solids (Chikogu et al., 2023). The use of additional filtration, such as the mesh filter material, can significantly improve the removal of suspended solids, as evidenced by the 73.5% removal efficiency observed in the data. (Srimoon & Potipat, 2021).

Table 6: The data of Ammoniacal Nitrogen (AN)

Sample	Ammoniacal Nitrogen (AN) (mg/L)		
	Sample 1	Sample 2	Average
Influent Entering to FOG trap	2.90	2.74	2.82
Effluent from Existing FOG trap	1.57	1.22	1.40
Effluent from Existing FOG trap with a mesh filter materials improvement.	1.36	0.98	1.17

The data presented in Table 6 provides valuable insights into the removal of ammoniacal nitrogen (AN) in a grease trap system. The influent entering the grease trap had an average ammoniacal nitrogen (AN) concentration of 2.82 mg/L, while the effluent from the existing grease trap showed a reduction to 1.40 mg/L (Zhang, 2018). This indicates that the existing grease trap was able to remove approximately 50% of the ammoniacal nitrogen.

Further improvements were made to the grease trap by incorporating a mesh filter material. This modified grease trap system was able to reduce the ammoniacal nitrogen concentration in the effluent to an average of 1.17 mg/L, representing a removal efficiency of approximately 58%. The improved performance of the grease trap with the mesh filter material can be attributed to the enhanced ability to capture and retain organic matter and suspended solids, which are often associated with ammoniacal nitrogen.

4. Conclusion

The comparative analysis of charcoal and banana stem fiber filters in fat, oil, and grease (FOG) traps has provided valuable insights into their respective performance and effectiveness. The results have shown that both filter materials possess the ability to reduce oil and grease levels in wastewater, but the extent of their effectiveness varies. Activated carbon derived from coconut shells and rice husks has demonstrated a higher capacity to reduce oil and grease levels, achieving a 66.66% reduction (Fikri et al., 2021). In contrast, palm kernel shells activated carbon was less effective, only reducing oil and grease by 29 (Fikri et al., 2021)16%, while sawdust-activated carbon was found to be ineffective in this regard (Fikri et al., 2021).

The use of chitosan-filled filters, made from empty fruit bunches, has also been explored, but their performance was less impressive, removing only up to 29.86% of oil and grease (Sadikin et al., 2015). These findings suggest that the choice of filter material is a critical factor in the overall effectiveness of fat, oil, and grease traps. Charcoal-based filters, particularly those derived from coconut shells and rice husks, appear to be a more viable option for the efficient removal of these contaminants from wastewater. Further research and optimization of filter materials and configurations may lead to even greater improvements in the treatment of oil and grease-laden wastewater, ultimately contributing to more sustainable and environmentally friendly waste management practices.

References

- Beck, S E., Suwan, P., Rathnayeke, T., Nguyen, T M H., Huanambal-Sovero, V A., Boonyapalanant, B., Hull, N M., & Kootatep, T. (2021, May 31). Woven-Fiber Microfiltration (WFMF) and Ultraviolet Light Emitting Diodes (UV LEDs) for Treating Wastewater and Septic Tank Effluent. Multidisciplinary Digital Publishing Institute, 13(11), 1564-1564. <https://doi.org/10.3390/w13111564>
- Chikogu, A., Michelle, K., Amponsah, D., Dauda, A B., & Stephen, J. (2023, January 1). A fuzzy-topsis decision-making model for selections of wetland technology for greywater treatment. 48(2), 14-24. <https://doi.org/10.5937/poljteht2302014a>
- D'Amato, V A., & Liehr, S K. (2007, January 1). Factors Affecting the Performance of Primary Treatment Units in Decentralized Wastewater Systems. <https://doi.org/10.13031/2013.23998>
- Eyvaz, M., Arslan, S., Gürbulak, E., & Yüksel, E. (2017, September 20). Textile Materials in Liquid Filtration Practices: Current Status and Perspectives in Water and Wastewater Treatment. <https://doi.org/10.5772/intechopen.69462>
- Faria, J D A F., Sousa, A F E D., Reis, A., Filipe, V., & Barroso, J. (2016, September 16). Probe and Sensors Development for Level Measurement of Fats, Oils and Grease in Grease Boxes. Multidisciplinary Digital Publishing Institute, 16(9), 1517-1517. <https://doi.org/10.3390/s16091517>
- Fikri, E., Dhaifina, H., & Hidayah, N. (2021, March 30). Differences in thickness variations of activated carbon in decreasing oil and grease levels using modified grease trap on the canteen wastewater. Warsaw University of Life Sciences, 30(1), 106-116. <https://doi.org/10.22630/pniks.2021.30.1.10>

- Hasmiza Abdullah (2009). National Integrated Water Resources Management Plan 2016. Draft persidangan kesihatan persekitaran, 2014. UTM
- Kusumawardani, Y., Subekti, S., Astuti, W., & Soehartono, S. (2021, April 1). Portable wastewater treatment plant using banana stem filter media in small scale motor vehicle washing services. IOP Publishing, 746(1), 012039-012039. <https://doi.org/10.1088/1755-1315/746/1/012039>
- Palacios, A. (2015, November 18). Use of Banana Peel Based Filters to Reduce Heavy Metals in Wastewater. <https://doi.org/10.2118/177250-ms>
- Sadikin, A N., Nawawi, M G M., Othman, N., Ali, R R., & Asli, U A. (2015, June 2). Removal of Oily Wastewater Using Chitosan-filled Filter Media. Muhammadiyah University of Jakarta, 74(7). <https://doi.org/10.11113/jt.v74.4708>
- Srimoon, R., & Potipat, J. (2021, January 1). Development of chitosan beads as an oil adsorbent and its application in household grease traps., 47(3), 330-330. <https://doi.org/10.2306/scienceasia1513-1874.2021.046>
- Tang, X., Ding, A., Pronk, W., Ziemba, C., Cheng, X., Wang, J., Xing, J., Xie, B., Li, G., & Liang, H. (2018, October 1). Biological pre-treatments enhance gravity-driven membrane filtration for the decentralized water supply: Linking extracellular polymeric substances formation to flux stabilization. Elsevier BV, 197, 721-731. <https://doi.org/10.1016/j.jclepro.2018.06.155>
- Zhang, P. (2018, September 12). Biogas Production from Brown Grease and the Kinetic Studies. <https://doi.org/10.5772/intechopen.74083>

Development of a Wind-Powered Battery Bank for Mobile Phone

Noranizah Solihin^{1*} & Luqman Hazim Sakariah²

^{1,2}Jabatan Kejuruteraan Elektrik, Politeknik Merlimau, Melaka, Malaysia

* noranizah@pmm.edu.my

Abstract

The increasing reliance on mobile phones in daily life and the need for sustainable energy solutions have prompted the exploration of alternative power sources. This paper presents the development of an innovative wind-powered battery bank designed to charge mobile phones using wind resistance generated by a moving vehicle. The proposed solution harnesses the wind energy created by a vehicle in motion, converting it into electrical energy that can be stored and subsequently used to charge mobile devices. The primary objective is to create a portable, efficient, and eco-friendly solution that provides reliable power in various environments, including remote locations and during outdoor activities. The system comprises a compact wind turbine mounted on the vehicle, a battery storage component, and USB output ports. The turbine captures wind energy and converts it into mechanical energy, which is then transformed into electrical energy, and this electricity is stored in the battery bank, providing a renewable and reliable power source for mobile phones. The stored energy can be used to charge mobile phones through standard USB ports. The results indicate that the wind-powered battery bank can effectively generate and store sufficient energy to charge standard mobile phones, with the performance dependent on vehicle speed and environmental conditions. The study concludes that this innovative approach offers a viable, eco-friendly solution for mobile device charging on the go, promoting sustainability and convenience for users.

Keywords: Wind-powered Charging, Mobile Phone, Battery Bank, Renewable Energy

1. Introduction

With the rapid growth of mobile phones and their integration into daily life, the need for reliable and sustainable energy sources to power these devices has become increasingly critical. Mobile phones are essential for communication, business, and entertainment, ensuring they remain operational at all times. Traditional battery banks, which store electrical energy for later use, have become a popular solution. However, these power banks still rely on conventional electricity sources for charging, thus contributing to the depletion of non-renewable energy resources and increasing carbon emissions. Numerous innovations have been developed to make use of renewable energy sources for a range of purposes. Energy conservation and management are the two key components of renewable energy. The renewable energy sources that are most frequently used include solar, hydro, and wind. Out of the three energy sources, wind power is recognized for its reliability because, aside from wind being generated naturally, anything that moves produces wind. (G. Subhashini, 2018).

The development of a wind-powered battery bank presents a new approach to address these issues. By harnessing wind energy, which is abundant and renewable, such a battery bank can provide a sustainable and environmentally friendly alternative to traditional charging methods. The wind-powered battery bank operates on a straightforward principle of energy conversion, utilizing the kinetic energy from wind, particularly the wind resistance experienced by a moving vehicle, and transforming it into electrical energy. This innovation aligns with global efforts to reduce carbon footprints. It offers a practical solution for individuals in remote or off-grid locations where access to conventional power sources is limited.

This project focuses on the design and development of wind-powered battery banks, including their design efficiency, portability, durability, and cost-effectiveness. The concept of using wind energy generated by a moving vehicle introduces a novel approach to mobile power generation, combining the principles of aerodynamics and renewable energy technologies.

Previous studies have highlighted the potential of wind energy for small-scale applications. For instance, (Saxena, 2013) explored harvesting energy from low-speed wind flows to power mobile electronics applications devices. A DC generator and integrated circuit are used in this method at a constant rate. A DC motor is used as a generator in the place of an AC generator with a regulator circuit comprising different components like a Voltage regulator IC, Battery, Charging pin, and a capacitor for ripple-free voltage.

Some research has emerged to recycle wind energy from air conditioning condenser fans in outdoor buildings (Arni Munira Markom, 2022), which is to develop renewable wind energy from the condenser fan of an air conditioner using Arduino as a microcontroller. This research moves towards a portable, low-cost, environmentally friendly mini device that harnesses renewable energies with endless resources for future alternative power generation and reduces the burden of consumers' electricity bills.

The idea of integrating wind turbines with moving vehicles is not entirely new. Proposed research by (G. Subhashini, 2018) to design and develop a wind energy harvesting system to charge a power bank on a motorcycle. The proposed system is expected to deliver an output of 5V which is sufficient to charge any portable storage bank. The investigation of the wind turbine concept of portable charges (Abdul Hakim Bin Razuan, 2021) is applied on the motorcycle due to its aerodynamics which can easily capture the wind by placing the cooler fan that is used to generate electrical energy on it. Motorcycles are also mostly used to travel farther away easily without getting stuck in traffic jams.

By applying the portable charges on the motorcycle, the riders do not have to worry about the mobile phone battery during travel. Vehicles such as motorcycles do not have a constant speed and this affects the wind speed that is produced during motorcycle moves. When the wind speed varies the voltage produced also varies because the faster the wind speed the higher the voltages produce. The paper presents the design and implementation of a portable battery charger using a multi-direction wind turbine (Kharudin Ali, 2016) examines a prototype of a battery charger developed for application with mobile phones as an example to address the design considerations, plus demonstrates the performance of the charger adapted to a practical application system. Findings from the investigation show the mobile charger is better than normal mobile charging as it uses wind power as a renewable energy source.

Developing a wind-powered battery bank holds significant potential for both environmental and practical benefits. Environmentally, it leverages renewable energy, thus contributing to the reduction of greenhouse gas emissions. Practically, it provides a reliable power source for mobile phones in areas with limited or unstable electricity supply, enhancing connectivity and accessibility. While previous studies have explored various aspects of wind energy and portable power solutions, the integration of these concepts into a vehicle-mounted system represents a novel approach. As the demand for sustainable technology grows, this innovation can position itself as a competitive and desirable product in the market.

2. Research Methodology

Developing a Wind-Powered Battery Bank for Mobile Phones involves a combination of hardware design and research processes. The proposed methodology consists of three major parts which are the selection of components and block diagram, a flowchart of the project and circuit connection and hardware development. The process selection of components such as DC motor, TP4056 module, Lithium-ion battery, On-off switch, DC-DC boost chopper, Wire jumper, fan blade, and any other necessary electronic components is very important in the hardware design.

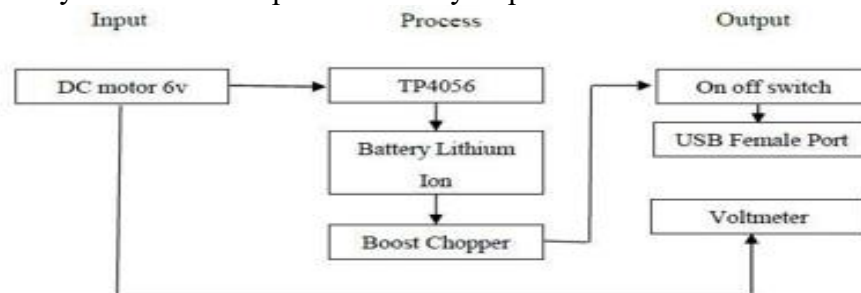


Figure 1: Block diagram of the Wind-Powered Battery Bank for Mobile Phones

This block diagram illustrates a system that involves converting the output from a DC motor into a usable voltage for charging or powering devices through a USB port. The system takes mechanical energy (or another energy source) converted to electrical energy by the DC motor, then charges a lithium-ion battery using a TP4056 module. Before the motor charges the battery, TP4056 will operate as a protection module to cut off the circuit when the battery is fully charged. The stored energy in the battery is then boosted to 5V by a boost converter and supplied to a USB port, with a switch to control the output and a voltmeter to monitor it. Below is a detailed description of each part in the block diagram:

1. Input: The Direct Current (DC) motor is connected to the blade as the input for the wind turbine. Wind resistance from a vehicle will spin the blade and the generator will produce electricity. This motor generates a DC voltage of 6V. It could be powered by various sources, such as mechanical rotation (like a hand crank or a wind turbine).
2. Process: Process elements involve TP4056 Module, Lithium-Ion Battery, and Boost Chopper (Boost Converter). The TP4056 is a lithium-ion battery charging module. It is designed to charge single-cell lithium-ion batteries. It typically requires an input voltage of 4.5V to 5.5V, which means the 6V from the DC motor is suitable. It regulates the charging current and voltage to ensure the battery charges safely and efficiently. Lithium-ion batteries are commonly used due to their high energy density and rechargeability. The typical voltage of a fully charged lithium-ion cell is about 4.2V. A boost converter is a type of DC-DC converter that steps up the voltage from the input to a higher output voltage. This system takes the voltage from the lithium-ion battery (around 3.7V to 4.2V) and boosts it to 5V, which is suitable for USB devices.
3. Output: The output element includes an On-Off Switch, USB Port, and voltmeter. This switch controls the connection between the boost converter and the USB port. USB ports can connect USB devices to charge or power them. The port provides a standard 5V output, which is compatible with most USB-powered devices. The voltmeter monitors the output voltage to ensure that the system is providing the correct voltage to the USB port.

Figure 2: Flowchart of Functional Project

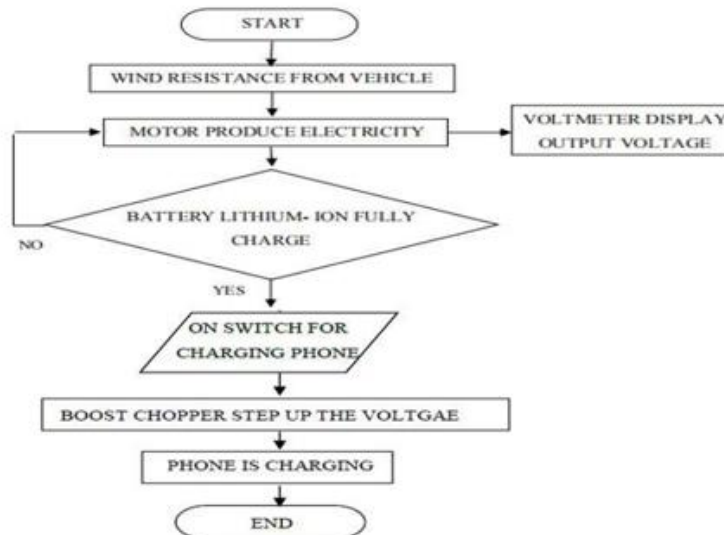


Figure 2 shows the flowchart of the functional project while Figure 3 shows the circuit connection of a Wind-Powered Battery Bank for Mobile Phones. The flowchart describes a process where wind energy from a moving vehicle is captured and converted into electrical energy by a motor. As the vehicle moves, it encounters air resistance or wind resistance to generate power. A voltmeter is connected to the output of the motor to measure the voltage of the electricity being produced and display it. This helps in monitoring the performance and output of the motor. The captured wind resistance drives a motor which converts the kinetic energy into electrical energy. The generated electricity then is directed to a lithium-ion battery for storage. Once the battery is fully charged, a switch activates a boost converter to step up the voltage to the appropriate level for charging a phone. This ensures that renewable energy is efficiently used to keep the phone charged.

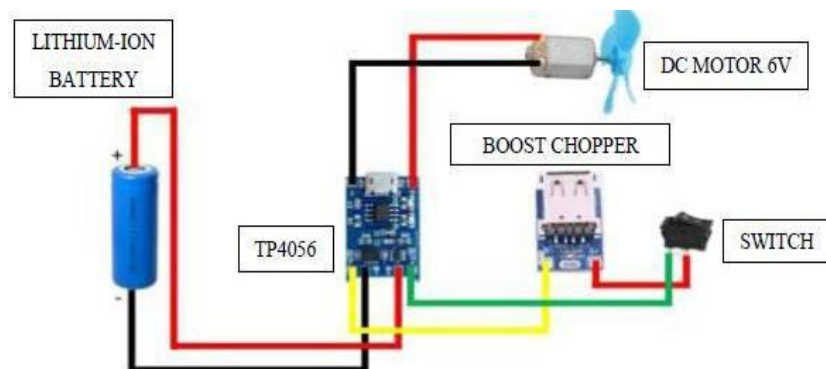


Figure 3: Schematic diagram of the Wind-Powered Battery Bank for Mobile Phones

For hardware development, several core components are used to develop this project. The TP4056 is the main component of this system as a protection module for the lithium-ion battery. All the hardware equipment then was installed in the hard plastic box. This style of box was chosen since it is both sturdy and lightweight when all the parts are included in it. This box is made of durable plastic, water-resistant, and is made to be portable. The total weight of this product is estimated to be between 200g to 400g at an approximate size of 12 cm x 15 cm x 8cm. Figure 4 (a), (b), and (c) shows the picture of the hardware development from the top, side, and inside view of the project while Table 1 shows technical specification of Wind-Powered Battery Bank for Mobile Phones.

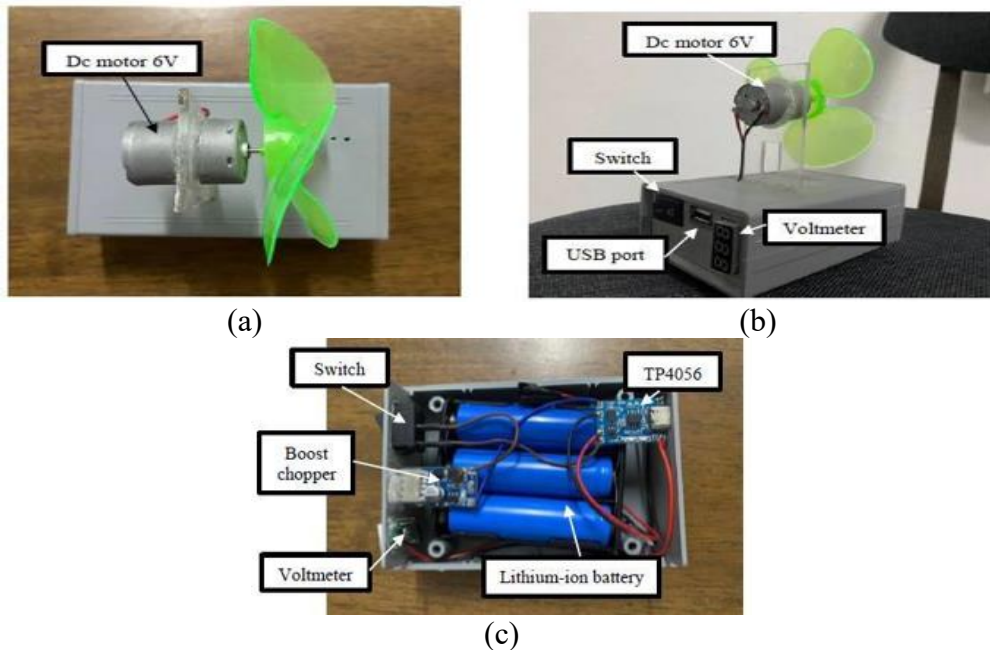


Figure 4: (a) Top view, (b) Side view. (c) Inside view

Table 1: Technical Specification of Wind-Powered Battery Bank for Mobile Phones

Description	Details
Working rate voltage	DC 4.5 - 5.5 V
Working rate current	1A
Power rating	4.2W
Charge precision	1.5%
Product box	Hard plastics
Product dimension	12cm × 15cm × 8cm (approx.)
Gross weight	200g – 400g (approx.)
Box color	Grey

3. Results and Discussion

Selection of the Motor Blade

Analysis of the research is first taken part in the designing and testing of the blades. The design of the blades that are used to capture the wind stream is determined based on the voltage output produced by the motor. There are four blades of different sizes (diameters) analyzed as shown in Figure 5.

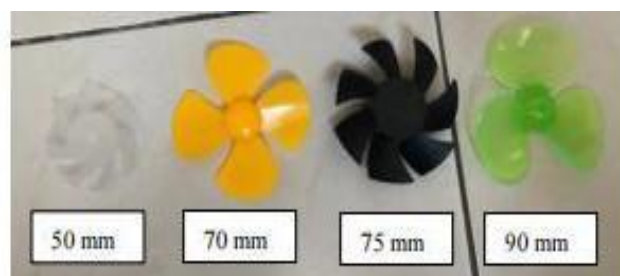


Figure 5: Four Blades of Different Sizes

The selection of the motor blade was carried out through an empirical analysis, where the voltage output produced by the motor was measured for four different blade sizes: 90 mm, 80 mm, 75 mm, and 50 mm. The test involved using a fan to generate a wind stream and recording the voltage output for each blade size as shown in Table 2 below.

Table 2: Fan blade selection testing

Blades	Output Voltage
90mm	3.6V
80mm	3.4V
75mm	3.0V
50mm	0V

The 90 mm blade produced the highest voltage output of 3.6V, indicating it was the most effective at capturing the wind stream and converting it into electrical energy. This data suggests a direct correlation between blade size and voltage output, up to a certain extent. Larger blades tend to capture more wind, resulting in higher voltage generation. However, this trend might not continue, as other factors such as blade weight, aerodynamics, and structural design also affect the voltage generation.

DC Motor Efficiency

The fan's speed and the voltage produced have been tested using the wind stream produced by fans with different speeds. Based on Table 3 the speed of the fan is directly proportional to the output voltage produced. The maximum wind speed produced by the fan is 7.1 m/s and can produce a voltage of about 4.6V, while the minimum speed of the fan is 5m/s with the voltage produced being about 3V. The results from Figure 6 show that the higher the fan speed, the higher the output voltage.

Table 3: The Wind Speed of the Fan and the Output Voltage

Fan Speed	Anemometer	Output Voltage
1	5.0 m/s	3V
2	6.5 m/s	3.9V
3	7.1 m/s	4.6V

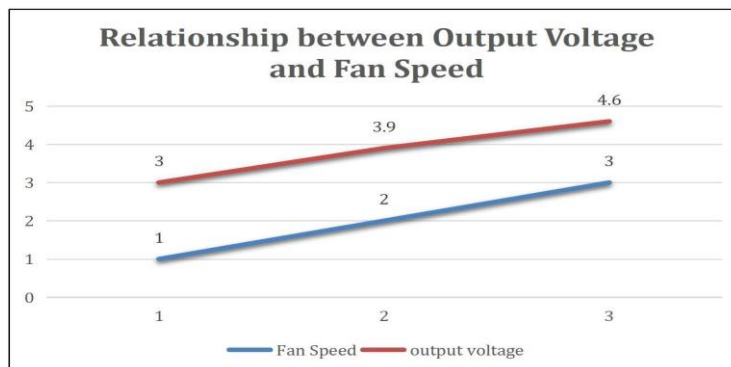


Figure 6: Relationship between Fan speed and Voltage produced

The battery bank for the mobile phone charger was tested outdoors in medium wind conditions. The practical application of this system was tested in real-world conditions, particularly in a travelling scenario using a motorcycle and a car in Figure 7 and Figure 8.



Figure 7: Testing on Outdoor Application on Motorcycles

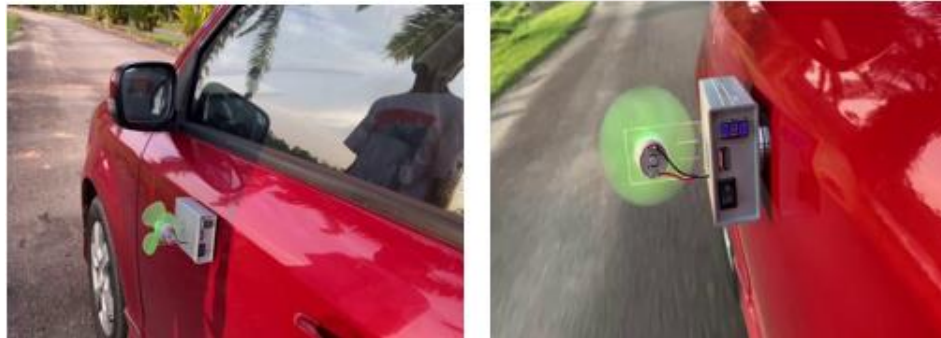


Figure 8: Testing on Outdoor Application on Cars

Table 4: Output Voltage Produce on both Vehicles at 40km/hr - 50km/hr

Motorcycles	Car
4.53V	4.87V

The speed range for these tests was between 40 km/hr and 50 km/hr. The results, displayed in Table 4, indicate that the voltage output from the mobile charging system is slightly higher in cars (4.87V) compared to motorcycles (4.53V). However, the output voltage difference between both vehicles is not so significant, suggesting that this battery bank for mobile phone charger works reliably across various types of vehicles within the given speed range.

4. Implications and Direction for Future Research

This research demonstrates the feasibility of using wind energy for mobile phone charging, providing a sustainable and portable power solution for travellers. This research also explores the use of renewable energy, specifically wind energy, to create a portable charger that harnesses the wind stream generated by a moving vehicle. This innovation aims to conserve non-renewable energy sources and contribute to environmental preservation. Utilizes wind energy, a renewable and clean energy source that does not produce pollution or waste, making it environmentally friendly. It also allows vehicle users to charge their mobile phones on the go, eliminating the worry about battery life during long journeys.

Demonstrates the use of small-scale wind turbines in everyday life, implying that with additional research, these wind-powered chargers can be made more compact and efficient. The principles of this project also can be extended to other vehicles, such as bicycles, trains and even boats. This initial success indicates potential for improvement and further research possibly enabling the charger to handle medium-sized devices like laptops. Continued research and development can further enhance the technology, making it more efficient, widely applicable, reducing our environmental impact and fostering a culture of renewable energy use.

References

- Abdul Hakim Bin Razuan, P. F. (2021). Wind Powered Portable Charger: Generate Electricity from The Motorcycle Movement Using Wind Energy Concept. *eportfolio.utm.my*.
- Arni Munira Markom1, M. H. (2022). Electricity generation from renewable energy based on abandoned wind fan. *Indonesian Journal of Electrical Engineering and Computer Science*, Vol. 26, No. 1, April 2022, pp. 1~8.
- G. Subhashini, R. A. (December 2018,). Wind Turbine Mounted on A Motorcycle for Portable Charger. *International Journal of Power Electronics and Drive System (IJPEDS)*, Vol. 9, No. 4, pp. 1814~1822.

- Harivardhagini, S. (2023). A Cost-Effective Approach to Design a Portable Mobile Charging Device using Wind Energy. *CVR Journal of Science and Technology*, Volume 25, December 2023.
- Kharudin Ali, W. S. (2016). Design and Implementation of Portable Mobile Phone Charger using Multi Directional Wind Turbine Extract. *Indian Journal of Science and Technology*, Vol 9(9), DOI: 10.17485/ijst/2016/v9i9/88711, March 2016.
- Saxena, K. &. (2013). A novel design of wind driven mobile battery charger. *International Journal of Science, Engineering and Technology Research (IJSETR)* Volume 2, Issue 3, March 2013

Smart Early Detection of Rheumatoid Arthritis Tool on Nails with A Certainty Factor Technology Approach Based on Image Processing

Abi Mufid Octavio¹, Andinusa Rahmandhika^{2*}, Muhammad Lutfi Kamal³, Nuri Virdausia⁴, Frenischa Yincenia Wijaya⁵, Desta Karina⁶ & Achmad Fauzan Hery Soegiharto⁷

^{1,2,3,4,5,6,7}University of Muhammdiyah Malang, Indonesia

*andinusa@umm.ac.id

Abstract

Rheumatoid Arthritis is an autoimmune disease that attacks the thyroid gland, generally affecting the elderly. In the case, to diagnose Rheumatoid Arthritis, a medical check-up is required by medical personnel, but it is necessary to know that this disease can also be diagnosed early through a complex nail structure. This research is the first stage to get the design and prototype of Smart Early Detection Rheumatoid Arthritis Tool. The purpose of this stage of research is to get a tool that is able to capture nail images and process them. The stages of this research begin with design, prototype design and trial or evaluation. The results show that this research prototype in the form of a tool or prototype of the Smart Early Detection Rheumatoid Arthritis Tool is able to capture and process nail images. The continuation of this research is the integration of image processing with machine learning.

Keywords: Rheumatoid Arthritis, Diagnostics, Image Processing, Machine Learning, Healthcare

1. Introduction

Indonesia ranks as the 4th most populous country in the world (Pratama et al., 2019). The ever-increasing population and the huge growth rate pose a dilemma for the government. In the last ten years (2010 - 2020) Indonesia's population growth rate reached 1.25 percent per year according to the Central Bureau of Statistics. The increase in population growth will be directly proportional to the demands for health facilities and the fulfilment of adequate health services and in accordance with applicable requirements.

The factors that affect public health in Indonesia are: 1) Uneven distribution of health care facilities between villages and cities. 2) The income or economy of each individual, because the income level of a person can measure whether that person has a good health status or not. 3) Poor environment which makes exposure to germs and viruses easier to spread. 4) Genetic Factors: A family history of RA can increase a person's risk of developing the disease. Genetics is a factor that can cause a person to contract a disease, one of these diseases is Rheumatoid Arthritis (Elsi Mariza, 2023). Genetic conditions may play a role in a person's predisposition to the development of Rheumatoid Arthritis. Varying genetic interactions in diverse populations can have significant implications for the level of risk of developing RA. Rheumatoid Arthritis (RA) itself is a type of chronic autoimmune disease in arthritis that is common in the age ratio of 45 - 60.

The prevalence of Rheumatoid Arthritis in Indonesia from year to year is increasing to reach 23.3% - 31.6% of the total population of Indonesia. It is estimated that this number will continue to increase until 2025 with an indication that more than 25% will experience paralysis (Febriansa et al., 2021). Rheumatoid Arthritis is a chronic inflammatory disorder caused by immune instability, which leads to the destruction of joint organs and synovial lining. The first symptom that often occurs is pain in the joints of the hands, feet and knees, but many people underestimate this pain because it seems not to cause death.

However, persistent pain can hamper daily activities (Latuamury, 2022). Due to the absence of specific signs and symptoms and the lack of knowledge about this disease, there is a misunderstanding of the community who do not carry out early examinations so that this disease is often known when it is acute and causes paralysis until the arrival of complications, namely blockage of blood vessels to the heart which can interfere with the work of pacemakers resulting in cardiac arrest and can cause death (R. M. Putri et al., 2020).

Supportive examination in Rheumatoid Arthritis disease is an examination that must be carried out to establish a definite diagnosis. However, there are some difficulties in early detection of Rheumatoid Arthritis (RA) disease due to the onset that cannot be known with certainty and the results of the physical examination can also vary depending on the examiner (Risa Fitri Awaliah & Apriani Apriani, 2022). Typically, Rheumatoid Arthritis is diagnosed based on a combination of patient symptoms, physician examination results, risk factor assessment, family history, joint assessment with sonographic ultrasound, and assessment of laboratory markers such as elevated serum levels of CRP and ESR and detection of Rheumatoid Arthritis (Sari & Saftarina, 2022).

Based on this problem, an innovation was created, namely an early diagnostic tool for Rheumatoid Arthritis (RA) using the Certainty Factor method integrated with Artificial Intelligence (AI) technology under the name Smart Early Diagnostic Rheumatoid Arthritis. This innovation has the advantage of being a tool product that is able to diagnose early Rheumatoid Arthritis disease accurately and has a short time efficiency level. Smart Early Detection Rheumatoid Arthritis Tool (SEDRAT) is a tool that develops the scientific concept of artificial intelligence combined with the analysis of certainty factor methods based on image processing and machine learning to get more definite diagnostic results.

This tool is equipped with a GoPro camera, laser beam and database from various health journals. The laser beam will detect the visual condition of the nail, then the raspberry pi will command the GoPro camera to transmit the photo to the laptop and then enter the image processing stage which has been calibrated with the MATLAB program to display data, where the data is in the form of statistical data and graphs that are more complete and concrete, then the data is validated with a database of health journals regarding indications of Rheumatoid Arthritis disease on the nails contained in machine learning and decided through the certainty factor method so that it has diagnostic results with a high accuracy value.

In its application, this tool was created to help make it easier to determine the early diagnosis of Rheumatoid Arthritis before entering the acute phase, which later the diagnostic results are used as a reference for the first treatment to reduce the risk of people contracting Rheumatoid Arthritis disease. In addition, this tool is a very efficient means for health workers and the public in conducting effective and inexpensive examinations. Of course, this answers the problem of the lack of public awareness to conduct general check-ups on health conditions and is able to reduce the high number of people infected with the disease.

2. Methodology

The research design used in this research is true experiment research. In this research conducted, the aim is to obtain designs and prototypes. This study uses two independent variables, so to get data, a Smart Early Diagnostic Rheumatoid Arthritis prototype design is needed. Based on the research variables, it will be used as a reference in its manufacture which aims to obtain the dimensions and design of the prototype.

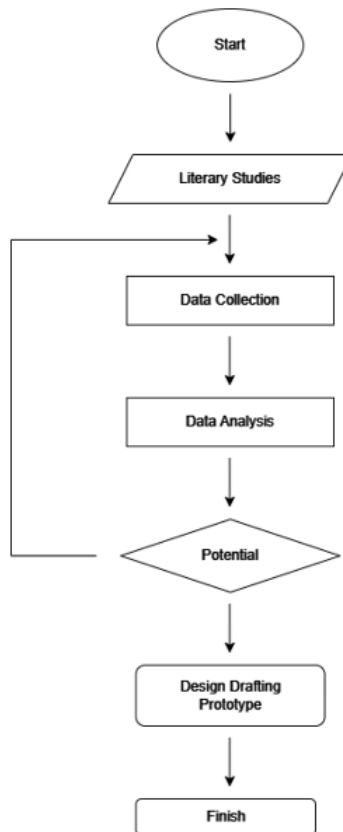


Figure 1: Flowchart of Methodology

Secondary data collection is done by 1) Collecting various data and journals from Google to get references to previous tools, with the results of getting a journal from the Walchand Institute of Technology India regarding applications to detect disease. Where these data are needed for design or initial design. 2) Discussing with the team and Mr. Andinusa Rahmandhika about image processing. 3) Discuss with the team to get information or problems about Rheumatoid Arthritis disease.

3. Results

The preparation of technical design begins with the identification of problems by conducting interviews with patients who will later obtain a result through a needs analysis to answer the problems of health facility services. After that, it is continued with product conceptualization so that the products created are able to support and facilitate the community to carry out diagnostics quickly, if the product concept has been completed, then proceed with determining specifications in the form of selecting components and selecting the right technology.

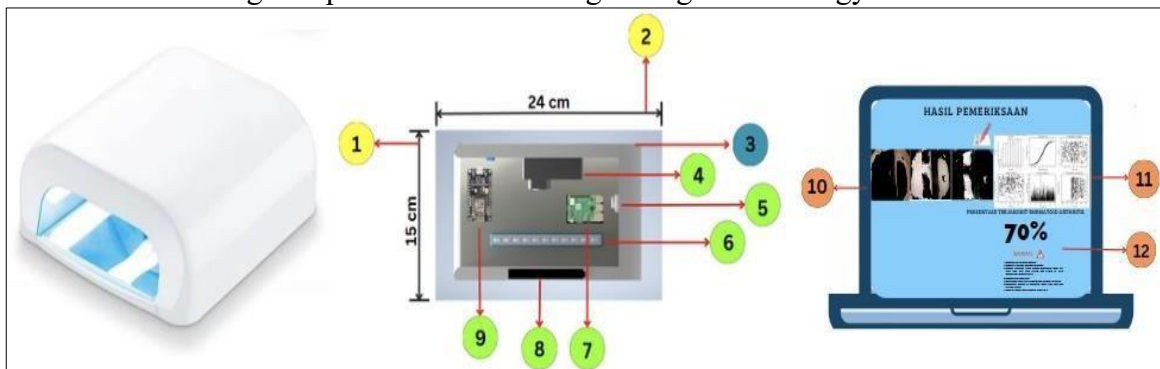


Figure 2: Technical Design

Table 1: Component Layout

No	Description
Size	
1.	15 cm Wide
2.	24 cm Long
Material	
3.	Filament
Component	
4.	GoPro Camera
5.	Waterpass Laser Fluke
6.	LED light
7.	Raspberry Pi
8.	Battrey Lippo
9.	WiFi Module
Technology	
10.	Image Processing
11.	Certainty Factor

Experimental Process

Prototype testing is used to see the response of the prototype performance. Here the nail is inserted into the Smart Early Diagnostic Rheumatoid Arthritis Tool to take a photo of the nail from the patient. After that, the photo is sent to MATLAB using a Wi-Fi module which will be processed using image processing like the nail below:



Figure 3: Nail before Image Processing

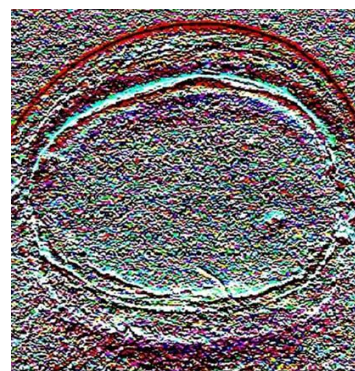


Figure 4: Nail after Image Processing

From the image, it looks like the nail is in a healthy condition without any abnormal indications, but after image processing two abnormal objects appear. This shows that the Smart Early Diagnostic Rheumatoid Arthritis Tool (SED RAT) can work well. SED RAT can read the contour or texture of the nail, which cannot be seen visually by the eye. Smart Early Diagnostic Rheumatoid Arthritis Tool was created to answer the needs of innovation in the world of health.

The hope is that this tool will be able to reduce the factor of contracting Rheumatoid Arthritis disease, especially in Indonesia. On the other hand, the author also hopes to be able to develop or provide innovations to the Smart Early Diagnostic Rheumatoid Arthritis Tool in the future. One of them is by calibrating machine learning with the Smart Early Diagnostic Rheumatoid Arthritis Tool. With that, this tool is able to diagnose early and provide high accuracy to patients in predicting the outbreak of Rheumatoid Arthritis disease.

Acknowledgment

This paper is an output of the science project of the Ministry of Education, Culture, Research and Technology, Learning and Student Information System and University of Muhammadiyah Malang.

References

- Elsi Mariza. (2023). Gambaran Faktor Dominan Pencetus Arthritis Rheumatoid di Wilayah Kerja Puskesmas Danguang Danguang Payakumbuh Tahun 2018. *MENARA Ilmu*, 12(8), 98–106.
- Febriansa, A. F., Asfar, A., & Ramli, R. (2021). Pengaruh Refleksi Massage Therapy terhadap Penurunan Kualitas Nyeri pada Lansia Penderita Rheumatoid Arthritis. *Window of Nursing Journal*, 2(1), 220–227. <https://doi.org/10.33096/won.v2i1.384>
- Latuamury, S. R. (2022). Korelasi Nyeri Rheumatoid Arthritis Dan Kemandirian Aktivitas Pada Lansia. *Pasapua Health Journal*, 4(2), 113–119.
- Pratama, A. R., Sudrajat, S., & Harini, R. (2019). Analisis Ketersediaan dan Kebutuhan Beras di Indonesia Tahun 2018. *Media Komunikasi Geografi*, 20(2), 101. <https://doi.org/10.23887/mkg.v20i2.19256>
- Putri, R. M., Amir, L., & Alini. (2020). Pengaruh Terapi Back Massage Terhadap Penurunan Nyeri Rheumatoid Arthritis Pada Lansia. *Jurnal Ners Universitas Pahlawan*, 4(2), 40–46.
- Risa Fitri Awaliah, & Apriani Apriani. (2022). Pemeriksaan Rheumatoid Factor (Rf) Dengan Laju Endap Darah (Led) Yang Meningkat Pada Pasien Suspect Rheumatoid Arthritis (Ra). *Jurnal Medical Laboratory*, 1(1), 10–14. <https://doi.org/10.57213/medlab.v1i1.3>
- Sari, W. P., & Saftarina, F. (2022). Penatalaksanaan Holistik Wanita Usia 57 Tahun Dengan Osteoarthritis Melalui Pendekatan Kedokteran Keluarga. *Jurnal Penelitian Perawat Profesional*, 4(4), 1235–1245. <http://jurnal.globalhealthsciencegroup.com/index.php/JPPP>

Effect of Channel Model on Flame Stability in Meso-Scale Combustor

Murjito^{1*}, Achmad Fauzan Hery Soegiharto², Yogi Danu Krisnanto³ & Farhan Rahmatullah⁴

^{1,2,3,4}University of Muhammdiyah Malang, Indonesia

Abstract

Meso-combustor is a fuel combustion device with a size between 1 mm and 10 mm. This study aims to determine the characteristics of the butane flame in the meso-combustor due to the type of fuel inlet channel. The observed characteristics are flammability limit and flame visualization. The meso-combustor is composed of a stainless-steel vaporization segment, combustion chamber and quartz glass exhaust channel. In this study, 3 types of meso-combustors were used. Type A has fuel and air channels facing each other. Type B meso-combustor has side-by-side fuel and air channels with 1.5 mm channel spacing. Type C meso-combustor is similar to type B but with 2 mm channel spacing. The results show that flame in meso-combustor type A can be stabilized at reactant velocity of 45 - 24 cm/s and equivalence ratio of 1.1 - 1.84. The flame in type B meso-combustor can be stabilized at reactant velocity 50 - 26 cm/s and equivalent ratio in the range of 1 - 1.7. Flame on meso-combustor type C can be stabilized at reactant velocity 56 - 29 cm/s and equivalent ratio with a range of 1.1 - 1.48. Meso-combustor type A gives the brightest flame at an equivalence ratio of 1.78213 with reactant velocity $U = 44.4276$ cm/s. There is a bright color at the bottom of the circular arc indicating that the fuel is concentrated in that area. Of the three meso-combustor types, type A has the widest or most stable flammability due to good mixing between fuel and air.

Keywords: Meso-scale combustor, Butane, Flammability Limit, Flame Visualization, Flame Temperature

1. Introduction

Meso-combustors are fuel combustion devices with sizes between 1 mm and 10 mm (Yuasa, 2005). A good fuel for micro-combustion is butane because of its easy handling, small storage area and safety factor and ease of transportation (Yuliati, Seo & Mikami, 2012). Maintaining flame stability in the Meso-combustor is very difficult due to the large heat loss and flame cooling. As long as the flame is still stable, the temperature in the meso-combustor tends to increase as the reactant flow velocity increases (Yang et al., 2014). The role of the flame holder in the combustion chamber is as a place where the flame comes out and also as a fire holder. Heat recirculation also affects flame stability in the combustion chamber (Choi, Park & Suzuki, 2008).

In meso-combustors that use a mixing section where fuel and air are injected from separate channels, incomplete fuel mixing will affect the visualization of the flame. Excessive reactant flow velocity and equivalent ratio can cause high temperatures and damage to the meso-combustor (Choi et al., 2009). The length of the fuel-air mixing section affects the mixing. If it is too short, the fuel is not well mixed, if it is too long, it will suck heat and cool the flame. The main mixing process is carried out by molecular diffusion. The position of the fuel intake hole and the position of the air intake hole will affect the mixing. The position of the injection hole can increase or decrease the fuel mixing in the combustor (Wan et al., 2014). Turbulence formation is an important factor in the fuel mixing system in the meso-combustor. Spray behavior is predominantly influenced by gas motion, gas turbulence and mixing between fuel vapor and air in the combustion chamber. The combustion that occurs is caused by the turbulent mixing of the fuel vapor (Blummer et al., 2018).

However, the flame characteristics due to the placement of the duct system have not been investigated further, to determine the exact position of the duct system. The purpose of the research in this paper is to determine the characteristics as well as the best position of the air intake duct and fuel intake duct in the air-fuel mixing section. The variables observed are channel type, flame flammability and flame visualization.

2. Research Methodology

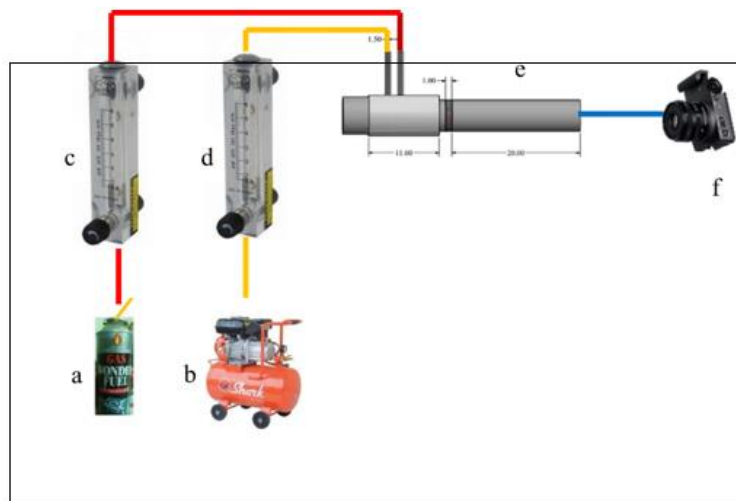


Figure 1: Scheme of The Research Installation.

A) Butane Gas, B) Compressor, C) Gas Flowmeter, D) Air Flowmeter, E) Meso-Scale Combustor, F) Camera

The butane fuel (C_4H_{10}) is flowed to the gas flow meter using a hose connector and then flowed back to the meso-scale combustor. The amount of fuel discharge is set on the gas flow meter to determine the maximum and minimum values of air flow. the flow rate of fuel and air is varied to obtain a stable flame on the flame holder (Sudarmanta & Winardi, 2006; Kummitha, 2017). In this research, the flammability limit, and flame visualization will be investigated. A camera with a macro lens is used to obtain images of the flame visualization.

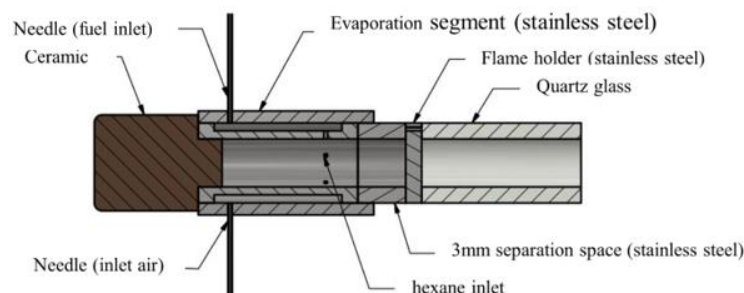


Figure 2: Meso-combustor Type A

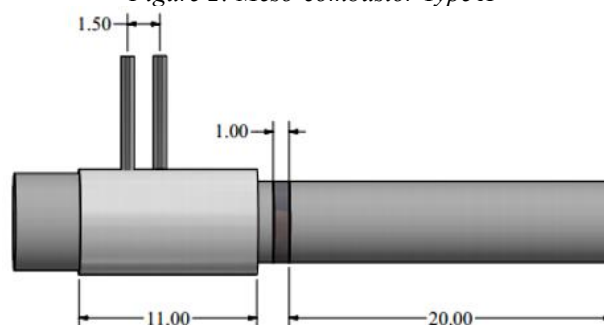


Figure 3: Meso-combustor Type B

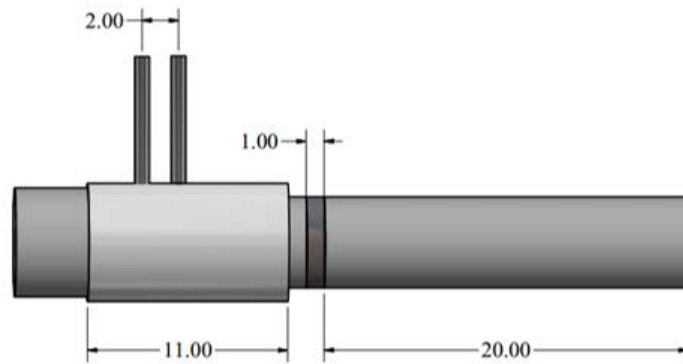


Figure 4: Meso-Combustor Type C

The tested meso-combustor is shown in Figure 2, Figure 3, and Figure 4. The meso-combustor is made of duralium with an outer diameter of 5 mm and an inner diameter of 3.5 mm, with a length of 30 mm upstream and 10 mm downstream. A 1 mm thick flame holder is placed between the resiculator and the glass tube by modeling the gas and air channel spacing of 1.5 mm; 2 mm which are placed parallel. Figure 2 is Meso-combustor type A with gas and air channels modeled facing each other. Figure 3 is a type B meso-combustor, where the air channel and the fuel channel are side by side in line with a distance of 1.5 mm. Figure 4 is a meso-combustor type C where the air channel and fuel channel are side by side in line with a distance of 2 mm.

3. Results and Discussion

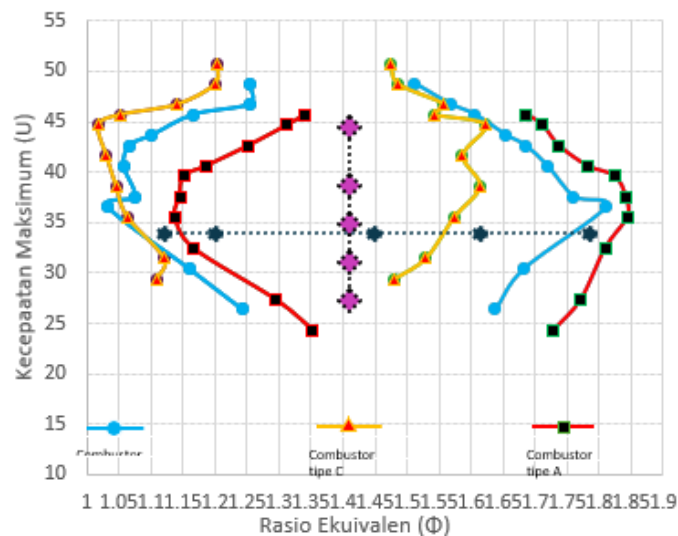


Figure 5: Flammability Limit

Figure 5 is a graph of the relationship between the equivalent ratio and the maximum velocity of the butane fuel combustion reactants by comparing combustor type A with combustor types B and C. The area between the minimum curve and the maximum curve is the flame area that can be stabilized in the combustor. The graph of the relationship between the equivalent ratio and the reactant velocity shows that most of the flame stability is in the equivalent ratio zone above 1 ($\Phi > 1$), in the sense that the combustion of butane in the meso-combustor is in the fuel rich mixture zone. In the combustor area with types B and C, the maximum velocity of the reactant flow is seen with a range of 50 - 26 cm/s and an equivalent ratio with a range of 1 - 1.7. In contrast to combustor type A as a comparison with a range of 45 - 24 and an equivalent ratio of 1.1 - 1.84.

From this study, combustor type A as a comparison has a wider flammability limit but combustor types B and C are able to increase the maximum speed of reactant flow because the higher the flow rate, the higher the heat generated and the energy requirement to heat the reactants will increase. The low heat energy generated is not enough to provide activation energy to the reactants, so the flammability limit decreases.

This shows that if the perfect fuel mixing can increase the flammability, on the contrary, if the imperfect fuel mixing can increase the reactant flow velocity. Heat energy should be recirculated upstream of the combustor but is reduced due to imperfect mixing and because the heat resistance of the flame holder increases which will affect the stability of the flame in the combustor, and make the flame area narrow suddenly. From this research, the reactant flow velocity (U) (min, max) and the equivalent ratio (ϕ) (min, max) were obtained, which can be seen from graph below:

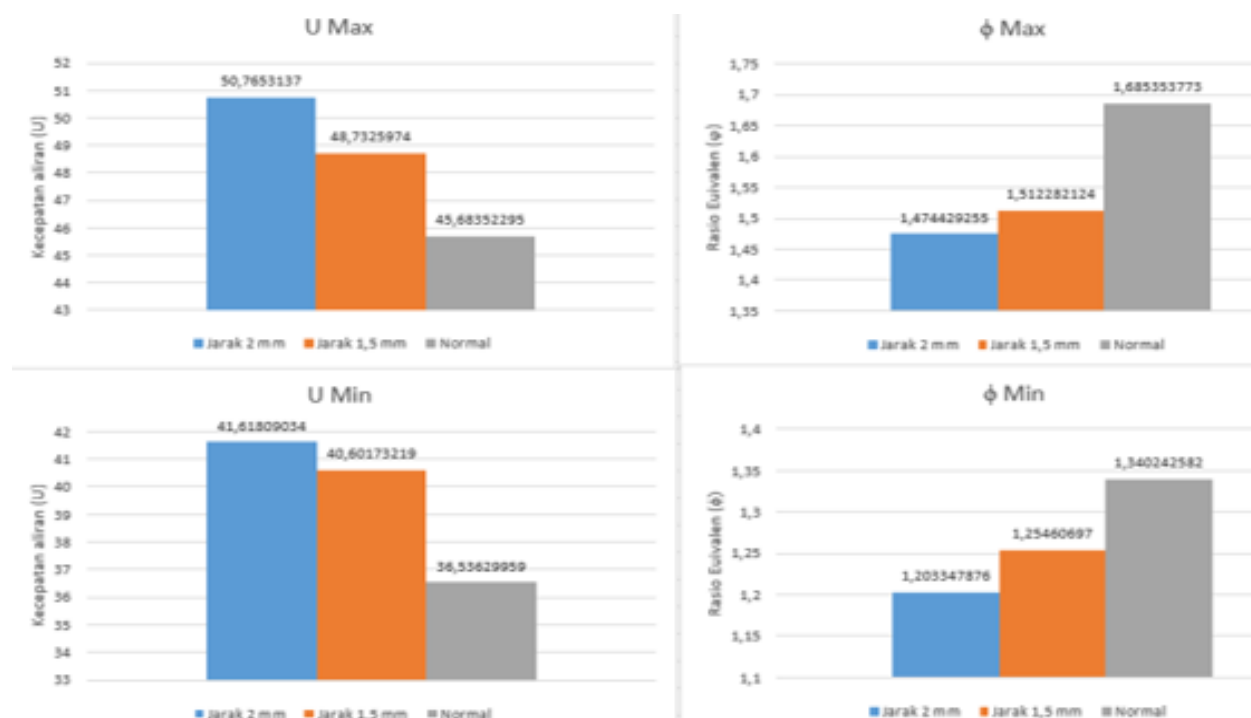


Figure 6: Reactant Flow Velocity (U) (min,max) and Equivalent Ratio (ϕ) (min,max)

In Figure 6, combustor type C has a maximum flow velocity limit of 50.7653137 and a minimum limit of 41.618090. Of the three combustor models, combustor type C maximum and minimum reactant flow velocity values are higher than combustor types A and B. The higher the reactant flow rate, the higher the heat generated. The higher the reactant flow rate, the higher the heat generated. If the reactant flow velocity is set above this value with the equivalent ratio kept fixed, the flame will escape from the flame holder and a blow-off event will occur which can cause the glass tube to break. The greater burning speed of laminar than butane is attributed to the production of H atoms that are easily decomposed and dominated by C2 chemical reactions (Li et al., 2018; See & Ihme, 2014).

Type A combustors have a maximum equivalent ratio (ϕ) limit of 1.68535 and a minimum of 1.34024. The higher the equivalent ratio value, the richer the fuel mixture. This proves that combustor type A has a better fuel mixture than the other two combustor models.

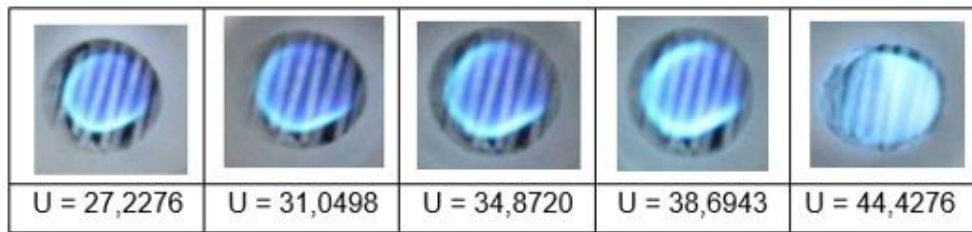


Figure 7: Meso-combustor flame visualization type B with constant U



Figure 8: Meso-combustor flame visualization type C with constant U



Figure 9: Meso-combustor flame visualization type A with constant U

Figures 7 - 9 above show the visualization of the flame inside the meso-combustor having different thermal conductivities. The above visualizations were taken with U 27.2276 cm/s; 31.0498; 34.8720; 38.6943; 44.4276 and the equivalence ratio (ϕ) was kept constant at 1.409. In the figure above, it can be seen that the flame area is getting wider. At a low mixture flow rate ($U = 27.2276$ cm/s), the supply of reactants every second for combustion is low, so combustion produces low heat energy. The low heat energy produced is not enough to provide activation energy to the reactants, so that some reactants are burned, and others are not burned. Unburned reactants help cool the flame in the combustion chamber, plus the heat convection that occurs on the combustor wall to the environment causes the heat loss that occurs in the combustor to be greater than the heat generated, this causes the distance between the flame and the combustor wall to widen.

Conversely, at high mixed flow rates ($U = 44.4276$ cm/s), the supply of reactants per second for combustion is high, so that combustion produces high heat, the high heat energy produced is sufficient to provide activation energy to the reactants, so that the unburned reactants become small, causing the distance between the flame and the combustor wall to get smaller, this is because the heat loss that occurs is smaller than the heat produced. Temperature analysis shows that heat loss in the wall can reduce the temperature in the outer recirculation area (See & Ihme, 2014). The length of heat transfer will significantly affect the temperature distribution inside the combustor (Tang et al., 2015).

The explanation above shows that combustor type A has a wide flame area and a bright blue flame, this is because the higher the reactant supply every second, the more fuel and air that burns, causing the flame to enlarge. In contrast to combustor types B and C, the flame area is smaller and the flame is dark blue.

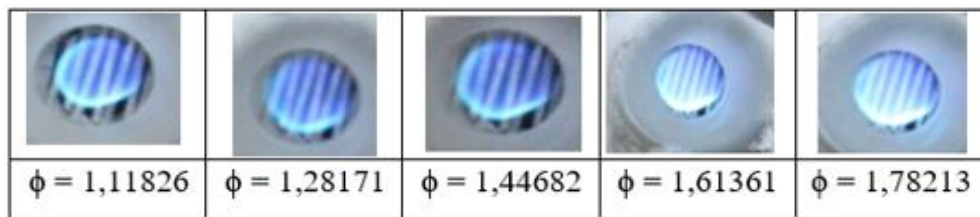


Figure 10: Meso-combustor flame visualization type B with constant ϕ

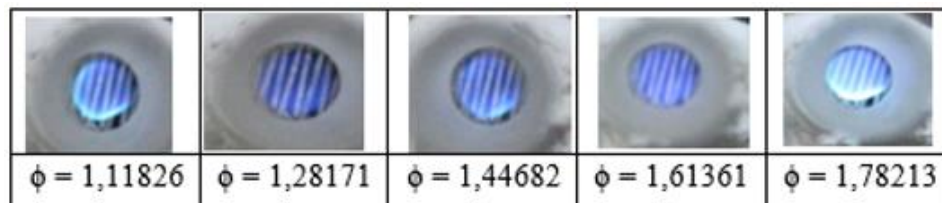


Figure 11: Meso-combustor flame visualization type C with constant ϕ

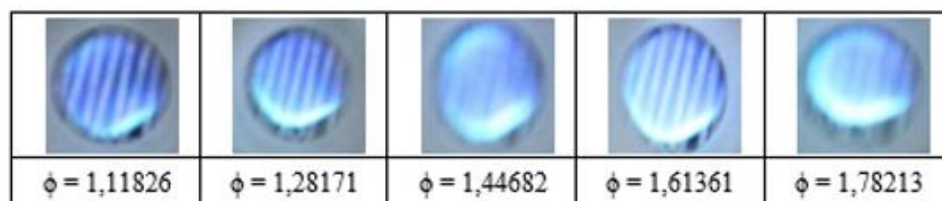


Figure 12: Meso-combustor flame visualization of normal type with constant ϕ

Figure 10 - 12 above shows that at an equivalent ratio of 1.11826 in all types of combustors is dark blue, thin and at an equivalent ratio of 1.61361 and 1.78213 the fire is bright blue, wide. The higher the equivalent ratio the richer the mixture will be (fuel - rich mixture). The dark blue flame color is due to less fuel mixture while the rich mixture (equivalent ratio 1-4) becomes lighter than before (equivalent ratio 1) and the richest mixture (equivalent ratio 1-7) has a light blue flame color (the brightest). The larger blow-off limit is attributed to the change in flow field downstream from the combustion chamber. When there is no bluff-body the flame is smaller and the strain level is greater on the right side of the combustion chamber leading to flame separation at a smaller blow-off limit (Li et al., 2018).

This proves that a perfect fuel mixture will produce a bright blue color, and the poorer the reactant mixture, the darker the flame color, shows that the increase in the equivalent ratio at a constant reactant flow velocity will result in a bright blue flame color. The asymmetry of the flame shape with the combustor axis is due to the inhomogeneous mixing of fuel and air, which causes differences in color in the flame area and causes color gradation.

4. Conclusion

The conclusion of the research on the combustion characteristics of meso-combustor with a model of variation in the distance between the butane and gas channels that the stability of the flame can be achieved and the graph of the relationship of the equivalent ratio with the reactant velocity shows most of the flame stability is in the zone of the equivalent ratio above 1 ($\Phi > 1$), in the sense that the combustion of butane in meso-combustor is in the zone of fuel rich mixture. In the combustor area with variations in distance, the maximum velocity of the reactant flow is seen in the range of 50 - 26 cm/s and the equivalent ratio in the range of 1 - 1.7. Unlike the normal type combustor as a comparison with a range of 45 - 24 and an equivalent ratio of 1.1 - 1.84. The visualization of the flame itself shows that the flame becomes wider as the reactant velocity increases with a constant equivalent ratio and thicker as the equivalent ratio increases with a constant reactant velocity.

Visualization of the three types of combustors shows that the combustor type with a channel model is able to increase the speed of reactant flow, this is due to the high supply of reactants per second for high combustion, so that combustion produces high heat, but the asymmetry of the shape of the flammability graph is due to less homogeneous mixing between fuel and air, it causes a sudden narrowing. In contrast to the normal combustor type which has a wide flammability due to good mixing between fuel and air.

Acknowledgment

This research was supported by University of Muhammadiyah Malang. We thank our colleagues from the Mechanical Engineering program who provided insight and expertise that greatly assisted the research. The author thanks lecturers and examiners for assistance and comments that greatly improved the manuscript. Furthermore, we would like to acknowledge the invaluable support of University of Muhammadiyah Malang, program of study mechanical engineering for providing the funding that enabled this research to be conducted.

References

- Bluemner, R., & et al. (2018). Experimental study of reactant mixing in model rotating detonation combustor geometries. *Flow, Turbulence and Combustion*, 102(2), 255-277.
- Choi, B.-I., & et al. (2009). Experimental and numerical studies of mixing and flame stability in a micro-cyclone combustor. *Chemical Engineering Science*, 64(24), 5276-5286.
- Choi, H. S., Park, T. S., & Suzuki, K. (2008). Turbulent mixing of a passive scalar in confined multiple jet flows of a micro combustor. *International Journal of Heat and Mass Transfer*, 51(17-18), 4276-4286.
- E, J., & et al. (2016). Numerical investigation on hydrogen/air non-premixed combustion in a three-dimensional micro combustor. *Energy Conversion and Management*, 124, 427-438.
- Kummitha, O. R. (2017). Numerical analysis of hydrogen fuel scramjet combustor with turbulence development inserts and with different turbulence models. *International Journal of Hydrogen Energy*, 42(9), 6360-6368.
- Li, L., & et al. (2018). Numerical investigation on mixing performance and diffusion combustion characteristics of H₂ and air in planar micro-combustor. *International Journal of Hydrogen Energy*, 43(27), 12491-12498.
- Li, W., & et al. (2018). Experimental and kinetic modelling investigation on pyrolysis and combustion of n-butane and i-butane at various pressures. *Combustion and Flame*, 191, 126-141.
- See, Y. C., & Ihme, M. (2014). Large eddy simulation of a partially-premixed gas turbine model combustor. *Proceedings of the Combustion Institute*.
- Sudarmanta, B., & Winardi, S. (2006). Karakteristik Spray Combustion Palm Methyl Ester Dengan Pendekatan Model Turbulen RNG k-ε.
- Tang, A., & et al. (2015). Numerical study of premixed hydrogen/air combustion in a micro planar combustor with parallel separating plates. *International Journal of Hydrogen Energy*, 40(5), 2396-2403.
- Wan, J., & et al. (2014). A numerical investigation on combustion characteristics of H₂/air mixture in a micro-combustor with wall cavities. *International Journal of Hydrogen Energy*, 39(15), 8138-8146.
- Yang, W., & et al. (2014). Experimental and numerical investigations of hydrogen–air premixed combustion in a converging–diverging micro tube. *International Journal of Hydrogen Energy*, 39(7), 3469-3476.
- Yuasa, S., & et al. (2005). Concept and combustion characteristics of ultra-micro combustors with premixed flame. *Proceedings of the Combustion Institute*, 30(2), 2455-2462.

- Yuliati, L., Seo, T., & Mikami, M. (2012). Liquid-fuel combustion in a narrow tube using an electrospray technique. *Combustion and Flame*, 159(1), 462-464.
- Zarvandi, J., Tabejamaat, S., & Baigmohammadi, M. (2012). Numerical study of the effects of heat transfer methods on $\text{CH}_4/(\text{CH}_4 + \text{H}_2)$ -AIR pre-mixed flames in a micro-stepped tube. *Energy*, 44(1), 396-409

Design of Learnifybot: Supporting Hands-On Experience of Stem Education in Malaysia

Juliyanna Aliman^{1*}, Ariffuddin Ibrahim² & Er Zhi Han³

^{1,3}Mechanical Engineering Department, Politeknik Merlimau, Melaka, Malaysia

²Electrical Engineering Department, Politeknik Merlimau, Melaka, Malaysia

* juliyanna@pmm.edu.my

Abstract

In the dynamic landscape of contemporary education, fostering a deep interest in Science, Technology, Engineering, and Mathematics (STEM) among high school students is crucial. This project proposes the development of LearnifyBot, an innovative educational robot designed to address this issue by providing a versatile and engaging learning platform. LearnifyBot aims to enhance mechatronics education by offering practical learning experiences tailored for high school students. It operates using a battery source, ensuring flexibility and accessibility in various educational settings. The robot is built using the Arduino Integrated Development Environment (IDE), making it user-friendly for students, educators, and enthusiasts. Its capability to execute multiple projects, including basic movement, obstacle avoidance, line following, Wi-Fi control, Bluetooth control, and sumo robot functions, enriches learning opportunities and stimulates interest in STEM fields. This project also addresses the lack of dedicated teaching and training tools for mechatronics in the existing curriculum and supports students preparing for mechatronics competitions. By bridging the gap between theoretical knowledge and practical application, LearnifyBot has the potential to transform education and reignite students' interest in STEM, ultimately contributing to the development of a technologically skilled future workforce in Malaysia.

Keywords: STEM Education, Sumo Robot, Mechatronics

1. Introduction

In the ever-changing context of modern education, it is imperative that high school students create a deep interest in STEM subjects—Science, Technology, Engineering, and Mathematics. An alarming pattern has been identified by recent data from the Ministry of Education (KPM) in 2022: students' enrollment in STEM courses is declining, from 45.20 percent as of 2017 to 40.94 percent in 2022. This decline is a reflection of a larger issue—pervasive STEM challenges and a noticeable decline in interest in the sciences subjects—as pointed out by a 2022 study "Public Awareness of Science, Technology, and Innovation (STI) Malaysia" conducted by the Malaysian Science and Technology Information Centre (MASTIC) under the Ministry of Science, Technology, and Innovation (MOSTI) (Bernama, 2023).

Amidst this backdrop, the significance of hands-on STEM training, especially for students preparing for robot competitions, becomes evident. Enter the need for an innovative and versatile robotics solution—an entity that not only addresses STEM skill gaps but also offers a practical and engaging platform for training (Balakrishnan et al., 2019; Jayarajah et al., 2014; Lenovo, n.d.; Markus et al., 2021). In response to this demand, the concept of utilizing a single robot within the educational environment for training purposes is introduced. This robot, serving as a pivotal training kit, aligns with the principles of robot-sumo—a captivating facet of STEM engagement. Robot-sumo involves combat between two robots striving to push each other out of a designated arena, employing sensors for opponent detection and strategic maneuvers to remain within the arena boundaries (Carbone et al., 2022; Yee Jiea et al., n.d.).

In the realm of secondary education, specifically in the subject of Design and Technology (Reka Bentuk dan Teknologi - RBT) for form 3 under the Standard Based Curriculum for Secondary Schools (KSSM) framework, the need for effective teaching and training tools is paramount. (Shharudin et al., n.d.). Practical activities are integral to the learning process, especially in subjects that delve into the intricate world of mechatronics. (Su Ling et al., 2020), Mechatronics, being a multidisciplinary field encompassing mechanical engineering, electronics, computer science, and control engineering, requires hands-on experiences to solidify theoretical concepts.

The existing curriculum, while comprehensive, lacks a dedicated teaching and training kit tailored for practical activities in mechatronics. This gap hinders students' full comprehension of the fundamental principles underlying mechatronic systems. Recognizing this deficiency, the proposed project aims to develop a teaching and training kit specifically designed for the Design and Technology (Reka Bentuk dan Teknologi - RBT) subject. (Talib et al., 2019) This kit will catalyze practical exploration, allowing students to apply theoretical knowledge in a real-world context. Beyond the confines of the curriculum, the project extends its reach to address broader educational needs. (Tauro et al., 2017) Firstly, it recognizes the necessity for training kits tailored for competitions. (Kolberg et al., 2003) These competitions often involve intricate challenges that require a deep understanding of mechatronics. By providing a dedicated training kit, students participating in competitions will be better equipped to tackle the challenges posed by such events. (Talib et al., 2019)

Previously, a simple Lego SumoBot was created in 2020, used in a sumo-styled base of EV3 Intelligence brick but with low revolutions per minute (RPM) motors. Spike Prime sumo robots created in 2022 are limited to the LEGO SPIKE Prime robotic set. Edu Sumo Kit SKV3 produced by Mechabotics in 2022 equipped with advanced equipment but without thin and sharp angle blades to push opponents out of the arena. The Sumo Robot 1kg by Ikedo Kogeki is equipped with advanced equipment and is durable for longer battles but limited to autonomous sumo robots only and needs electronic adjustment to comply with another robot control.

Additionally, the project envisions creating a versatile training kit that goes beyond the classroom. It seeks to serve as an accessible tool for children and students to self-explore the realms of robotics and programming. By making the kit user-friendly and engaging, it aims to spark curiosity and encourage independent exploration, fostering a sense of discovery and innovation. In the field of STEM education, particularly within mechatronics, a significant challenge persists: the seamless integration of theoretical knowledge with practical application remains elusive. This project aims to address these issues, providing nuanced insights to enhance the educational experience for students enrolled in Design and Technology subjects.

A critical issue is the lack of dedicated teaching and training tools tailored for mechatronics within the existing curriculum. Without hands-on experiences, students struggle to grasp the intricacies of mechatronic principles, hindering their ability to translate theoretical concepts into practical understanding. This is evidenced by a survey analysis showing that 100% of respondents (80 participants) consider a robotic kit extremely important for STEM education, with 45% of participants from the education sector supporting this view. Further exacerbating this challenge is the underutilization of mechatronics competitions, such as sumo robots and line follower robot events, as learning opportunities. The absence of training kits specifically designed for these competition challenges limits students' ability to fully leverage these platforms for skill development and practical application. Survey results indicate that 91.3% of respondents (73 participants) envision a robotic kit being used for competition purposes.

Beyond formal education, there is a notable gap in the availability of accessible tools for self-exploration in robotics and programming. Existing resources fail to meet the diverse learning needs of students, hindering the cultivation of a self-driven interest in mechatronics. This is supported by survey analysis showing that 100% of respondents (80 participants) strongly agree on the demand and interest for a robotic kit. Despite the 4 recognized importance of mechatronics in STEM education, the current curriculum lacks cohesive integration of practical mechatronic applications. This disjointed approach diminishes the overall effectiveness of STEM education in preparing students for the demands of a technology-driven future.

The project's objectives must be given more attention in the design and creation of this project for it to succeed and continue growing. These goals include the following: i. To design a robot that can be used for various projects, allowing students to apply it across different learning activities, and ii. To develop a robot that serves as both an educational tool and a practical training aid.

2. Methodology

Methodology is the plan for developing, collecting, and analyzing data to support a study. It describes how a problem is investigated and solved, outlining the steps and strategies used to implement the project. This includes data collection methods, analysis techniques, and the overall research framework to ensure valid and reliable results. The methodology serves as a blueprint for researching to achieve the study's goals. "LearnifyBot" is a self-designed project based on market information and the availability of similar products on the market. The methodology is used to ensure that the study's objectives are achieved through valid and reliable data. By systematically detailing the project's progression, the methodology helps maintain focus on the research goals and ensures a structured approach to problem-solving.

Project design outlines the systematic approach taken to develop and implement the "LearnifyBot." This section covers the essential components, tools, and techniques used to create the project, ensuring that each element aligns with the project objectives. Key design considerations include selecting appropriate hardware and software, integrating components, and optimizing performance for specific tasks. The design phase also involves testing and refining the prototype to meet the desired functionality and reliability standards. By detailing the design process, this section provides a clear roadmap for building a successful and efficient robot. Figure 1 depicts a system block diagram, which is frequently used in engineering for process flow diagrams, hardware design, electronic design, and software design. The major components or functions are represented by blocks connected by lines that indicate the interactions of the blocks.

Figure 2 shows the circuit diagram of LearnifyBot where the ESP32 development board controls the XY-160D motor controller module, which manages several GM25-370 DC motors. The QRE1113 infrared reflectance sensor detects the edge of the arena (the edge of the dohyo ring) in robot-sumo competitions. If the system is configured as a line-following robot, this sensor detects and tracks a black line. The input from this sensor allows the system to make decisions based on the programmed logic. For example, when the robot reaches the edge of the dohyo ring, the sensor triggers the microcontroller to process a command to move backward and turn left. The XY-160D motor controller then signals the DC motor to execute this movement. In line-following mode, if the robot goes off track, the microcontroller adjusts the robot's movement to return to the black line. Additionally, the FS80NK diffuse reflection infrared sensor detects opponents in front of the robot in robot-sumo mode to initiate an automatic attack. In obstacle-avoidance mode, this sensor detects objects in front of the robot and adjusts its movement accordingly.

The system is powered by an 11.1V LiPo battery, which supplies the necessary power to all components. For the system to function correctly, all components must be properly connected, and error-free program code must be uploaded to the ESP32 development board.

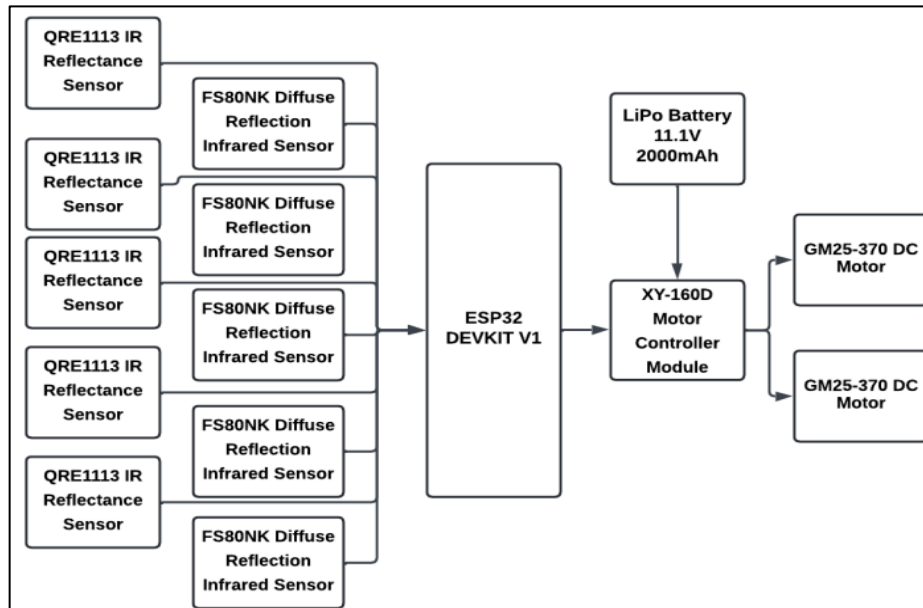


Figure 1: System Block Diagram of LearnifyBot

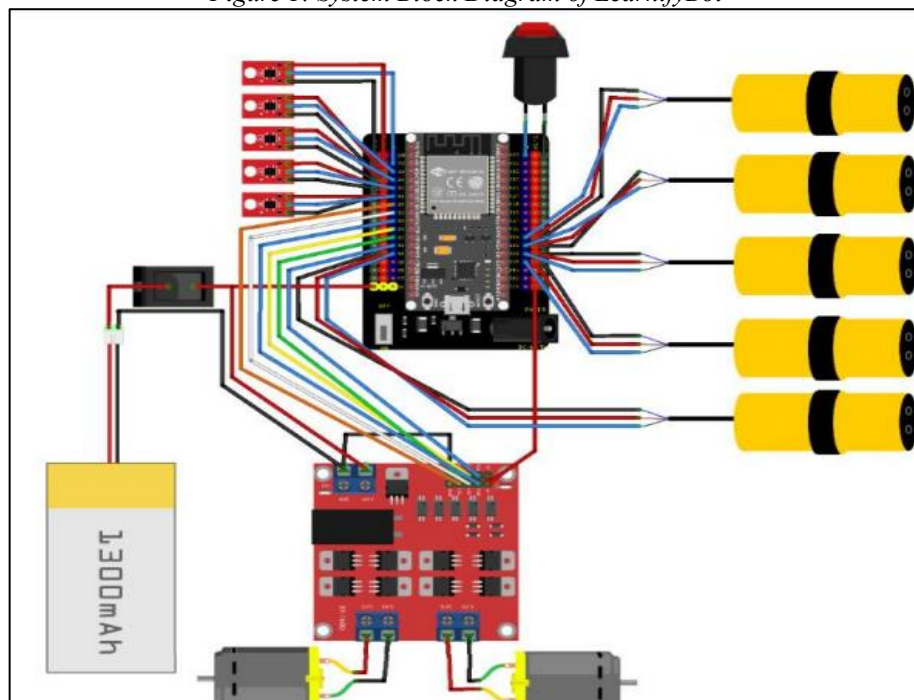


Figure 2: Circuit Diagram of LearnifyBot using Fritzing Software

A project's success depends on the choice of design. The steps in the design process include determining the project's form, comprehending the issue that has to be resolved, selecting the best solution, and submitting a suitable plan. Selecting and assessing design possibilities, utilizing analytical results to make educated decisions, recognizing current issues, and studying the design to make sure it satisfies all criteria are important tasks prior to project implementation. This methodical approach guarantees that the selected design will successfully meet the needs of the project and help to see it through to completion. Figure 3 depicts the *LearnifyBot's* design, which is primarily made using 3D printing.

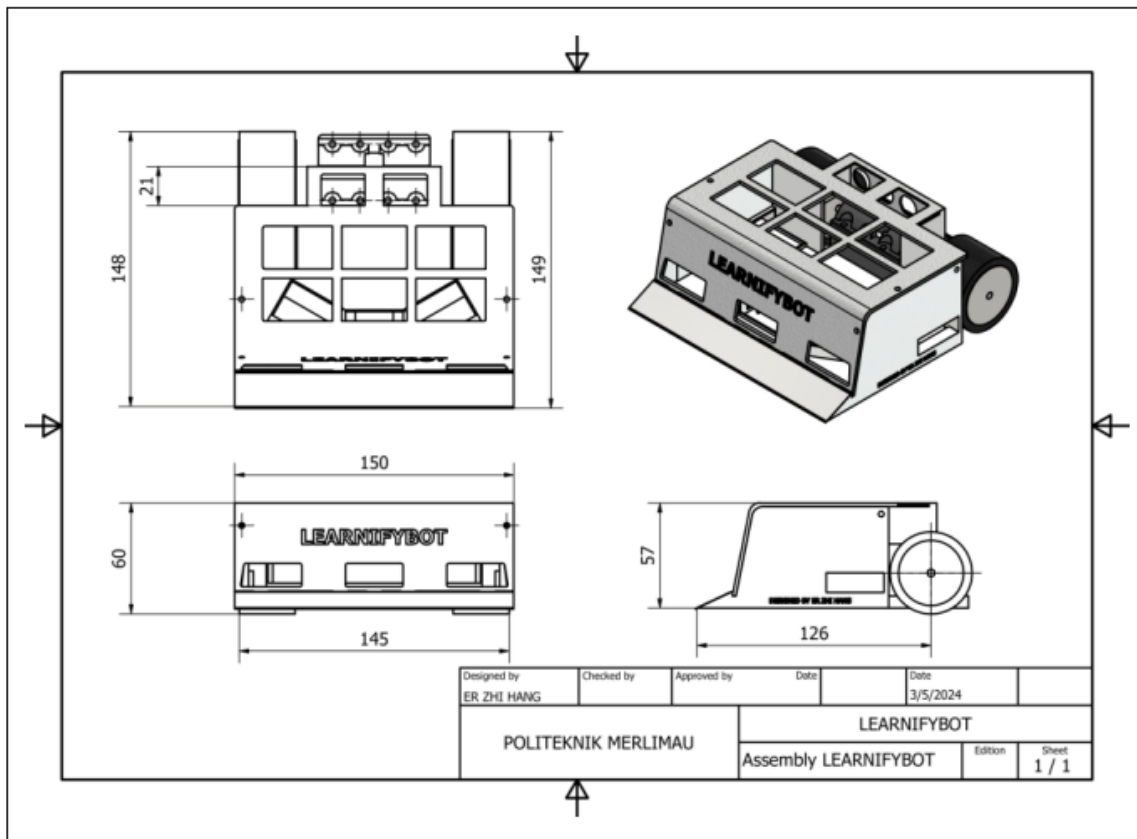


Figure 3: Design of LearnifyBot

3. Results

In completing this project, several scopes have been set so that this project can be completed and does not violate any of the guidelines that have been set, among them are: i—designed to accommodate and execute six different projects within a single robot, enhancing its educational value: Basic Movement, Obstacle Avoidance, Bluetooth Controlled, Line Following, Wi-Fi Controlled, and Robot-sumo. These projects allow students to explore various STEM concepts and applications, covering motor control, sensor integration, wireless communication, feedback control, IoT, and competitive robotics strategies.

Extensive research and analysis were conducted to determine the most suitable components for this project. The main function of a sumo robot is to have a high-torque motor that enables it to exert sufficient force to push opponents out of the ring. Additionally, data gathered from existing sumo robots revealed that silicone wheel sets outperform other types of wheels in the sumo arena due to their soft silicone material, which provides optimal surface contact for enhanced grip and high friction. This ensures that the robot is not easily pushed out of the arena by opponents.

Beyond the combat context, this single robot can be a transformative tool, providing a versatile platform for basic movement, obstacle avoidance, light searching, 2 lines following, and Wi-Fi control. This initiative aligns with Malaysia's commitment to STEM education, as highlighted in the Malaysia Education Blueprint 2013–2025, emphasizing the importance of education as a means to meet the demands of a STEM-driven economy. (Malaysia-Education-Blueprint-2013-2025; Simon & Gogolák, 2024). Several selected schools will test the final result through various robotics competitions.

4. Discussion and Conclusion

In the landscape of educational robotics in Malaysia was explored, identifying the need for innovation and improvement. LearnifyBot emerged as a response to this need, aiming to enhance mechatronics education by offering a hands-on learning experience, encouraging STEM exploration, and addressing the decline in STEM participation. The battery-operated and Arduino IDE-based design ensures flexibility and accessibility, making it a versatile tool for students, educators, and enthusiasts. LearnifyBot's potential impact extends to transforming mechatronics education and preparing students for competitions, ultimately igniting STEM interest in the Malaysian educational context.

In conclusion, in Malaysia, existing educational robots offer students a gateway to STEM subjects, but there's a need for improvement. Enter LearnifyBot, a project aimed at enhancing educational robotics, specifically in mechatronics education. LearnifyBot provides a hands-on learning experience, encouraging secondary students to explore STEM concepts with its versatile design. Operating on a battery source, LearnifyBot ensures flexibility and accessibility, while its user-friendly Arduino IDE makes it suitable for students, educators, and enthusiasts. LearnifyBot's capability to execute multiple projects diversifies learning opportunities and addresses the decline in STEM course participation. Acting as a vital training kit, LearnifyBot prepares students for mechatronics competitions, holding the potential to transform education and ignite STEM interest in Malaysia.

References

- Balakrishnan, B., Nor, M., Azman, A., Sharif, M., Yaacob, H., Hanim, H., & Zain, M. (2019). The effectiveness of hands-on modules in learning science: A case study in Malaysia. *The International Journal of Science, Mathematics and Technology Learning*, 26(1). <https://doi.org/10.18848/2327-7971/CGP>
- Bernama. (2023). Mosti to raise awareness on science, technology, and innovation as enrollment drops. *The Vibes*. <https://www.thevibes.com/articles/news/96585/mosti-to-raise-awareness-on-sciencetechnology-innovation-as-enrollment-drops>
- Carbone, G., Curcio, E. M., Rodinò, S., & Lago, F. (2022). A Robot-Sumo student competition at UNICAL as a learning-by-doing strategy for STEM education. *STEM Education*, 2(3), 262–274. <https://doi.org/10.3934/steme.2022016>
- Jayarajah, K., Saat, R. M., & Rauf, R. A. A. (2014). A review of science, technology, engineering & mathematics (STEM) education research from 1999-2013: A Malaysian perspective. *Eurasia Journal of Mathematics, Science and Technology Education*, 10(3), 155–163. <https://doi.org/10.12973/eurasia.2014.1072a>
- Kolberg, E., Reich, Y., & Levin, I. (2003). Project-based High School Mechatronics Course. <https://www.researchgate.net/publication/294623089>
- Lenovo. (n.d.). STEM Education & Robotics: How Does Hands-On Learning Help? | Lenovo IN. Retrieved 19 May 2024, from <https://www.lenovo.com/in/en/education/stem/robotics/Malaysia-Education-Blueprint-2013-2025>. (n.d.).
- Markus, L., Sungkim, S., & Ishak, Mohd. Z. Bin. (2021). Issues and Challenges in Teaching Secondary School Quantum Physics with Integrated STEM Education in Malaysia. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 6(5), 190–202. <https://doi.org/10.47405/mjssh.v6i5.774>
- Shharudin, Y., Nashir, I. M., Firdaus, M., & Politeknik, A. (n.d.). Analysing the Validity of Lower Secondary School Students' Personality Towards Design and Technology. *Politeknik & Kolej Komuniti Journal of Social Sciences and Humanities*, 6(1), 2021

- Simon, J., & Gogolák, L. (2024). Development of an IoT-based 3D printed Mobile Robot Platform for training of Mechatronics Engineering Students. *Analecta Technica Szegedinensia*, 18(1), 18–30. <https://doi.org/10.14232/analecta.2024.1.18-30>
- Su Ling, L., Pang, V., & Lajium, D. (2020). A Case study of teachers' pedagogical content knowledge in the implementation of integrated STEM education. <https://ejournal.upsi.edu.my/index.php/JPSMM/article/view/2657>
- Talib, C. A., Mohd Rafi, I. B., Rajan, S. T., Abd Hakim, N. W., Ali, M., & Thoe, N. K. (2019). Steam Teaching Strategies in Related Subjects. *Education, Sustainability and Society*, 2(4), 14–18. <https://doi.org/10.26480/ess.04.2019.14.18>
- Tauro, F., Cha, Y., Rahim, F., Sattar Rasul, M., Osman, K., Halim, L., Dennisur, D., Esner, B., & Porfiri, M. (2017). Integrating mechatronics in project-based learning of Malaysian high school students and teachers. *International Journal of Mechanical Engineering Education*, 45(4), 297–320. <https://doi.org/10.1177/0306419017708636>
- Yee Jiea, P., Hussin, H., & Choo Chuan, T. (n.d.). Robotics Competition-Based Learning For 21st Century Stem Education.

Design of Cloud-Based Hydroponic Plant Monitoring System Using Aiven Cloud MySQL Database

Ariffuddin Ibrahim^{1*}, Julianna Aliman² & Muhammad Syafiq Lim³

^{1,3}Electrical Engineering Department, Politeknik Merlimau, Melaka, Malaysia

²Mechanical Engineering Department, Politeknik Merlimau, Melaka, Malaysia

*ariffuddin@pmm.edu.my

Abstract

The "Cloud-based Hydroponic Plant Monitoring System" offers a novel solution to the numerous issues that hydroponic farmers face in maintaining appropriate nutrient levels for plant development. This system, which uses Arduino UNO for sensor interface and ESP32 for IoT connectivity, provides real-time monitoring of critical factors such as pH and NPK levels, which are necessary for plant health. Farmers may use Internet of Things (IoT) technology to remotely access important data on pH and nutrient composition (Nitrogen, Phosphorus, Potassium) via an integrated cloud platform, with Aiven Cloud MySQL Database providing strong data storage. This new framework allows for remote monitoring as well as data visualization and analytics using Node.js, which improves insights into the functioning of the hydroponic system. Deployed on Vercel, the system provides accessibility and scalability while encouraging educated decision-making for accurate nutrition solution modifications. This initiative promotes sustainable farming methods by bridging the nutrient management gap and adopting data-driven agriculture. It increases hydroponic cultivation productivity, keeping up with the changing terrain of modern agriculture.

Keywords: Hydroponic, Aiven Cloud MySQL, Internet of Things

1. Introduction

Hydroponics is a rapidly growing agricultural practice that utilizes nutrient-rich water solutions to grow plants without soil. This method offers numerous advantages over traditional soil-based agriculture, including increased yield, reduced water usage, and improved pest control. However, monitoring and maintaining optimal growing conditions in hydroponic systems can be challenging, requiring constant vigilance and manual adjustments. Hydroponics is a rapidly emerging agricultural technology for growing plants without soil. This approach offers several advantages over traditional soil-based agriculture, including as increased production, reduced water usage, and improved pest management. However, monitoring and maintaining optimal growth conditions in hydroponic systems can be challenging, demanding frequent attention and human intervention.

Hydroponic plant culture is a new soilless agricultural approach in which plants grow in a nutrient-rich water solution. However, hydroponic growers have a continuing challenge: a lack of exact understanding into the nutritional condition of their crops. This information gap limits their capacity to successfully maintain optimal plant health, which impedes agricultural output maximization. Farmers encounter uncertainty in nutrient management in the lack of real-time data on nutrient levels, which can lead to difficulties such as imbalances, deficiencies, or toxicities, all of which can have a negative influence on plant health and production. This project intends to solve these problems by creating a cloud-based hydroponic plant monitoring system.

This system will use sensors and Internet of Things (IoT) technology to collect real-time data on important environmental variables including pH, nutrition levels, temperature, and humidity. The data will be sent to a cloud platform, where it will be evaluated and utilized to produce insights and suggestions for improving plant development.

Current challenges involving hydroponic plant monitoring include the following: i. Lack of automation: Current monitoring systems frequently rely on manual data gathering and processing, which may be time-consuming and error-prone. ii. Limited data access: Data is frequently stored locally, making it difficult to access remotely or share with others. iii. Inconsistent data analysis: Growers frequently lack the knowledge and tools to efficiently evaluate data and turn it into useful insights. iv. Limited control capabilities: Many present systems have only limited control over actuators like pumps and lights, making it difficult to automate reactions to changing conditions.

This dilemma highlights the important need for technology solutions that offer hydroponic growers with the tools and knowledge they need to control nutrients effectively. By solving this knowledge gap, the hydroponic sector may get closer to achieving the full potential of this unique farming approach. Precision monitoring systems and data-driven solutions are required to provide farmers with meaningful information and contribute to the sustainability and efficiency of hydroponic agriculture.

Implementation of user-friendly environment for farmers using AgriHydroponic application, which provides hybrid monitoring and controlling of hydroponics farm field, combines Raspberry Pi and IoT to aid farmers. They control hydroponic farms through a mobile app, with sensors sending plant data to the cloud. An AI system (DLCNN) monitors and alerts farmers about plant health. Farmers can adjust nutrient levels manually or rely on automated standard levels (Ramakrishnam Raju et al., 2022). This system can monitor the environment of the hydroponic device using some sensors in a real-time and steady fashion, and then correctly and automatically communicate the data of temperature, humidity, light intensity, water level, and pH in real time.

Using an Arduino Mega 328, pH sensor, DHT11 temperature/humidity sensor, and an IoT interface (Charumathi et al., 2017). An automated smart hydroponics system using the internet of things can be monitored and controlled from anywhere via the internet, allowing client-side and server-side users to view parameters such as water, pH level, room temperature, nutrient rich water-based solution temperature, and room humidity in real time (Lakshmanan et al., 2020). IoT technology is used to monitor hydroponics systems. The pH sensor, DHT sensor, and EC level sensor are interfaced using Node-MCU and MQTT software (Patil et al., 2020). IoT development in a hydroponic system employing Raspberry Pi and appropriate sensors (Lukito & Lukito, 2019).

2. Methodology

The methodology chapter outlines a step-by-step process for developing the "Cloudbased Hydroponic Plant Monitoring System". The Arduino UNO and ESP32 use WiFi to deliver sensor data directly to the Aiven Cloud MySQL database. The Node.js web app on Vercel's platform allows users to examine and interpret all collected data. Figure 1 depicts the project's flow and architecture, which integrates hardware components such as sensors and microcontrollers, as well as software components for IoT and Cloud to save, fetch, and analyze data before visualizing the data to the end user via a web application in chart form.

Aiven Cloud MySQL Database is a critical component of the project's data management and storage solution. It offers a reliable, scalable, and secure framework for storing sensor data received and processed by the Arduino UNO and ESP32 microcontrollers. Node.js serves many purposes in this project, serving as both the backend and frontend framework for the web application that visualizes and analyzes hydroponic sensor data. Using its event-driven, nonblocking I/O paradigm, Node.js rapidly manages data retrieval from the Aiven Cloud MySQL Database, which stores real-time sensor data on the ESP32 microcontroller. This comprises data from the NPK sensor via UART Serial, the pH sensor via ADC, and the DS18B20 temperature sensor using 1-Wire technology. The online application's front end is built using HTML, CSS, and JavaScript, and it uses the HighCharts.js library to generate dynamic and interactive charts for data visualization.

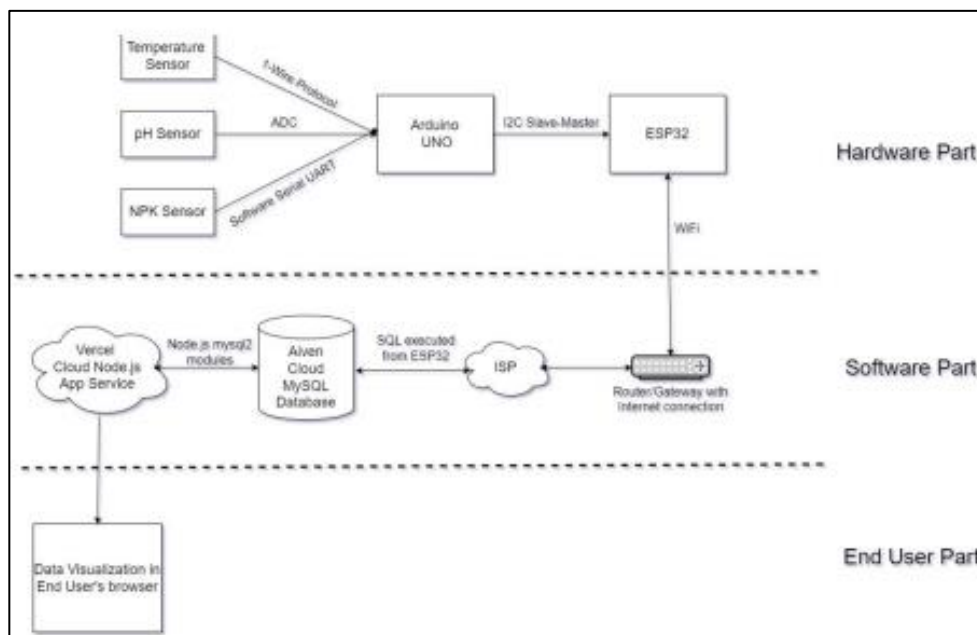


Figure 1: System block diagram of Cloud-Based Hydroponic Plant Monitoring System Using Aiven Cloud MySQL Database

Figure 2 depicts the project's design, which includes all sensors combined with Arduino UNO for sensor data reading and ESP32 for IoT and cloud connectivity in a hydroponic setting.

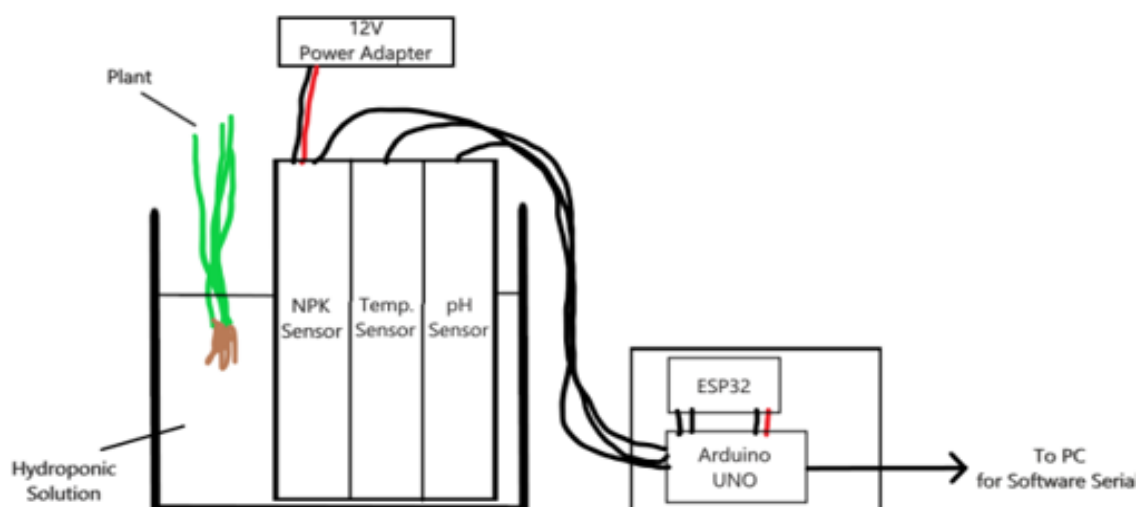


Figure 2: Connection for Sensors Integrated to Arduino UNO for Sensor Data Reading, and ESP32 for IoT and Cloud in a Hydroponic Setup.

Figure 3 depicts the flowchart of the project, illustrating the sequence of the system operation.

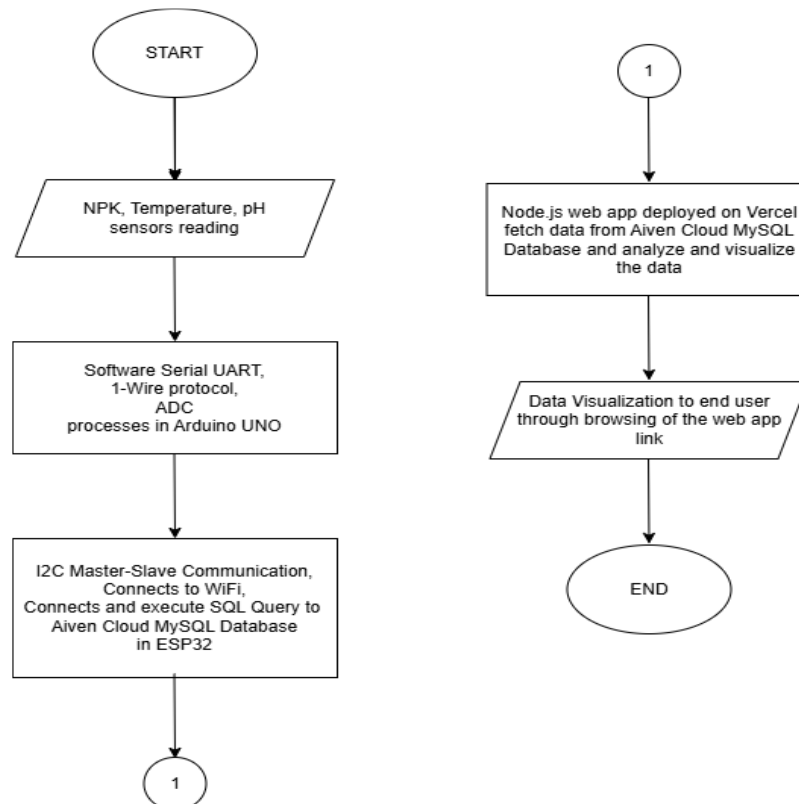


Figure 3: Flow chart of Cloud-Based Hydroponic Plant Monitoring System Using Aiven Cloud MySQL Database

Electronic components used in the system include the Arduino UNO Rev 3, NodeMCU ESP32-WROOM-32 Devkit Board, NPK Sensor Type 485, MAX485 TTL to RS485 Converter Module, DS18B20 Temperature Sensor, pH Probe E-201-C PHS-25, PH0-14 pH Sensor Module, and a 12V Power Adapter. The Arduino UNO is a critical component of the "Cloud-based Hydroponic Plant Monitoring System," acting as the principal controller for communicating with hydroponic sensors. Its primary function is to collect data from different sensors, such as pH and NPK sensors, and transfer it to the ESP32-WROOM-32 microcontroller for processing and subsequent transmission to a cloud-based database. The ESP32-WROOM-32 DevKit microcontroller board serves as a critical link between hydroponic sensors and a cloud-based database, utilizing its built-in WiFi connectivity to ensure continuous communication. It takes sensor data from the Arduino UNO and directly conducts SQL queries to send it to the Aiven Cloud MySQL database over WiFi, simplifying the process and assuring real-time access to critical hydroponic parameters for analysis and decision-making.

The NPK sensor is a useful instrument used in hydroponic systems to monitor the levels of three critical nutrients: nitrogen (N), phosphorus (P), and potassium (K). These nutrients are essential for plants' growth and health. MAX485 TTL to RS485 Converter module is a small yet useful gadget that connects an Arduino UNO to RS485-compatible devices like as sensors or screens. It functions as a bridge, transforming signals from the Arduino UNO, which operates on TTL logic, into signals that RS485 devices can interpret. The DS18B20 Temperature Sensor is a flexible and dependable device used for temperature monitoring in a variety of applications, including hydroponic systems. Using 1-line technology, it simplifies wiring by requiring just one data line for communication, making it simple to integrate into existing systems.

pH Probe E-201-C PHS-25 is a specialized sensor intended to measure pH levels in aqueous solutions, making it an indispensable tool for hydroponic plant monitoring systems. This probe employs a sensitive glass membrane that preferentially interacts with hydrogen ions in the solution, producing a voltage proportional to its acidity or alkalinity. By detecting this voltage, the pH level of the solution may be properly measured. The PH0-14 pH sensor module is a useful and accurate instrument for detecting pH levels in a variety of aqueous solutions, including hydroponic fertilizer solutions. This module uses an analog-to-digital converter (ADC) technique within the Arduino UNO microcontroller to transform the pH sensor's analog voltage output into digital data, allowing for accurate pH reading.

3. Results and Discussion

The Cloud-Based Hydroponic Plant Monitoring System Using Aiven Cloud MySQL Database has successfully managed, as shown in Figure 4.



Figure 4: Circuit connection of the Cloud-Based Hydroponic Plant Monitoring System Using Aiven Cloud MySQL Database

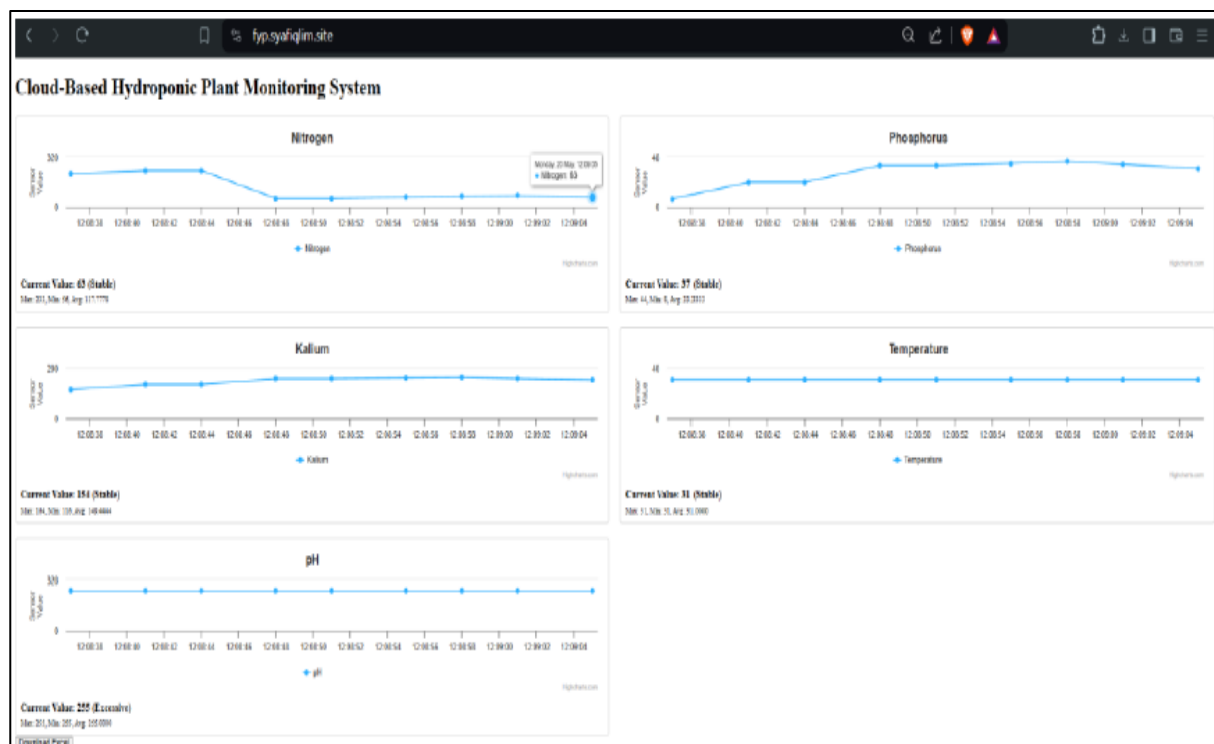


Figure 5: Web application for Data Visualization and Analytics of the Cloud-Based Hydroponic Plant Monitoring System Using Aiven Cloud MySQL Database

Figure 5 depicts the online application for data visualization and analysis. The final project development demonstrates a complete hydroponic monitoring system, which culminates in a user-friendly web application distributed on Vercel. The screenshot depicts dynamic data visualization and insightful analytics, which provide users with real-time insights into critical parameters such as pH levels, NPK composition, and temperature. It can also be accessed anywhere and at any time with ease; end users simply need to browse the link of the deployed domain on their own browser, such as Google Chrome, or even on smartphones. The web app is deployed on two domains, fyp.syafiqlim.site and syafiqlim-fyp-web.vercel.app, and ensures accessibility and scalability, indicating the effective integration of hardware and software components to improve hydroponic farming techniques.

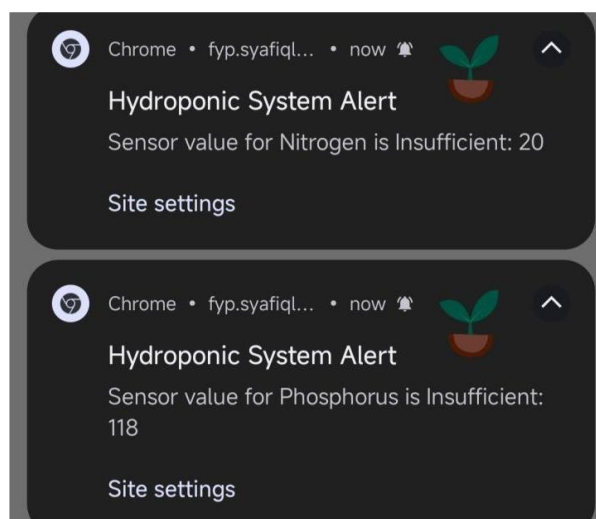


Figure 6: Notification feature through browser

Figure 6 depicts the system's notification function, which pushes alerts through the browser when the indication for each sensor is "Insufficient" or "Excessive".

4. Conclusion

Finally, the hydroponic monitoring system project is a big step forward in contemporary agriculture, solving crucial nutrient management issues and maximizing plant development in hydroponic conditions. The system's seamless integration of hardware and software components allows for exact tracking and visualization of critical parameters including pH levels and nutritional content. This real-time monitoring capability provides farmers with meaningful insights, allowing them to make prompt fertilizer modifications and improve overall crop health and output. Furthermore, the project's emphasis on remote accessibility and sophisticated analytics establishes a new standard for hydroponic farming, providing farmers with a comprehensive solution to bridge the nutrient management gap and sustainably optimize yields.

On the technological side, the project demonstrates advances in sensor technology, microcontroller programming, and cloud-based data administration. The use of various sensors, such as NPK sensors, pH sensors, and temperature sensors, displays the project's adaptability in monitoring critical environmental elements influencing plant development. Furthermore, the development of embedded software on microcontrollers such as Arduino UNO and ESP32 demonstrates programming and hardware interface skills. The use of cloud-based systems for data storage and retrieval guarantees scalability and accessibility, allowing for smooth data transfer and analysis to assist decision-making.

The benefits of the hydroponic monitoring system project go beyond technological improvements to include the possible influence on farming practices and sustainability. By giving farmers real-time information on plant health and nutrient status, the system encourages effective resource usage and decreases waste associated with traditional soil-based farming practices. Furthermore, its remote monitoring features provide flexibility and simplicity, allowing farmers to manage their crops from anywhere and at any time. Overall, the initiative marks a significant advancement in contemporary agriculture, providing a comprehensive solution for optimizing hydroponic farming operations while also contributing to global food security and environmental stewardship.

References

- Charumathi, S., Kaviya, R. M., Kumariyarasi, J., Manisha, R., & Dhivya, P. (2017). *Optimization and Control of Hydroponics Agriculture using IOT*. <https://ssrn.com/abstract=2941105>
- Lakshmanan, R., Djama, M., Selvaperumal, S. K., & Abdulla, R. (2020). Automated smart hydroponics system using internet of things. *International Journal of Electrical and Computer Engineering*, 10(6), 6389–6398. <https://doi.org/10.11591/IJECE.V10I6.PP6389-6398>
- Lukito, R. B., & Lukito, C. (2019). Development of IoT at hydroponic system using raspberry Pi. *Telkomnika (Telecommunication Computing Electronics and Control)*, 17(2), 897–906. <https://doi.org/10.12928/TELKOMNIKA.V17I2.9265>
- Patil, N., Patil, S., Uttekar, A., & Suryawanshi, A. R. (2020). Monitoring of Hydroponics System using IoT Technology. *International Research Journal of Engineering and Technology*. www.irjet.net
- Ramakrishnam Raju, S. V. S., Dappuri, B., Ravi Kiran Varma, P., Yachamaneni, M., Verghese, D. M. G., & Mishra, M. K. (2022). Design and Implementation of Smart Hydroponics Farming Using IoT-Based AI Controller with Mobile Application System. *Journal of Nanomaterials*, <https://doi.org/10.1155/2022/4435591>

Evaluation of Tourism Development Potential of Traditional Villages in Sichuan

Zhou Zi Hua¹, Omar Jamaludin^{1*} & Doh Shu Ing¹

¹Faculty of Civil Engineering Technology, University Malaysia Pahang Al-Sultan Abdullah, Kuantan Pahang, Malaysia

²Sichuan Vocational and Technical College, Sichuan, China

Abstract

Traditional villages carry historical memory and cultural heritage. Exploring tourism resources and evaluating the potential for tourism development are fundamental to the tourism development of traditional villages. Considering the blank state of research on traditional villages in Sichuan, this paper uses 396 traditional villages in Sichuan as research samples. It selects four target layers: tourism resources, locational conditions, development level, and ecological environment. Using the entropy method to determine weights, a tourism development potential evaluation system for Sichuan's traditional villages is constructed. ArcGIS software's spatial analysis functions are employed to classify and visualized the tourism development potential of Sichuan's traditional villages. The results show that Level 3 potential areas are distributed in Danba County in the northwest, Zhaohua County and Tongjiang County in the northeast, and Gulin County in the south. Level 2 potential areas are distributed across 28 counties, relatively scattered, mainly in Aba Prefecture, Luzhou City, and Ya'an City. Level 1 potential areas are primarily distributed in central and northwestern Sichuan. Based on the analysis conclusions, corresponding policy recommendations are proposed: (1) Propose specific development strategies for different potential areas. (2) Pay equal attention to protection and development, and pay more attention to the protection of the ecological environment. (3) Strengthen infrastructure construction and cultural heritage.

Keywords: Traditional Villages, Potential Evaluation, Tourism Development, Sichuan

1. Introduction

Traditional villages are those that have a historicity, a rich tangible and intangible cultural heritage, and are of great scientific and human value and therefore in need of protection (J. Gao & Wu, 2017; C. Liu et al., 2020). They are an important medium for disseminating and inheriting the excellent traditional Chinese culture and are of great practical significance for promoting the modernization of agriculture and rural areas (Nooripoor et al., 2021; Su et al., 2018). As a unique tourism resource, traditional villages play a vital role in promoting the strategy of rural revitalization, finding new economic growth points, optimizing the rural industrial structure, promoting the construction of ecological civilization, and reconstructing traditional rural culture and improving cultural strength (H. Zhang et al., 2021).

As an important part of cultural revival, traditional villages can effectively integrate tourism resources. Deeply developing the tourism potential of traditional villages, carrying out specific development for different types of villages, and encouraging traditional villages with suitable conditions to develop rural tourism will contribute to the protection and utilization of traditional villages, thereby supporting rural revitalization. With the rapid pace of urbanization, numerous traditional villages encounter challenges such as the erosion of historical and cultural heritage, standardization, and the increase of commercial activities.

Scholars have done a lot of research in the fields of community participation in development (Song et al., 2021), tourist perception (Chang & Li, 2022), tourism-related stakeholders (Shafieisabet & Haratifard, 2020), restoration and protection models (S. Liu et al., 2022), tourism impact (Shen & Shen, 2021), and village renewal (Tao et al., 2019). The research results are abundant.

Scholars have gradually shifted from qualitative research methods (Lu et al., 2022) such as traditional fieldwork methods and in-depth interviews to quantitative methods such as mathematical models, remote sensing images, and spatial analysis (S. Gao et al., 2023; C. Zhang et al., 2023; Q. Zhang et al., 2023). The topic of the discussion includes coupling relationship between people and villages (Shen & Shen, 2021), the local reconstruction of village culture (J. Zhang et al., 2023), the governance model of traditional villages (Sili et al., 2022), the emotional cognition of local villagers and tourists (Jiang et al., 2023), the spatial evolution of traditional villages (F. Wang et al., 2023), and the development and revitalization of tourism (Dai et al., 2023).

As for the evaluation methods of traditional villages, the status of traditional villages was initially evaluated through questionnaire survey and SWOT analysis (Q. Wang et al., 2023), and later used spatial analysis methods such as remote sensing and GIS to evaluate the landscape value and cultural heritage value (Brandolini et al., 2023). For the previous research on the evaluation of the tourism development potential of traditional villages, there is no established framework, and numerous academics adhere to a singular approach, with resource assessment predominantly depending on field studies and surveys, while the holistic approach is relatively uncommon. In addition, the method of determining the weight of evaluation indicators is mainly based on expert scoring, which is difficult to ensure the objectivity of evaluation (Jia et al., 2021).

Currently, a precise conceptual delineation and established protocol for assessing the potentiality of tourism development are lacking (Aytuğ & Mikaeili, 2017). Moreover, scholarly investigations into the tourism development potential of conventional rural settlements are notably scarce (Wu et al., 2020). Owing to its distinctive geographical benefits, Sichuan has evolved into a platform where diverse ethnic cultures intersect, interact, and amalgamate, characterized by a rich developmental legacy and an abundance of exceptional traditional villages.

Therefore, taking 396 traditional villages in Sichuan as an example, this study selected 15 evaluation indicators, including population density, economic level, historicity, honorary title, surrounding scenic spots, influence of the county, accessibility, habitation suitability altitude, tourism revenue, number of tourists, website attention, average annual precipitation, average annual temperature, vegetation index and air quality index, starting from the four target layers of tourism resources, location conditions, development degree and ecological environment.

Drawing from a case study of 396 traditional villages in Sichuan, this research opted for 15 assessment criteria. The entropy weight method was used to determine the weight of each evaluation index, combined with GIS and other spatial analysis methods, the evaluation model of tourism development potential of traditional villages in Sichuan was constructed, and the distribution of tourism development potential of traditional villages in Sichuan was quantitatively evaluated, and targeted development strategies were proposed according to different development types, laying the foundation for the sustainable development of traditional villages (Meng et al., 2022).

2. Study Area and Data Source

Overview of the Study Area

Sichuan is in the southwest of China, with complex landforms, with mountains as the main feature, with four landform types: mountains, hills, plains and plateaus. The total land area is 486,100 square kilometres and the population is 90.71 million. It has the largest Yi nationality settlement, the second largest Tibetan settlement, and the only Qiang nationality settlement in the country, and the fusion of multiple cultural practices and unique natural geographical features have led to a deep historical and cultural background. Most of the traditional villages in Sichuan were formed earlier, with a history of more than 100 years, and the traditional villages were built in the Qing Dynasty and before, with obvious ethnic characteristics, diverse architectural types, and a variety of tangible cultural heritage. With the passage of time, the surplus labour force in the village turned to the secondary and tertiary industries, and the processing industry and commercial.

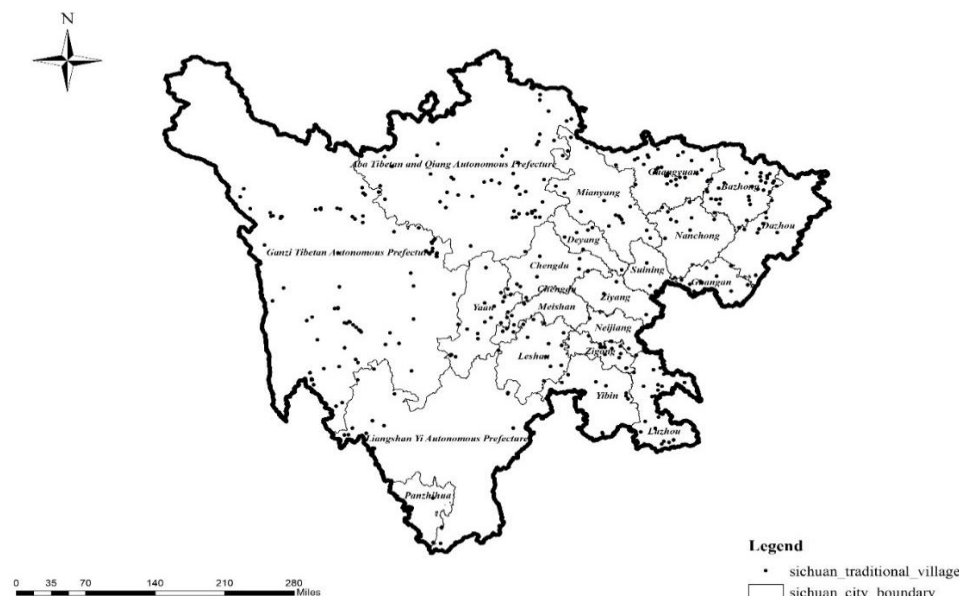


Figure 1: Overview of the study area

Source: Author's elaboration

Data Sources

According to the list of traditional villages published on the official website of the Ministry of Housing and Urban-Rural Development of China, 396 traditional villages in Sichuan were used as research samples. With the help of Google Maps, the geographical coordinates of the village are obtained, and the GIS is used for visualization and attributes. Other data are from the Chinese Academy of Sciences' geospatial data cloud platform, resource and environment data cloud platform, statistical yearbooks and related bulletins. The above data were unified with coordinates to establish a database of traditional village elements in Sichuan.

Research Methods

Utilize the entropy weight method for the calculation of weights. The entropy weight method, an impartial weighting mechanism, originated in the realm of thermodynamics, illustrating the disorder of thermal impacts to a specific degree. A decrease in the information entropy of the parameter indicates a heightened variation in the parameter value, signifying a richer content of information within the indicator, consequently amplifying the significance of the indicator in the holistic assessment.

Suppose that there are m evaluation objects in an evaluation system, and each object has an evaluation indicator. Firstly, the data is standardized, the form of the basic data is optimized,

$$y_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \quad (1)$$

$$y_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)} \quad (2)$$

$$y_{ij} = \frac{|x_{ij} - \bar{x}_j|}{\max(x_j) - \min(x_j)} \quad (3)$$

the positive indicators are processed positively (1), the negative indicators are reversed (2), and the moderate indicators are moderately processed (3) to obtain a perfect matrix type. The formula is as follows:

In formula: y_{ij} is the improved matrix factor model ($i = 1, 2, 3, \dots, m; j = 1, 2, 3, \dots, n$); Elements x_{ij} represents the initial matrix; $\min(x_j)$ represents the minimum value of the j -th indicator (the j -th column element of the initial matrix); $\max(x_j)$ denotes the maximum value of column j of the initial matrix and \bar{x}_j represents the average value of column j .

Calculate the entropy value of the indicator. The formula is as follows:

$$e_j = -k \times \sum_{i=1}^m [(y_{ij} / \sum_{i=1}^m y_{ij}) \ln(y_{ij} / \sum_{i=1}^m y_{ij})] \quad (4)$$

In formula: $k = 1 / (\ln m)$; e_j is the entropy value of the index ($0 \leq e_j \leq 1$), which can reflect the difference between the index x_{ij} values.

Determine the metric weights. It is calculated as follows:

$$w_j = (1 - e_j) / \sum_{i=1}^m (1 - e_j) \quad (5)$$

In formula: w_j is the weight of the indicator

Determination of Index Weights

In contrast to the overall progress of rural tourism, the advancement of tourism in traditional villages possesses a distinctive nature. The assessment of the potential growth of tourism resources encompasses various dimensions, playing a crucial role in the systematic organization and enduring exploitation of tourism resources; hence, the designated criteria must align with the inherent principles governing the progression of phenomena. Combined with the above analysis, referring to the existing research and the evaluation index of national traditional villages, starting from the four target layers of tourism resources, location conditions, development degree and ecological environment, 15 evaluation indicators were selected, including population density, economic level, historicity, honorary title, surrounding scenic spots, influence of the county, accessibility, habitation suitability altitude, tourism revenue, number of tourists, website attention, average annual precipitation, average annual temperature, vegetation index and air quality index. According to the relevant literature, the index grading and tourism development potential index were calculated.

Using the spatial analysis function of GIS software and combining with relevant data, the specific values of each evaluation index of 396 traditional villages were obtained. According to the above formula and calculation steps, the weights of the evaluation indicators of tourism development potential of traditional villages in Sichuan were obtained (Table 1).

Table 1: Evaluation Index Criteria and Weights of Tourism Development Potential of Traditional Villages

Target layer	Criterion layer	Indicator layer	Entropy	weight
Tourism resources	Population density	Population density by county in 2020	0.9977	0.0029
	Economic level	GDP per capita by county in 2020	0.9963	0.0047
	Historicity	The year when the village was built	0.9701	0.0379
	Honorary titles	Honorary title number grade	0.6029	0.5037
Location conditions	Surrounding scenic spots	The distance from the village to the nearest A-level scenic spot	0.9929	0.0091
	Influence of the county	The distance from the village to the county station	0.9942	0.0074
	Accessibility	Shortest distance from major road networks	0.9971	0.0036
	Habitation suitability altitude	Elevation	0.9812	0.0239
Development degree	Number of tourists	The number of village tourism receptions in 2020	0.9321	0.0861
	Tourism revenue	Total economic consumption of tourists in 2020	0.9463	0.0681
	Website attention	Baidu search quantity	0.9029	0.1232
Ecological environment	Average Annual precipitation	Average precipitation in each county in 2020	0.9698	0.0384
	Average annual temperature	Average temperature in each county in 2020	0.9740	0.0330
	Vegetation index	NDVI	0.9954	0.0058
	Air Quality Index	The state of air quality in 2020	0.9589	0.0522

Source: Author's Elaboration

3. Results

Grading and Assignment of Evaluation Indicators

According to the assessment criteria for tourism advancement in traditional villages in Sichuan, the impact of these criteria on the potential tourism growth in said villages was categorized. Subsequently, the criteria data were classified into five tiers using the natural breakpoint technique, with each tier assigned a score ranging from 1 to 5 points. The maximum value of each indicator is assigned a score of 5. At this rate of variation, the score gradually decreases to 1.

Table 2: Grading and Scoring of Evaluation Indicators of Tourism Development Potential of Traditional Village

Indicator layer	Grading	Score
Population density by county in 2020	Low-density areas	5
	Relatively low-density areas	4
	Medium density goes	3
	Relatively high-density area	2
	High-density area	1
GDP per capita by county in 2020	Underdeveloped	5
	Relatively Underdeveloped	4
	Medium	3
	Relatively developed	2
	Developed	1
The year when the village was built	Yuan Dynasty and before	5
	Ming dynasty	4
	Qing Dynasty	3
	Republic of China period	2
	After the founding of the PRC	1
Honorary title number grade	More than one national levels	5
	One national level	3
	None	1

The distance from the village to the nearest A-level scenic spot	Close	5
	Relatively close	4
	Medium	3
	Relatively far	2
	Far	1
The distance from the village to the county	Close	5
	Relatively close	4
	Medium	3
	Relatively far	2
	Far	1
Shortest distance from major road networks	Close	5
	Relatively close	4
	Medium	3
	Relatively far	2
	Far	1
Elevation	Low	5
	Relatively low	4
	Medium	3
	Relatively high	2
	High	1
The number of village tourism receptions in 2020	Large	5
	Relatively large	4
	Medium	3
	Relatively small	2
	Small	1
Economic consumption of tourists in 2020	Large	5
	Relatively large	4
	Medium	3
	Relatively small	2
	Small	1
Baidu search quantity	High popularity	5
	Relatively high popularity	4
	Medium popularity	3
	Relatively low popularity	2
	Low popularity	1
Average precipitation by county in 2020	Low	1
	Relatively low	2
	Medium	5
	Relatively high	4
	High	3
Average temperature by county in 2020	Low	1
	Relatively low	2
	Medium	5
	Relatively high	4
	High	3
NDVI	Sparse	1
	Relatively sparse	2
	Medium	3
	Relatively dense	4
	Dense	5
The state of air quality in 2020	Low	5
	Relatively low	4
	Medium	3
	Relatively high	2
	High	1

Source: Author's elaboration

The scores of all the grading scores of each index of traditional villages were multiplied and added by weight, and the GIS spatial analysis method was used to assign values and obtain the classification of tourism development potential of traditional villages in Sichuan. The study found that its potential value ranged from 1.054~4.542, with an average score of 1.809. The higher the score, the higher the level, and the greatest development potential.

Based on the natural breakpoint method, the data of each indicator are divided into five levels. There were 88 traditional villages in the first-level value range (1.054~1.352), accounting for 22.22% of the total. There were 73 traditional villages in the second-level value range (1.353~1.674), accounting for 18.43% of the total. There were 152 traditional villages in the third-level value range (1.675~2.056), accounting for 38.38% of the total, and 57 traditional villages in the fourth-level value range (2.057~2.788), accounting for 14.39% of the total. There were 26 traditional villages in the five-level value range (2.789~4.543), accounting for 6.57% of the total.

Distribution Characteristics of Cities

From the perspective of the tourism utilization potential of traditional villages in Sichuan, the traditional villages with tourism utilization potential at each level in most cities are distributed. Among the traditional villages with potential for tourism utilization at the fifth level, there are only 26 villages, which are distributed in 14 cities, including Bazhong City, Luzhou City and Chengdu City, among which Guangyuan City has the largest number of 4.

The total number of traditional villages with the potential for fourth-level tourism utilization is 57, and except for Ziyang City and Meishan City, all other cities are distributed, and Ya'an City has the most with 7. There are a total of 152 traditional villages with the potential of third-level tourism, except for Liangshan Yi Autonomous Prefecture and Panzhihua City, which are not distributed, the rest of the cities and prefectures are distributed, and Guangyuan City ranks first with 25.

There are a large number of villages with tertiary development potential in the south of JI and northeast Sichuan. There are a total of 73 traditional villages with secondary tourism utilization potential, distributed in 14 prefectures and cities, including Ganzi Tibetan Autonomous Prefecture and Aba Tibetan and Qiang Autonomous Prefecture. There are 88 traditional villages with first-class tourism utilization potential, distributed in Ganzi Tibetan Autonomous Prefecture, Aba Tibetan and Qiang Autonomous Prefecture, and Xichang Yi Autonomous Prefecture, among which Ganzi Tibetan Autonomous Prefecture has the largest number of 55.

In conclusion, the uneven distribution of traditional villages with tourism potential in Sichuan is evident at various levels, indicating a tendency towards development enhancement in both eastern and western regions. The strong tourism potential in traditional villages is predominantly found in northeastern and central Sichuan, while villages with moderate potential are concentrated in the south. Conversely, traditional Chinese villages with limited tourism potential are primarily situated in the northwest region of Sichuan.



Figure 2: Classification map of tourism development potential of traditional villages in Sichuan
Source: Author's elaboration

Distribution Characteristics of Cities

Based on the assessment of the distribution and tourism potential of traditional villages in Sichuan, the region's tourism potential zones are identified within the administrative boundaries of counties in Sichuan, highlighting areas with significant tourism development prospects in the province. The objective of the Sichuan provincial tourism utilization potential zone is to concentrate on enhancing the tourism resources of traditional villages, advancing the tourism progression of traditional villages, reinforcing the preservation and administration of traditional villages.

The identification of the potential area for tourism utilization of traditional villages in Sichuan contributes to fortifying the centralized and contiguous safeguarding and development of traditional villages in the locality, enhancing the comprehensive planning of traditional villages in the area, and propelling overall advancement and regional synchronized progress. Simultaneously, it aids in executing the primary responsibility in the construction endeavors of traditional village tourism development, with a focus on local entities, amalgamating pertinent resources, and executing policies promptly and effectively.

Based on the comprehensive score of the evaluation of the tourism utilization potential of traditional villages in Sichuan, the corresponding scores of "fifth, fourth, third, second, and first level" were assigned according to the potential grading results 5,4,3,2,1. Based on the county-level administrative division, the comprehensive value of tourism utilization potential of traditional villages at the county level in Sichuan was counted. The results showed that a total of 124 districts and counties had traditional villages, accounting for 68.13%.

The range of the comprehensive value of development potential is 1~48. With the help of ArcGIS, the comprehensive value of tourism utilization potential of traditional villages in the county was divided into three levels, from high to low, which were divided into three levels (28~48), two levels (11~27) and one level (1~10). The distribution of tourism utilization potential areas of traditional villages in Sichuan Province is shown in the figure, the darker the color of the districts and counties, the higher the level, and the blank indicates the districts and counties without the distribution of traditional villages.

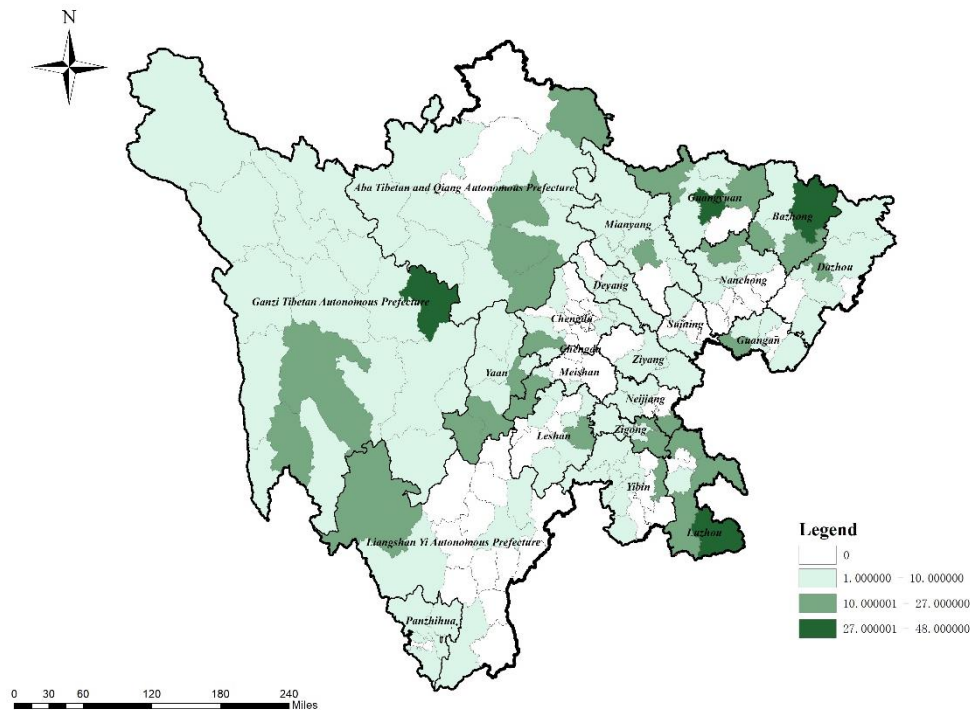


Figure 3: Distribution of Tourism Development Potential Areas of Traditional Villages in Sichuan
Source: Author's Elaboration

Third-level Potential Area

There are 4 third-level potential areas, mainly located in Danba County in the northwest of Sichuan, Zhaohua County and Tongjiang County in the northeast, and Gulin County in the south. There are 56 traditional villages in the third-level potential area, accounting for 14.14%. As the county with the highest comprehensive potential, Tongjiang County has a total of 16 traditional Chinese villages, all of which are third-level potential traditional villages, indicating that the number of traditional villages in Tongjiang County is large, but the overall development potential of traditional villages is medium. Tongjiang County is situated within the central region of eco-tourism in the Qinba Mountains, serving as a model county for the concentrated and continuous safeguarding of traditional villages in Sichuan Province. Tongjiang County lies a wealth of historical and cultural heritage, as well as abundant tourism assets. Zhaohua District ranks second in terms of potential value, with a total of 13 traditional Chinese villages, including 3 fifth-level potential traditional villages, 1 fourth-level potential traditional village, and 9 third-level potential traditional villages.

Zhaohua District is located on the "shu Road" of the Bashu Cultural Tourism Corridor, and the northern, central and southern areas of the region are distributed in three major areas, respectively cantered on Zhaohua Ancient City, Meiling Village and Bolingou Town, and there are certain characteristic differences between the villages. Danba County ranks third in terms of potential value, with a total of 19 traditional villages, including 1 fifth-level potential traditional village, 1 fourth-level potential traditional village, 16 second-level potential traditional villages, and 1 first-class potential traditional village. However, its climate comfort period is short, and the high altitude has a certain impact on the development of tourism activities. Gulin County ranks fourth in terms of potential value, with a total of 8 traditional Chinese villages, including 2 fifth-level potential traditional villages, 3 fourth-level potential traditional villages, and 3 third-level potential traditional villages. Relying on Taiping Ancient Town, Erlang Ancient Town, Tuanjie Village and other scenic spots with distinctive characteristics, it attracts a large number of tourists.

Second-Level Potential Areas

The potential areas at the second level are widely distributed across 28 districts and counties, encompassing a total of 168 traditional villages, representing 42.42% of the overall traditional village count. Within these second-level potential areas, the quantity of traditional villages is considered moderate, with a medium level of potential. Notably, Aba Prefecture, Luzhou City, and Ya'an City stand out for hosting the highest number of second-level potential areas. Specifically, Heishui County in Aba Prefecture boasts the largest quantity of traditional villages, albeit with a lower rating compared to others. While the remaining districts and counties have fewer traditional villages, their collective standing is average.

First-Level Potential Area

The first-level potential areas are distributed in central and northwest Sichuan, and there are many regions, including 92 counties, with a total of 172 traditional villages, accounting for 43.43%. Except for some counties in Ganzi Prefecture and Aba Prefecture, most of the counties have small number of local traditional villages. Although the potential level of traditional villages in the region is high, the number is too small. For example, although the number of traditional villages with high potential in Ya'an City is relatively large, the comprehensive value of tourism utilization potential within each county is not high because they are scattered in multiple districts.

4. Discussion

There are many traditional villages in Sichuan, but the overall level of tourism utilization potential is not high. Based on the analysis conclusions, corresponding policy recommendations are proposed: Propose specific development strategies for different potential areas. Pay equal attention to protection and development and pay more attention to the protection of the ecological environment. Strengthen infrastructure construction and cultural heritage. From the perspectives of grading and zoning, the development strategies are put forward respectively.

The Development Strategy Based on The Grading of Village Tourism Utilization Potential

For the fourth-level and fifth-level traditional villages with tourism utilization potential, the following development approaches are proposed: firstly, maintain the characteristics of rural areas, enhance their core competitiveness, and continually enrich their content and form through the exploration, inheritance, development, and utilization of intangible cultural heritage and folk traits in these areas are vital steps to enhance the protective value and societal influence of the corresponding resources in traditional villages.

Subsequently, by integrating various resources and leveraging location advantages, synergizing tourism resources, and capitalizing on both location benefits and existing development foundations, one can escalate investments, conduct relevant strategic planning, and propel the development and utilization of tourism resources. Ultimately, it becomes imperative to revitalize and harness, foster cultural and creative industries, uncover the distinctive cultural worth of traditional heritage, and convert cultural assets into a propellant for tourism progression.

For the third-level traditional villages with the potential of tourism, they should expand their own advantages, carry out special improvements, and reduce the impact of constraints through certain means and strategies. Protect the environment of traditional villages, repair traditional buildings, sort out historical information and culture and establish archives, and protect the ecological environment and production and living environment of the countryside as much as possible. At the same time, it is essential to fully leverage the governmental authority to offer various forms of assistance.

This includes providing financial and policy backing to stimulate investments from private entities in the enhancement of rural infrastructure, thereby establishing a solid groundwork for the advancement of tourism. Additionally, efforts should be made to boost talent acquisition, identify developmental deficiencies, devise effective strategies, motivate university graduates to return to their native regions for entrepreneurial ventures, enable aspiring entrepreneurs to establish themselves in rural areas, and facilitate the rejuvenation of rural areas through industrial development. Although the traditional villages with the potential of first-level and second-level tourism utilization have certain ecological and cultural value, they have not formed tourism resources and are relatively scarce. The comprehensive development conditions are lower than those of other levels of traditional villages. First, the protection of cultural heritage should be strengthened. Most of the traditional villages are in remote areas. The infrastructure development in traditional villages is relatively lacking, therefore, to safeguard their unique characteristics and cultural significance, an increase in financial investment is deemed essential. It is imperative to actively seek financial aid and boost monetary contributions towards the preservation and sustainable use of traditional villages.

Moreover, fostering the involvement of diverse forms of social capital in the conservation efforts is crucial. Simultaneously, the cultivation of distinctive industries and enhancement of industrial capabilities tailored to local circumstances are also necessary. This facilitates the conversion of resource strengths into industrial advantages, thereby driving the revitalization of rural areas. This kind of traditional villages are mainly distributed in the northwest of Sichuan, with outstanding ecological value, and can combine the ecological environment and living environment of the village to develop industries. Most of them are ethnic minority villages, and they are relatively concentrated, which can develop the characteristic tourism industry of ethnic villages, promote the linkage development between traditional villages, become a development community, share resources, complement each other's advantages, and develop tourism products with national characteristics.

The Development Strategy Based on The Zoning of Tourism Utilization Potential

The number of third-level potential areas is small. First, focus on continuous protection and overall layout. The local government should adhere to the development in the protection and protection in the development, carry out the centralized and contiguous protection and utilization of traditional villages, incorporate them into the tourism strategic planning, organize the preparation of centralized and contiguous protection plans and tourism plans, and coordinate and arrange them. In this process, it is necessary to pay attention to the overall consideration of spatial layout, optimize the integration of traditional village resources, and avoid low-level duplicate construction and development. Second, seize development opportunities and enhance competitive advantages.

Make full use of the location advantages of the Tibet-Qiang-Yi Cultural Industry Corridor, the Bashu Cultural Tourism Corridor, and the core area of eco-tourism, sort out the advantages of its own tourism resources, strengthen the activation and utilization of traditional villages, and build a tourism brand. The second-level potential area is at a medium level, and the general tourism utilization potential of traditional villages in the district and county is not high. First, Enhance the overall potential of the region, strengthen government guidance, promote the centralized and contiguous protection of traditional villages, improve relevant mechanisms, raise funds from multiple channels, and do a good job in protection, such as the repair of traditional buildings, the protection of intangible cultural heritage, the sorting and archiving of traditional village materials, etc., learn from the advanced models of other places, explore the tourism development model of traditional villages suitable for themselves, and promote the improvement of the overall tourism utilization potential.

Second, enhance road accessibility, improve transportation facilities, shorten the transportation time from the city to the village, enhance the location advantage, and build the traditional village into a tourist destination for urban residents to spend their leisure and vacation. Third, implement hierarchical development with support for high-potential traditional villages and low-potential traditional villages. Based on accurately grasping the advantages, shortcomings and development potential of traditional villages, tourism planning should be scientifically formulated. For the traditional villages with rich tourism resources, excellent location conditions and distinctive characteristics, we should focus on supporting them in all aspects, and provide support for villages with limited tourism assets and an underdeveloped status, the approach involves revitalizing the existing while simultaneously introducing novel elements, prioritizing initial growth before further expansion.

There are many first-level potential areas. Most counties possess a limited quantity of traditional villages and low potential. First, policy inclination and increase support the local government should carry out appropriate policy inclination for traditional villages, and ensure that the maintenance, repair and development of tourism resources of traditional villages can be guaranteed by policies by increasing financial support and guiding multiple forces such as social villagers to participate in them. Second, enhance tourism publicity, it is imperative to cultivate the tourism market by leveraging the distinctive cultural aspects of traditional villages. Exploiting the potential of Internet-based new media platforms for promotional endeavors is essential, along with organizing themed exhibitions or festivals centered around traditional villages. These strategies collectively aim to augment the allure of tourism destinations and bolster the appeal to prospective source markets.

5. Conclusion

In this study, the data of the evaluation indexes in relation to traditional villages in Sichuan was subjected to spatial and statistical analysis using ArcGIS. The entropy method was then employed to determine the weights, leading to an assessment of the tourism utilization potential. Subsequently, a proposed tourism development path for traditional villages in Sichuan was derived based on the evaluation and analysis outcomes, focusing on tourism development potential classification and zoning. The key findings of the research can be summarized as follows:

1. The evaluation system of tourism utilization potential of traditional villages in Sichuan was constructed, involving 15 indicators in four dimensions: tourism resources, location conditions, development degree and ecological environment. Then, the weights of each index were obtained by the entropy weight method, and the evaluation results of the tourism utilization potential of traditional villages in Sichuan were calculated, and the average score was 1.809, indicating that the tourism utilization potential of traditional villages in Sichuan was not high as a whole. After dividing the development potential into five levels, it is found that the number of traditional villages with five-level potential is small, with a total of 26, accounting for 6.57% of the total. Mainly distributed in Guangyuan City, northeast of Sichuan, it is rich in tourism resources, has obvious advantages, has a good foundation for tourism development.
2. The counties of Sichuan were divided into three level traditional village tourism utilization potential areas, and the tourism development potential of each county in Sichuan was revealed, and the analysis found that the number of third-level potential areas was small, located in Danba County in the northwest, Zhaohua County and Tongjiang County in the northeast, and Gulin County in the south. The area of third-level potential encompasses numerous traditional villages, abundant tourism resources, favorable conditions, and a significant overall level of tourism utilization potential. This region plays a pivotal role in the development and conservation of traditional villages in Sichuan.

3. Based on the conclusions drawn from the analysis, the ensuing policy recommendations put forth encompass proposing distinct development strategies tailored to various potential areas, with an emphasis on upholding a balance between protection and development, particularly highlighting the importance of safeguarding the ecological environment. Concurrently, there is an urging to bolster infrastructure development and preserve cultural heritage.

Acknowledgement

The support provided by University Malaysia Pahang Al-Sultan Abdullah for this study is highly appreciated.

References

- Aytuğ, H. K., & Mikaeili, M. (2017). Evaluation of Hopa's Rural Tourism Potential in the Context of European Union Tourism Policy. *Procedia Environmental Sciences*, 37, 234–245. <https://doi.org/10.1016/j.proenv.2017.03.039>
- Brandolini, F., Compostella, C., Pelfini, M., & Turner, S. (2023). The Evolution of Historic Agroforestry Landscape in the Northern Apennines (Italy) and Its Consequences for Slope Geomorphic Processes. *LAND*, 12(5), 1054. <https://doi.org/10.3390/land12051054>
- Chang, X., & Li, Z. (2022). Tourists' Perceived Restoration of Chinese Rural Cultural Memory Space. *SUSTAINABILITY*, 14(22), 14825. <https://doi.org/10.3390/su142214825>
- Dai, M. L., Fan, D. X. F., Wang, R., Ou, Y. H., & Ma, X. L. (2023). Does rural tourism revitalize the countryside? An exploration of the spatial reconstruction through the lens of cultural connotations of rurality. *Journal of Destination Marketing & Management*, 29, 100801. <https://doi.org/10.1016/j.jdmm.2023.100801>
- Gao, J., & Wu, B. (2017). Revitalizing traditional villages through rural tourism: A case study of Yuanjia Village, Shaanxi Province, China. *Tourism Management*, 63, 223–233. <https://doi.org/10.1016/j.tourman.2017.04.003>
- Gao, S., Yang, X., Long, H., Zhang, F., & Xin, Q. (2023). The Sustainable Rural Industrial Development under Entrepreneurship and Deep Learning from Digital Empowerment. *SUSTAINABILITY*, 15(9), 7062. <https://doi.org/10.3390/su15097062>
- He, W., Wang, L.-Y., Yu, W.-J., Zhang, G.-J., Zhong, B., Liao, S., Wang, Q., Li, R.-R., Yang, L., Yao, R.-**n, Liu, Y., Danba, Z., Qin, S.-C., Wang, S.-A., Wang, Y.-**a, Huang, Y., & Wang, Q. (2021). Prevalence and spatial distribution patterns of human echinococcosis at the township level in Sichuan Province, China. *Infectious Diseases of Poverty*, 10(1), Article 1. <https://doi.org/10.1186/s40249-021-00862-z>
- Jia, Z., Gao, M., Xu, S., Lyu, Y., Feng, J., Zhou, Z., Yu, T., & Wu, W. (2021). Sociocultural vitality versus regulation policy and tourism development in preservation of traditional rural landscape: A case from Guizhou, China. *International Journal of Sustainable Development And World Ecology*, 28(2), 179–192. <https://doi.org/10.1080/13504509.2020.1788661>
- Jiang, Y., Li, N., & Wang, Z. (2023). Parametric Reconstruction of Traditional Village Morphology Based on the Space Gene Perspective-The Case Study of Xiaoxi Village in Western Hunan, China. *SUSTAINABILITY*, 15(3), 2088. <https://doi.org/10.3390/su15032088>
- Liu, C., Dou, X., Li, J., & Cai, L. A. (2020). Analyzing government role in rural tourism development: An empirical investigation from China. *Journal of Rural Studies*, 79, 177–188. <https://doi.org/10.1016/j.jrurstud.2020.08.046>
- Liu, S., Ge, J., Bai, M., Yao, M., He, L., & Chen, M. (2022). Toward classification-based sustainable revitalization: Assessing the vitality of traditional villages. *Land Use Policy*, 116. Scopus. <https://doi.org/10.1016/j.landusepol.2022.106060>
- Lu, S., Rao, X., & Duan, P. (2022). The Rural Gentrification and Its Impacts in Traditional Villages? A Case Study of Xixinan Village, in China. *Sustainability*, 14(16), 10077. <https://doi.org/10.3390/su141610077>

- Meng, Q., Wang, C., Xu, T., Pi, H., & Wei, Y. (2022). Evaluation of the Sustainable Development of Traditional Ethnic Village Tourist Destinations: A Case Study of Jiaju Tibetan Village in Danba County, China. *Land*, 11(7), Article 7. <https://doi.org/10.3390/land11071008>
- Nooripoor, M., Khosrowjerdi, M., Rastegari, H., Sharifi, Z., & Bijani, M. (2021). The role of tourism in rural development: Evidence from Iran. *GeoJournal*, 86(4), 1705–1719. <https://doi.org/10.1007/s10708-020-10153-z>
- Shafieisabet, N., & Haratifard, S. (2020). The empowerment of local tourism stakeholders and their perceived environmental effects for participation in sustainable development of tourism. *Journal of Hospitality and Tourism Management*, 45, 486–498. <https://doi.org/10.1016/j.jhtm.2020.10.007>
- Shen, K., & Shen, H. (2021). Chinese traditional village residents' behavioural intention to support tourism: An extended model of the theory of planned behaviour. *Tourism Review*, 76(2), 439–459. <https://doi.org/10.1108/TR-11-2019-0451>
- Sili, M., Isabel Haag, M., & Belen Nieto, M. (2022). Constructing the Transitions and Co-Existence of Rural Development Models. *Sustainability*, 14(8), 4625.
- Song, H., Zhu, C., & Fong, L. H. N. (2021). Exploring Residents' Perceptions and Attitudes towards Sustainable Tourism Development in Traditional Villages: The Lens of Stakeholder Theory. *Sustainability*, 13(23), 13032. <https://doi.org/10.3390/su132313032>
- Su, L., Huang, S. (Sam), & Huang, J. (2018). Effects of Destination Social Responsibility and Tourism Impacts on Residents' Support for Tourism and Perceived Quality of Life. *Journal of Hospitality & Tourism Research*, 42(7), 1039–1057.
- Tao, W., Jiamin, M., Dongsheng, W., Adeyeye, K., & Peng, Y. (2019). Extenics: A new approach for the Design, Reconstruction and Renewal of Traditional Villages. *Procedia Computer Science*, 162, 908–915. <https://doi.org/10.1016/j.procs.2019.12.067>
- Wang, F., Zhao, X., Qiu, Y., & Luo, J. (2023). Adaptability of traditional villages as tourist destinations in Yellow River Basin, China. *Indoor And Built Environment*, 32(3), 574–589. <https://doi.org/10.1177/1420326X221126056>
- Wang, Q., Liu, W., & Mao, L. (2023). Spatial Evolution of Traditional Village Dwellings in Heilongjiang Province. *Sustainability*, 15(6), 5330. <https://doi.org/10.3390/su15065330>
- Wu, Y., Sun, X., Sun, L., & Choguill, C. L. (2020). Optimizing the governance model of urban villages based on integration of inclusiveness and urban service boundary (USB): A Chinese case study. *Cities*, 96, 102427. <https://doi.org/10.1016/j.cities.2019.102427>
- Zhang, C., Xiong, W., Shao, T., Zhang, Y., Zhang, Z., & Zhao, F. (2023). Analyses of the Spatial Morphology of Traditional Yunnan Villages Utilizing Unmanned Aerial Vehicle Remote Sensing. *LAND*, 12(11), 2011. <https://doi.org/10.3390/land12112011>
- Zhang, H., Duan, Y., & Han, Z. (2021). Research on Spatial Patterns and Sustainable Development of Rural Tourism Destinations in the Yellow River Basin of China. *Land*, 10(8), 849. <https://doi.org/10.3390/land10080849>
- Zhang, J., Yan, J., Sun, R., Wang, M., & Cai, B. (2023). Spatial characteristics and residents' perception differences of different types of rural areas in suburbs of metropolis. *Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering*, 39(20), 211–220. Scopus. <https://doi.org/10.11975/j.issn.1002-6819.202211213>
- Zhang, L. (2022). Quality Evaluation and Spatial Differentiation of Rural Human Settlements: A Case Study of Sichuan Province, China: Proceedings of the 2nd International Conference on Public Management and Big Data Analysis, 114–119. <https://doi.org/10.5220/0012070800003624>
- Zhang, Q., Zhang, J., Lu, S., Liu, Y., Liu, L., Wang, Y., & Cao, M. (2023). Multi-Resolution Feature Extraction and Fusion for Traditional Village Landscape Analysis in Remote Sensing Imagery. *Traitement Du Signal*, 40(3), 1259–1266. <https://doi.org/10.18280/ts.400344>

Benefit of Bim at Design and Planning Stage: A Review

Huang Lei¹, Shu Ing Doh^{2*} & Zhang Bai Feng³

¹Faculty of Civil Engineering Technology, Universiti Malaysia Pahang, 26300, Malaysia

^{1,3}ShuiFa Group Co., Ltd, 250101, China

Abstract

Building Information Modelling (BIM) significantly enhances the design and planning stages of construction projects through improved visualization, coordination, accuracy, and efficiency. Detailed 3D visualizations provided by BIM allow stakeholders to better understand and evaluate designs, facilitating the early identification of potential issues and informed decision-making. This capability promotes better communication among stakeholders, ensuring a smoother transition from design to construction. Additionally, BIM serves as a collaborative platform where all stakeholders can access and update the project model in real-time, reducing discrepancies and improving coordination among architects, engineers, and other team members. One of the significant advantages of BIM is its capability for clash detection, which identifies conflicts between building components early in the design phase. This feature enhances coordination among different trades and reduces rework, improving overall project accuracy and efficiency. Furthermore, BIM supports better cost estimation through detailed quantity take-offs and integration with estimating software. This enhances the accuracy of cost estimates, reduces the risk of cost overruns, and ensures better budget management. BIM also streamlines the design process by integrating various design tools and workflows into a single platform, enabling designers to quickly explore multiple design alternatives and optimize solutions. This integration facilitates faster project completion and higher-quality designs by supporting parametric design techniques and providing tools for design optimization and analysis. Collectively, these capabilities of BIM contribute to a more accurate, efficient, and successful construction process.

Keywords: BIM, Design and Planning, Clash Detection, Cost Estimation, Visualization

1. Introduction

Building Information Modelling (BIM) is a multifaceted concept that holds different meanings for various professionals. According to Smith (2014), BIM is a term that encompasses diverse definitions across the industry, leading to misperceptions at various levels. Some specialists view BIM as a basic computer program, while others see it as a process for documenting and designing building data. Additionally, certain professionals describe BIM as an innovative approach requiring new strategies among project partners. This variety of interpretations illustrates the need for a clear, unified definition to harmonize the understanding of BIM.

The National Building Information Model Standard (NBIMS) Project Committee provides a comprehensive definition: BIM is a digital representation of physical and functional characteristics of a facility.” It serves as a shared knowledge resource for information about a facility, providing a consistent basis for decisions throughout its lifecycle, from earliest conception to demolition. Essentially, BIM involves collaboration among different parties at various phases of a facility's lifecycle to input, extract, update, or modify information (Atazadeh et al, 2017). However, this definition can be generalized to encompass digital tools that contribute to project data creation. Anderson et al (2012) argue that locative data in a spreadsheet can be considered data modelling akin to BIM, especially when alphanumeric data simulates real business processes. Sun et al (2017) support a generic definition of BIM, suggesting that it can be found in the integration of spreadsheets within organizational relationships.

The distinction between BIM and other modelling software is crucial. Eastman et al. (2011) emphasize that BIM is more than just a modelling technology; it is a methodology for designing and constructing buildings using modelling tools. BIM involves multiple procedures and specialists to produce, discuss, and investigate the model. Azhar et al. (2015) concurs, noting that BIM represents the structural and functional characteristics of a facility, where data is linked to various aspects of the model.

2. Benefit of BIM at Design and Planning Stage

BIM offers numerous benefits during the design and planning stages of construction projects. These stages are critical for ensuring project success, and BIM enhances these processes through improved visualization, coordination, accuracy, and efficiency.

3D Visualization

During the design stage in particular, BIM provides detailed 3D visualizations that allow stakeholders to better understand and evaluate the design (Eastman et al., 2011; Mahalingam & Prabu, 2023). Mahalingam and Prabu (2023) further added that detailed 3D visualization of building design enhances better understanding and communication among the stakeholders. This helps in identifying potential design issues early and facilitates more informed decision-making. By offering a clear and comprehensive view of the project, BIM enables stakeholders to foresee and address potential challenges, ensuring a smoother transition from design to construction.

Moreover, BIM serves as a shared platform where all project stakeholders can access and update the project model in real time. This collaborative approach helps in resolving design conflicts and improves coordination among architects, engineers, and other stakeholders (Azhar, 2011). The ability to work on a shared model reduces discrepancies and ensures that all team members are on the same page, which is crucial for maintaining project coherence and avoiding costly rework. Hadipriono et al. (2020) also emphasized that BIM fosters collaboration among project stakeholders by providing a shared platform for accessing and updating project models, leading to better coordination and fewer design conflicts.

This integrated approach ensures that any changes made by one party are immediately visible to all others, thereby minimizing misunderstandings and facilitating a more seamless workflow. BIM significantly enhances coordination and collaboration among project stakeholders in construction projects, thereby improving overall project outcomes through enhanced visualization, real-time collaboration, and effective communication.

Clash Detection

BIM provides a centralized platform where project stakeholders can access and update project information in real-time, fostering collaboration and ensuring that all team members are working with the most current data (Wu, 2022). This real-time access ensures that any changes or updates are immediately reflected across the entire project team, which is critical for maintaining accuracy and coherence throughout the project lifecycle. BIM enables stakeholders to visualize the project in 3D, which improves understanding and communication of complex design concepts (Tan et al., 2018). This visual representation facilitates better collaboration and decision-making, as all stakeholders can clearly see and understand the design, making it easier to provide feedback and make informed decisions. Qiao et al. (2020) further highlighted that BIM enhances communication among project teams by providing a visual representation of the project's design and construction details. This clarity helps prevent misunderstandings and fosters effective collaboration.

One of the significant advantages of BIM is its capability for clash detection, which involves identifying conflicts between building components early in the design phase (Lu et al., 2019). By resolving clashes before construction begins, BIM improves coordination among different trades and reduces rework. Gündoğdu and Günaydın (2019) confirmed that the integrated nature of BIM allows for automatic detection of clashes and inconsistencies within the design, reducing the likelihood of errors and the need for rework. Similarly, Hardin and McCool (2015) emphasized that BIM's integrated nature allows for automatic clash detection and consistency checks within the design, resulting in a more accurate and efficient design process.

BIM also allows stakeholders to receive real-time updates and notifications about project changes, ensuring that everyone is informed and can adjust their work accordingly (Gu & Singh, 2019). This capability promotes collaboration and helps keep the project on track, as all team members are always working with the latest information. Additionally, BIM enhances communication among project stakeholders by providing a platform for sharing information and updates, which helps prevent misunderstandings and errors due to miscommunication (Mo et al., 2021). Wei et al. (2020) suggested that BIM enhances communication among project teams by providing visual representations of the project's design and construction details, further preventing errors resulting from misunderstandings or misinterpretations of project requirements.

BIM also enables the simulation and analysis of design scenarios, allowing project teams to identify potential issues before construction begins (Lu et al., 2019). This proactive approach helps prevent errors and reduces the need for costly rework. Furthermore, BIM promotes the standardization and documentation of design and construction processes, ensuring consistency and accuracy throughout the project lifecycle (Mahmoudi et al., 2019). BIM offers several mechanisms through which it can reduce errors in construction projects, including clash detection, enhanced coordination among project stakeholders, improved communication, and the ability to simulate and analyze design scenarios. These features collectively contribute to a more accurate, efficient, and successful construction process (Bazjanac et al., 2019).

Better Cost Estimation

BIM provides detailed quantity take-offs and cost information, enhancing the accuracy of cost estimates and budgets (Sacks, 2018). By ensuring that project budgets are based on precise and comprehensive data, BIM significantly reduces the risk of cost overruns. BIM enhances the accuracy and efficiency of cost estimation in construction projects through various mechanisms such as detailed quantity take-offs, improved visualization, and integration with estimating software. For instance, BIM allows for detailed and accurate quantity take-offs by extracting data directly from the digital model. This reduces manual errors and ensures that estimates are based on precise measurements (Wang et al., 2019). The precision of the digital model means all quantities are automatically calculated, minimizing human error and improving the reliability of the estimates.

Moreover, BIM can be integrated with estimating software, allowing for seamless transfer of information between the BIM model and the estimating tools. This integration streamlines the estimation process and enhances accuracy (Pham et al., 2020). When BIM and estimating software work together, it eliminates the need for duplicate data entry and ensures that the most current information is always used. BIM also enables the visualization of cost data within the digital model, providing stakeholders with a clear understanding of how design decisions impact project costs (Mahalingam & Prabu, 2021).

This visual representation helps stakeholders make informed decisions during the design process, as they can see the financial implications of their choices in real time. This transparency ensures that cost considerations are integrated into the design phase, leading to better budget management.

Furthermore, BIM supports parametric cost estimation, allowing for the development of cost models based on design parameters such as area, volume, and material quantities. This approach provides a more accurate and efficient way to estimate project costs (Banihashemi et al., 2020). Parametric estimation uses the relationships between design parameters and cost to quickly generate accurate cost predictions, facilitating faster and more reliable budgeting. Additionally, BIM enables the analysis of historical cost data from previous projects, helping to develop more accurate cost estimates for current projects (Zayed & Elsayed, 2020).

This data-driven approach leverages past project data to inform current estimates, improving the reliability of cost estimation. Historical data provides a benchmark that helps anticipate potential cost variances and enhances the overall accuracy of the budget. BIM enhances cost estimation in construction projects by enabling detailed quantity take-offs, integrating with estimating software, visualizing cost data, supporting parametric cost estimation, and analysing historical data. These capabilities collectively improve the accuracy, efficiency, and reliability of cost estimates, contributing to better project financial management.

Efficient Design Process

BIM streamlines the design process by integrating various design tools and methodologies, enabling faster project completion and allowing designers to quickly explore multiple design alternatives (Bryde et al., 2013). BIM enhances the efficiency of design processes in construction projects through mechanisms such as enhanced collaboration, streamlined workflows, and integrated design tools. One of the key benefits of BIM is its facilitation of collaboration among project stakeholders by providing a centralized platform for sharing information and updates in real-time (Lin & Lin, 2020). This streamlined communication and decision-making process leads to more efficient design workflows. By enabling all stakeholders to work from the same up-to-date information, BIM reduces misunderstandings and ensures that everyone is on the same page, which is crucial for maintaining project coherence and efficiency.

BIM integrates various design tools and workflows into a single platform, allowing designers to work more efficiently and effectively (Ma et al., 2019). This integration eliminates the need for manual data transfer between different software applications, saving time and reducing errors. When all design tools are part of the same ecosystem, data consistency is maintained, and the overall design process is expedited. Moreover, BIM enables designers to quickly iterate and explore design alternatives by creating digital prototypes of building components and systems (Amor & Augenbroe, 2020). This iterative process allows for faster decision-making and optimization of design solutions. Designers can easily modify designs and immediately see the impacts of these changes, enabling a more dynamic and flexible design process.

BIM also supports parametric design techniques, which allow designers to create intelligent building elements that can automatically adjust based on predefined parameters (Sun et al., 2019). This automation reduces manual effort and speeds up the design process. Parametric design facilitates the creation of complex geometries and configurations that would be cumbersome and time-consuming to develop using traditional methods.

Additionally, BIM facilitates design optimization and analysis by providing tools for simulating various scenarios and analysing the performance of building systems (Kim et al., 2020). These tools help designers make informed decisions that improve the overall quality of the design. By simulating different design scenarios, designers can identify the most efficient and effective solutions, ensuring that the final design meets all performance and sustainability criteria. BIM significantly enhances the design process in construction projects by integrating design tools, facilitating collaboration, enabling quick iteration of design alternatives, supporting parametric design, and providing tools for design optimization and analysis. These capabilities collectively lead to faster project completion and higher-quality designs.

3. Conclusion

Building Information Modelling (BIM) significantly enhances the design and planning stages of construction projects through improved visualization, coordination, accuracy, and efficiency. BIM's detailed 3D visualizations enable stakeholders to better understand and evaluate designs, facilitating early issue identification and informed decision-making. Acting as a collaborative platform, BIM allows real-time access and updates to the project model, reducing discrepancies and improving coordination among team members. Clash detection capability in BIM identifies conflicts early, enhancing coordination among trades and reducing rework, thus improving project accuracy and efficiency. Additionally, BIM supports better cost estimation through detailed quantity take-offs and integrates with estimating software, ensuring better budget management. By streamlining the design process and enabling quick exploration of alternatives, BIM facilitates faster project completion and higher-quality designs, thus contributing to a more accurate, efficient, and successful construction process.

References

- Amor, R., & Augenbroe, G. (2020). An Analysis of BIM-based Design Performance Metrics. *Automation in Construction*, 110, 103009.
- Anderson, A., Marsters, T., Dossick, C. S., & Neff, G. (2012). Construction to Operations Building Information Exchange (COBie) and the Quality of Information. *Automation in Construction*, 18(7), 875-879.
- Atazadeh, B., Kalantari, M., Rajabifard, A., & Ho, S. (2017). Modelling Building Ownership Boundaries within BIM Environment: A Case Study in Victoria, Australia. *Computers, Environment and Urban Systems*, 61, 24-38.
- Azhar, S., Nadeem, A., Mok, J. Y., & Leung, B. H. (2015). Building Information Modeling (BIM): A New Paradigm for Visual Interactive Modeling and Simulation for Construction Projects. *Virtual and Physical Prototyping*, 10(3), 123-139.
- Banihashemi, S., Hosseini, M. R., & Fathi, M. (2020). Estimation of Construction Costs using the Building Information Modeling (BIM) Method and Parametric Estimating Method. *Journal of Civil Engineering and Management*, 26(3), 251-261.
- Bazjanac, V., Haves, P., Sucic, D., Xu, W., Maile, T., & Chen, Y. (2019). A Comprehensive Analysis of the Impact of Model Fidelity and Level of Detail on Clash Detection Performance. *Automation in Construction*, 98, 175-187.
- Bryde, D., & Broquetas, M. (2013). The Project Benefits of Building Information Modelling (BIM). *International Journal of Project Management*, 31(7), 971-980.
- Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*. John Wiley & Sons.
- Gu, N., & Singh, V. (2019). Cloud-based Building Information Modelling (BIM) for Collaborative Decision Making. *Automation in Construction*, 107, 102931.

- Gündoğdu, S., & Günaydın, H. M. (2019). A Comprehensive Review on Building Information Modelling (BIM) in Construction Industry: Motivations, Barriers, and Benefits. *Journal of Building Engineering*, 26, 100868.
- Hadipriono, F. C., Yuniarto, M. I., & Li, L. (2020). Building Information Modeling (BIM) Adoption and its Impact on Collaborative Design and Construction Processes: A Systematic Literature Review. *Automation in Construction*, 117, 103226.
- Hardin, B., & McCool, D. (2015). *BIM and Construction Management: Proven Tools, Methods, and Workflows*. John Wiley & Sons.
- Hosseini, M. R., Chileshe, N., Zuo, J., & Baroudi, B. (2016). Factors Affecting Construction Organizations' Readiness for the Implementation of Building Information Modeling: A Case Study of Two Regions in Australia. *Construction Innovation*, 16(1), 62-84.
- Kim, H. K., Lee, J. S., & Kim, H. J. (2020). Evaluating the Impact of Design Change Propagation using Building Information Modeling (BIM). *Automation in Construction*, 112, 103124.
- Lin, Y., & Lin, Y. (2020). Assessing the Impact of Building Information Modeling (BIM) on Design Coordination and Project Performance. *Automation in Construction*, 116, 103204.
- Lu, W., Lin, Y., & Zhang, J. (2019). Fuzzy-based Modeling of Construction Errors: An Approach Integrating BIM and Evidence Theory. *Automation in Construction*, 102, 97-109.
- Ma, Z., Li, H., Guo, H., Liu, Y., & Shen, Q. (2019). BIM-enabled Integrated Design Platform for Green Building Projects: Development and Application. *Journal of Computing in Civil Engineering*, 33(1), 04018063.
- Mahalingam, A., & Prabhu, G. G. S. (2021). Building Information Modeling (BIM): A Review on Benefits, Challenges, and its Future. *Journal of Building Engineering*, 36, 102044.
- Mahmoudi, M., Akbarnezhad, A., & Ghoddousi, P. (2019). A BIM-based Framework for Assessing Construction Supply Chain Disruptions. *Automation in Construction*, 104, 182-197.
- Mo, Y. L., Wang, S., & Kiani, A. K. (2021). Investigating the Impact of Virtual Reality-based Immersive BIM on Construction Conflict Identification and Resolution. *Automation in Construction*, 121, 103471.
- Pham, H., Fung, I. W., & Tam, C. M. (2020). Framework for BIM-enabled Construction Cost Estimating: Current Status and Future Directions. *Journal of Construction Engineering and Management*, 146(7), 04020074.
- Qiao, K., Zhang, X., & Li, H. (2020). Clash Detection and Risk Mitigation in BIM-based Projects. *Automation in Construction*, 112, 103118.
- Sacks, R., Eastman, C. M., Lee, G., & Teicholz, P. (2018). *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers*. John Wiley & Sons.
- Smith, P. (2014). BIM & the 5D Project Cost Manager. *Procedia - Social and Behavioral Sciences*, 119, 475-484.
- Sun, C., Jiang, S., Skibniewski, M. J., Man, Q., & Shen, L. (2017). A Literature Review of The Factors Limiting the Application of BIM in The Construction Industry. *Technological and Economic Development of Economy*, 23(5), 764-779.
- Sun, M., Lu, W., & Wang, X. (2019). Integrating Building Information Modeling (BIM) and Generative Design for Building Layout Optimization. *Automation in Construction*, 100, 109-119.
- Tan, Y., Mao, C., Yu, Y., & Zhang, J. (2018). A Cloud-based Approach to Facilitate BIM-based Collaborative Design. *Automation in Construction*, 87, 39-48.
- Wang, J., Luo, H., Tam, V. W., Huang, G. Q., & Skibniewski, M. J. (2019). A Systematic Review of Research Trends and Methods in Building Information Modeling-Based Facility Operation and Maintenance. *Automation in Construction*, 104, 131-146.

- Wei, Y., Ren, A., Luo, L., Song, J., Li, H., & Jiang, Z. (2020). A Knowledge-based Approach for Automated Quality Assurance of BIM Model in Construction Projects. *Journal of Computing in Civil Engineering*, 34(6), 04020057.
- Wu, W., Issa, R. R. A., & Chen, S. (2020). BIM-based Framework for Improving Construction Project Communication Management. *Journal of Construction Engineering and Management*, 146(3), 04019105.
- Zayed, T., & Elsayed, K. (2020). Enhancing BIM-based Cost Estimating Using Historical Cost Data and Machine Learning Techniques. *Journal of Construction Engineering and Management*, 146(11), 04020110.

Production of Biochar from Sugarcane Biomass under Slow Pyrolysis Process

Is Aizat Samsuri^{1*}, Auni Nurain Borhan², Nurul Insyirah Mohamad Noor³ & Nor Ahmad Danial Abdul Wahab⁴

^{1,2,3,4}Department of Agrotechnology and Bio-Industry, Politeknik Nilai, Malaysia

*isaizat@polinilai.edu.my

Abstract

Deforestation from charcoal production is a major environmental threat, contributing to climate change and biodiversity loss. This study explores biochar production from sugarcane biomass as a sustainable alternative. With rising charcoal demand in developing countries and improper sugarcane waste disposal, biochar offers a solution to both issues. The research focuses on optimizing conditions for sugarcane biomass production, identifying the best biochar production methods, and assessing the physicochemical properties of the resulting biochar. Two biomass conditions—coarse and fine—were evaluated during the pre-pyrolysis process, with pyrolysis conducted over 8 hours. Post-pyrolysis testing characterized biochar properties such as pH, calorific content, electrical conductivity (EC), total dissolved solids (TDS) reduction, and bulk density. Optimal conditions were identified at a 5 kg load over 8 hours, yielding 0.8 kg of biochar. Key findings include a pH of 7, calorific content of 39.974 MJ/kg, EC ranging from 0.8 to 2.5 deciSiemens/m, 18% TDS reduction, and bulk density of 0.08 g/ml. This research provides valuable insights into sustainable biomass conversion and efficient pyrolysis methods, highlighting critical physicochemical properties of biochar. These findings support environmentally friendly and economically viable practices, offering a sustainable solution to deforestation and waste disposal challenges. This study not only addresses immediate environmental concerns but also paves the way for future research and applications in biochar production and utilization, contributing to environmental conservation and sustainable development.

Keywords: Sugarcane Biomass, Pyrolysis, Biochar

1. Introduction

Deforestation is a major environmental concern that contributes to climate change, biodiversity loss, and degradation of natural resources. In many countries, the production of charcoal from trees contributes significantly to deforestation according to Sedano et al. (2016). Charcoal consumption is increasing, particularly in developing countries, because of its low cost and wide use in cooking and heating. Nevertheless, the production of charcoal from trees involves the clearing of forests, which reduces carbon sequestration potential and contributes to higher levels of carbon dioxide in the atmosphere. Furthermore, according to Dhanesha (2021), the production of charcoal from trees depletes biomass and worsens climate change. When forests are cleared for the production of charcoal, the trees are frequently burned, releasing carbon into the atmosphere and contributing to greenhouse gas emissions. Furthermore, loss of forest cover can cause soil erosion, which adds to climate change and environmental degradation.

Aside from deforestation, according to Soffian et al. (2022), improper domestic waste disposal, such as sugarcane biomass, leads to environmental issues such as water or river contamination and greenhouse gas emissions. Sugarcane biomass is a major problem in many countries, particularly in developing countries such as Malaysia. Excessive home trash exacerbates the situation, and correct disposal of sugarcane waste is critical to mitigating its negative environmental impact.

As a result, making biochar from sugarcane biomass provides a sustainable solution to both sugarcane waste and charcoal production. According to Renan Valenca (2021) biochar is a form of charcoal that has been found to lower greenhouse gas emissions while also improving soil fertility. Furthermore, according to Rob Goodier (2021) biochar has the potential to act as a water filter, reducing water or river contamination caused by improper waste disposal. We may lessen our dependence on charcoal made from trees and the environmental impact of sugarcane waste by creating biochar from sugarcane biomass.

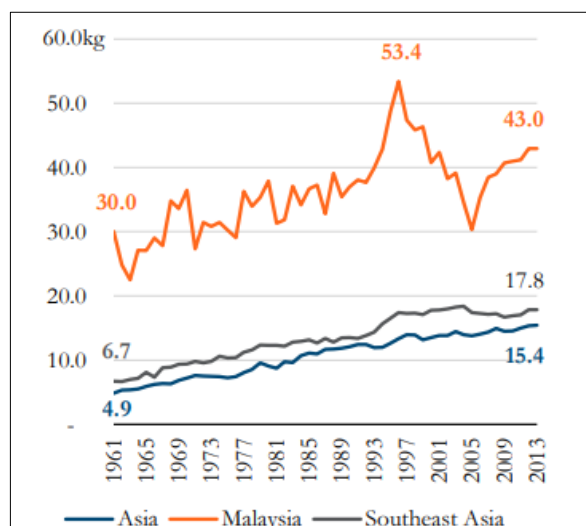


Figure 1: Supply per capita (kg/person) per year of sugar, Malaysia Selected Regions, 1961-2013
Source: FAO (n.d.-b)

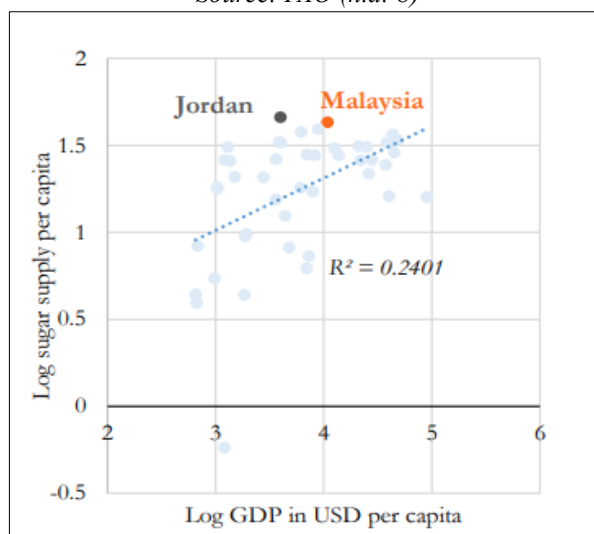


Figure 2: Supply per capita vs GDP in USD per capita, 2013
Source: FAO (n.d.-b) and Bank (n.d.-a, FAO (n.d.-a)

2. Problem Statement

Improper domestic waste disposal is a major issue all over the world, affecting not only people's health and safety but also hurting the ecosystem. Sugarcane waste is a type of residence garbage that is frequently improperly disposed of, resulting in a variety of difficulties such as greenhouse gas emissions and land deterioration. The LBJ area's lack of data on sugarcane biomass production restricts effective agricultural planning and resource allocation. Christofolletti et al. (2013) conducted a study that highlights the issue of sugarcane waste disposal and emphasizes the importance of effective waste management systems. Another concern related to domestic waste is the manufacturing of charcoal through forest removal.

The process may cause deforestation biomass and affect climate change. Rashidy Kazeuka's (2013) research highlights the importance of maintaining forests and ecosystems and suggests that different methods of manufacturing charcoal be studied. The lack of a documented optimal method for producing biochar from sugarcane bagasse restricts the use of this valuable agricultural waste product for long-term soil improvement.

Additionally, the insufficient data on the physicochemical properties of bagasse-derived biochar from sugarcane raises concerns about its suitability for specific applications, impeding its integration into various industries. Properly characterizing the biochar is crucial for understanding its potential uses and environmental impact. Rashidy Kazeuka's research (2013) underscores the need for comprehensive investigations into the manufacturing and application of biochar from sugarcane waste to ensure sustainable practices.

Fixing issues related to sugarcane waste disposal and biochar production from sugarcane bagasse requires a thorough strategy that includes effective waste management systems, sustainable forest practices, and thorough studies into biochar production and its properties. These efforts are vital not only for protecting human health and the environment but also for making the best use of limited agricultural resources.

3. Methods

Sugarcane Bagasse Collection

Sugarcane bagasse was collected from identified sugarcane drink stalls. Sugarcane which was later mentioned as biomass was dried and stored in a dry store for pyrolysis purpose.

Pyrolysis Chamber

Pyrolysis chamber was made from 50 L steel drums, welded with cylindrical mildsteel (50 mm diameter) and dismantled top with clamp. Small gap was made on top of the tank to provide a pressure release mechanism, provided one way heating pathway bottom-up.



Figure 3: Pyrolysis Chamber

Pyrolysis and Biochar Production

Pyrolysis chamber was employed and provided limited oxygen with heats ranging between 300 - 800°C to ensure the carbonization process takes place. Precise temperature control was ensuring it stayed consistently above 300°C using the thermostat. Oxygen inflow was controlled by covering the opening gap with wet clothes. Fire supply was consistently monitored through temperature monitoring through addition of firewood. The experimental protocol involved four treatment cycles with coarse and fine bagasse at 15kg and 5kg, respectively, each cycle lasting 8 hours. Fine bagasse was size reduced before pyrolysis.

Biochar Characterization – pH, Electrical Conductivity (EC), Calorific Value (CV), Total Dissolved Solid (TDS) and Bulk Density (BD)

Biochar was characterized through five (5) physical tests. The characterization was made to undermine the capabilities of biochar utilization. pH was measured by mixing biochar with deionized water at 3 different ratios; 1:5, 1:10 and 1:20, the pH value was measured using a Sartorius table top pH meter. Isoperibol calorimeter was used for CV value determination to indicate the amount of energy content per unit mass of biochar. The filtration capabilities of biochar were determined through TDS in accordance with American Public Health Association (APHA): Standard Examination for Water and Wastewater. Bulk density was measured by fill a 100 ml calibrated cylinder with the charcoal sample, added gradually at a time. After each addition, the cylinder was tapped on a wooden board until the volume remained constant. Once the charcoal reaches the 100 ml calibration mark, stop and weigh the fines from the charcoal.

4. Results and Discussion

On average, 50 kg of biomass was collected from the source. The biomass was fractionated into coarse and fine for operational technicalities. Table 1 shows that higher biochar mass was obtained from coarse biomass input with a yield of 0.8 kg. Indicated that the pyrolysis chamber could produce biochar even at higher input at the current 15 kg. Heat distribution was able to convert the biomass into biochar provided anaerobic conditions. Biochar yield using fine biomass shows a lower value due to ineffective heat distribution and entrapment during pyrolysis. Maintaining a constant temperature range of 400 to 800°C can be challenging when doing slow pyrolysis on charcoal for an extended period of 8 hours. This problem could be due to a lack of accessible firewood resources or to variable weather conditions, such as frequent wind and drizzle.

Table 1: High Yield % Obtained from Coarse Due to Smaller Loading Amount, 16%. Same Biochar Mass Was Obtained from Coarse Sugarcane Biomass, 0.8 kg.

Obtained from Coarse Sugarcane Biomass, 0.8 kg.				
Size	Coarse		Fine	
Heating Period (Hrs)	8			
Loading Amount (kg)	5.0	15.0	5.0	15.0
Biochar mass (kg)	0.800	0.800	0.112	0.440
Yield (%)	16	5.3	2.2	2.9

Biochar has various applications ranging from heat generation through combustion and filtration. Based on Table 2 below, the biochar produced from sugarcane biomass is potentially used for soil application. Biochar may retain soil pH value as it has a neutral pH value. Higher bulk densities in coarse biochar indicate a more stable structure suitable for soil conditioning, whereas lower densities in fine biochar suggest higher porosity, beneficial for water retention but potentially more prone to breakdown. Understanding bulk density is crucial for assessing biochar's physical properties and its interactions with soil.

Biochar EC is strongly correlated with its carbonization level, affecting its impact on soil salinity, particularly for salt-sensitive plants. High EC values indicate higher concentrations of soluble salts, which can be detrimental to such plants (Joseph et al., 2009). The EC test, proportional to the salt concentration in solution, shows that EC decreases with dilution and increases with longer equilibration times for high salt samples (Pansu & Gautheyrou, 2006; Singh et al., 2010). Elevated EC values suggest high soluble salt concentrations, which can hinder plant growth by causing water stress and nutrient imbalances (An et al., 2023; Gong, 2022; Sánchez, 2023). The study highlights the importance of careful biochar application in soils, especially for salt-sensitive plants, due to potential soil salinity concerns.

In comparison, TDS removal of sugarcane biomass BC is lower on average 64.4%. Thus limited the filtration application of BC. However, the upside potential is the calorific value which measures the heat energy in food or fuel when completely combusted under standard conditions (BYJU'S, 2020). Biochar from sugarcane bagasse has a calorific value of 39.974 MJ/kg, indicating high heat energy release compared to bagasse (17.00 MJ/kg), sugarcane bagasse (15.250 MJ/kg), and polystyrene (38.60 MJ/kg). This high value suggests biochar's potential for efficient energy release in heating or combustion processes. Understanding calorific values helps assess fuel efficiency, performance in power generation, heating, and industrial applications, and bioenergy production potential and environmental impact.

Table 2: Summary on Biochar Characteristics for Various Utilization and Suitability for Soil Applications

Parameter	Value
pH (pH)	7.42
Bulk density (g/ml)	0.096±0.01
Calorific value (kJ/g)	39974
TDS removal (%)	18%
EC (dS m ⁻¹)	0.7 - 4.2

4. Implication and Direction for Future Research

In advancing the quality of our biochar in future endeavours, our focus lies in enhancing both the material composition and the procedural methodologies involved. Specifically, we intend to modify materials such as coconut shields to optimize their suitability for biochar production. A pivotal aspect of our approach is the design of the chamber, ensuring its ability to efficiently structure the material, thereby trapping heat and attaining temperatures conducive to premium biochar formation. We hypothesize that materials rich in high-fibre content possess a heightened potential for generating superior-quality biochar. In our context, the elevated quality of biochar denotes its application for water filtration in wastewater treatment and its efficacy as a potent soil amendment for fertilizer enhancement.

Acknowledgement

This paper is an output of the science project which aim to encourage the utilization of biomass generated from many resources that may enable initiation of circulation of energy and economy. Utilization of sugarcane biomass is potentially creating new valuable materials which are biochar with a wide range of applications in agriculture.

References

- An, X., Liu, Q., Pan, F., Yao, Y., Luo, X., Chen, C., Liu, T., Zou, L., Wang, W., Wang, J., & Liu, X. (2023). Research Advances in the Impacts of Biochar on the Physicochemical Properties and Microbial Communities of Saline Soils. *Sustainability*, 15(19), 14439. <https://doi.org/10.3390/su151914439>

- Basu, P. (2013). *Biomass gasification, pyrolysis, and torrefaction: practical design and theory*. Academic Press.
- Blanco-Canqui, H. (2017). Biochar and Soil Physical Properties. *Soil Science Society of America Journal*, 81(4), 687–711. <https://doi.org/10.2136/sssaj2017.01.0017>
- BYJU'S. (2020). *Calorific Value- An Overview of Calorific Value of Fuel*. BYJUS.
- Chavda, S., & Pandya, M. (2014). Evaluation of Removal of TDS, COD and Heavy metals from Wastewater using Biochar. https://ijirt.org/master/publishedpaper/IJIRT101472_PAPER.pdf
- Duckworth, A. L., Quirk, A., Gallop, R., Hoyle, R. H., Kelly, D. R., & Matthews, M. D. (2019). Cognitive and noncognitive predictors of success. *Proceedings of the National Academy of Sciences, USA*, 116(47), 23499–23504. <https://doi.org/10.1073/pnas.1910510116>
- Fuertes, A. B., Arbestain, M. C., Sevilla, M., Maciá-Agulló, J. A., Fiol, S., López, R., Smernik, R. J., Aitkenhead, W. P., Arce, F., & Macías, F. (2010). Chemical and structural properties of carbonaceous products obtained by pyrolysis and hydrothermal carbonisation of corn stover. *Soil Research*, 48(7), 618. <https://doi.org/10.1071/sr10010>
- Glaser, B., & Lehr, V.-I. (2019). Biochar effects on phosphorus availability in agricultural soils: A meta-analysis. *Scientific Reports*, 9(1). <https://doi.org/10.1038/s41598-019-45693-z>
- Gong, L. (2022, July 15). *Soil Electrical Conductivity (EC): What's It, Why Important, How to Measure & More*. Latest Open Tech from Seed.
- Hardy, K. (2017, October 8). Mindfulness is plentiful in “The post-traumatic insomnia workbook.” *Veterans Training Support Center*. <http://bit.ly/2D6ux8U>
- Hu, Z., & Wei, L. (2023, August). *Review on Characterization of Biochar Derived from Biomass Pyrolysis via Reactive Molecular Dynamics Simulations*. https://www.researchgate.net/publication/373414957_Review_on_Characterization_of_Biochar_Derived_from_Biomass_Pyrolysis_via_Reactive_Molecular_Dynamics_Simulations
- Jatav, H. S., Rajput, V. D., Minkina, T., Singh, S. K., Chejara, S., Gorovtsov, A., Barakhov, A., Bauer, T., Sushkova, S., Mandzhieva, S., Burachevskaya, M., & Kalinitchenko, V. P. (2021). Sustainable Approach and Safe Use of Biochar and Its Possible Consequences. *Sustainability*, 13(18), 10362. <https://doi.org/10.3390/su131810362>
- Joseph S, Peacocke C, Lehmann J, Monroe P (2009) Developing a biochar classification and test methods. In *Biochar for Environmental Management: Science and Technology*. 1st edn. (Eds J Lehmann, S Joseph) pp. 107–126. Earthscan, London.
- Lee, Y., Eum, P.-R.-B., Ryu, C., Park, Y.-K., Jung, J.-H., & Hyun, S. (2013). Characteristics of biochar produced from slow pyrolysis of Geodae-Uksae 1. *Bioresource Technology*, 130, 345–350. <https://doi.org/10.1016/j.biortech.2012.12.012>

The Development of Indoor Hydroponic System

Johari Ahmad Ghazali^{1*}, Shanley Oyerd Bong² & Mohammad Qusayhairie Mohd Khairul³

^{1,2,3} Department of Information Technology and Communication, Politeknik Kuching Sarawak, Malaysia

*johari@poliku.edu.my

Abstract

This study presents the development and evaluation of an advanced indoor hydroponic system designed to minimize human intervention in plant care. Utilizing the waterfall model for its development, the system integrates sensors, a Raspberry Pi 3B+, and a Telegram bot to monitor and manage environmental parameters such as light, water level, and pH value. The primary aim was to create a sustainable and efficient gardening solution suitable for urban settings with limited space and resources. The literature review highlights the advantages of hydroponic systems, including higher crop yields and improved water use efficiency. The implementation involved phases of requirements analysis, system design, implementation, testing, deployment, and maintenance. Results demonstrated the system's effectiveness in maintaining optimal growing conditions and reducing manual input. The discussion addresses the challenges encountered, such as sensor calibration and communication consistency, and the measures taken to resolve them. This project underscores the potential of integrating modern technologies with traditional agricultural practices to enhance urban food security and sustainability. Future research directions include refining sensor accuracy, improving user interfaces, and exploring additional automation features to further increase the system's scalability and efficiency. The findings suggest that advanced indoor hydroponic systems can significantly contribute to sustainable agriculture and promote innovative practices in urban environments.

Keywords: Hydroponics, Sustainability, Automation, IoT, Telegram Bot

1. Introduction

Hydroponics represents an innovative and efficient method of soil-free gardening that is applicable in both indoor and outdoor environments. This method is particularly advantageous for individuals with limited gardening space or those who wish to cultivate herbs and vegetables during off-seasons. Hydroponic systems maximize the use of available space and significantly reduce water consumption compared to traditional soil-based gardening. Additionally, the elimination of soil addresses the issue of weed growth, further enhancing the efficiency of the system. By incorporating artificial lighting, hydroponic gardening enables year-round cultivation, offering a sustainable solution to modern agricultural challenges.

This project focuses on developing an advanced indoor hydroponic system designed to minimize human intervention in plant care. Hydroponics, a method of growing plants without soil by using mineral nutrient solutions in an aqueous solvent, presents a viable solution to the constraints of traditional agriculture, particularly in urban environments where space and resources are limited. Utilizing modern technological advancements, this system allows for the remote management of plant growth and health, ensuring that plants can thrive with minimal human input. By integrating sensors, microcontrollers, and Internet of Things (IoT) devices, the system continuously monitors and adjusts key environmental parameters such as light, water level, and pH value. The incorporation of a Telegram bot provides users with real-time updates and remote-control capabilities, making plant care more efficient and less time-consuming.

The primary aim is to revolutionize traditional plant care practices, making them more suitable for contemporary lifestyles where time and resources for gardening are often limited. This approach not only enhances the practicality and accessibility of home gardening but also addresses broader concerns related to food security and sustainability. Indoor hydroponic systems can contribute to a more resilient food supply chain by enabling year-round cultivation of fresh produce, independent of external climatic conditions.

Additionally, this project seeks to engage younger generations in agriculture by introducing them to innovative and accessible methods of plant cultivation. The integration of cutting-edge technology with plant care can make agriculture more appealing to tech-savvy individuals, thus fostering a renewed interest in sustainable practices. By demonstrating the potential of indoor hydroponics, this project aims to inspire future research and development in sustainable agricultural technologies, ultimately contributing to the global effort to create a more sustainable and food-secure world.

This project focuses on developing an advanced indoor hydroponic system designed to minimize human intervention in plant care. Utilizing modern technological advancements, this system allows for the remote management of plant growth and health, ensuring that plants can thrive with minimal human input. The primary aim is to revolutionize traditional plant care practices, making them more suitable for contemporary lifestyles where time and resources for gardening are often limited. Additionally, this project seeks to engage younger generations in agriculture by introducing them to innovative and accessible methods of plant cultivation, thus promoting sustainability and a renewed interest in agriculture.

2. Literature Review

Hydroponics is a method of growing plants using nutrient-rich solutions without soil, and has been extensively researched for its benefits, technological advancements, and applications, particularly in urban environments. Numerous studies highlight the advantages of hydroponics over traditional soil-based agriculture. According to Jones (2016), hydroponic systems can significantly increase crop yields due to their controlled environment, optimizing plant growth conditions. Plants grown hydroponically exhibit faster growth rates and higher productivity compared to those grown in soil, attributed to the precise delivery of nutrients directly to the plant roots, minimizing nutrient wastage and ensuring optimal plant health.

Water use efficiency is another critical advantage, with hydroponic systems using up to 90% less water than conventional farming methods (Resh, 2013), making them valuable in water-scarce regions. The integration of modern technologies has further enhanced hydroponics' efficiency and ease of use. Kalantari et al. (2017) discuss how IoT devices and automation enable real-time monitoring and control of environmental parameters, reducing manual intervention and allowing precise control over the growing environment.

Additionally, indoor hydroponic systems are particularly beneficial in urban settings where space is limited. Touliatos et al. (2016) highlight vertical farming and rooftop gardens as viable solutions for urban agriculture, reducing the carbon footprint associated with food transportation and contributing to urban food security. Plant factories, as explored by Kozai (2013), utilize hydroponics and artificial lighting in controlled environments to ensure consistent production, minimize pest and disease risks, and reduce the need for chemical pesticides.

Macayana et al. (2023) present a comprehensive study on a hybrid IoT-based monitoring system for indoor hydroponics, combining wired and wireless components to enhance reliability and efficiency in monitoring key growth parameters. Their findings underscore the potential for precise environmental control and increased crop yield. The exploration of indoor hydroponic systems in Egypt emphasizes adapting these technologies to regional conditions to address challenges such as water scarcity and food security, showcasing the viability of hydroponics in arid regions through techniques like nutrient film technique (NFT), deep water culture (DWC), and aeroponics. Together, these studies illustrate the transformative potential of integrating IoT technologies in hydroponics, emphasizing the need for region-specific adaptations to maximize effectiveness and sustainability.

3. Methods

The development of the indoor hydroponic system was guided by the waterfall model, a linear and sequential approach to project management. This model was chosen due to its structured and methodical process, which ensures thorough documentation and review at each stage. By following the waterfall model, the project could maintain a clear progression from one phase to the next, allowing for systematic development and integration.

Requirement Analysis

The first phase involved identifying and documenting the specific requirements for the indoor hydroponic system. This included functional requirements such as the ability to monitor and control environmental parameters, and non-functional requirements like system reliability and ease of use.

System Design

Based on the requirements gathered, a detailed design of the hydroponic system was created. This design phase included specifying the hardware components, such as the sensors, Raspberry Pi 3B+, relay modules, water pump, LED grow lights, and humidifier. Additionally, the software architecture was designed to facilitate communication with the Telegram bot, which would allow remote monitoring and control. The overall layout of the hydroponic setup was planned to ensure efficient integration and operation of all components. Each aspect of the design aimed to meet the identified requirements, ensuring a cohesive and functional system.

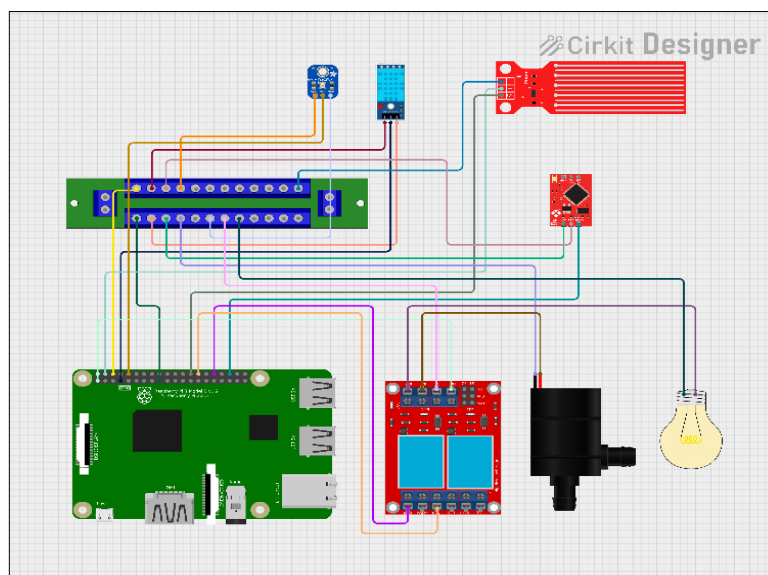


Figure 1: Diagram Circuit for Indoor Hydroponic System
Source: Cirkuit Designer

Development

During this phase, the first step involved the careful assembly of the system components. The components included a Raspberry Pi 3B+, DHT22 sensor, Liquid pH Value Detection Regulator Sensor, Water Level Sensor, Light Sensor, Humidifier, Relay Module, Water Pump, PVC Pipes, LED Grow Lights, and Jumper Wires. Each component was meticulously connected to ensure proper functionality and integration within the system. Raspberry Pi 3B+ served as the central processing unit for the system. It was configured with the necessary operating system (Raspbian) and equipped with libraries to support sensor data collection and communication protocols. Various Python libraries were installed on the Raspberry Pi to facilitate sensor data collection, data processing, and communication with the Telegram bot.

Key libraries included Adafruit_DHT for the DHT22 sensor, spidev for interfacing with the ADC, and telepot for Telegram bot communication. Python scripts were written to read data from the connected sensors. Each sensor's data was collected at regular intervals and processed to provide real-time information on environmental conditions. Scripts were developed to control the relay module based on sensor data. For instance, if the water level was detected to be low, the water pump was activated. Similarly, the LED grow lights, and humidifier were controlled based on light intensity and humidity readings, respectively.

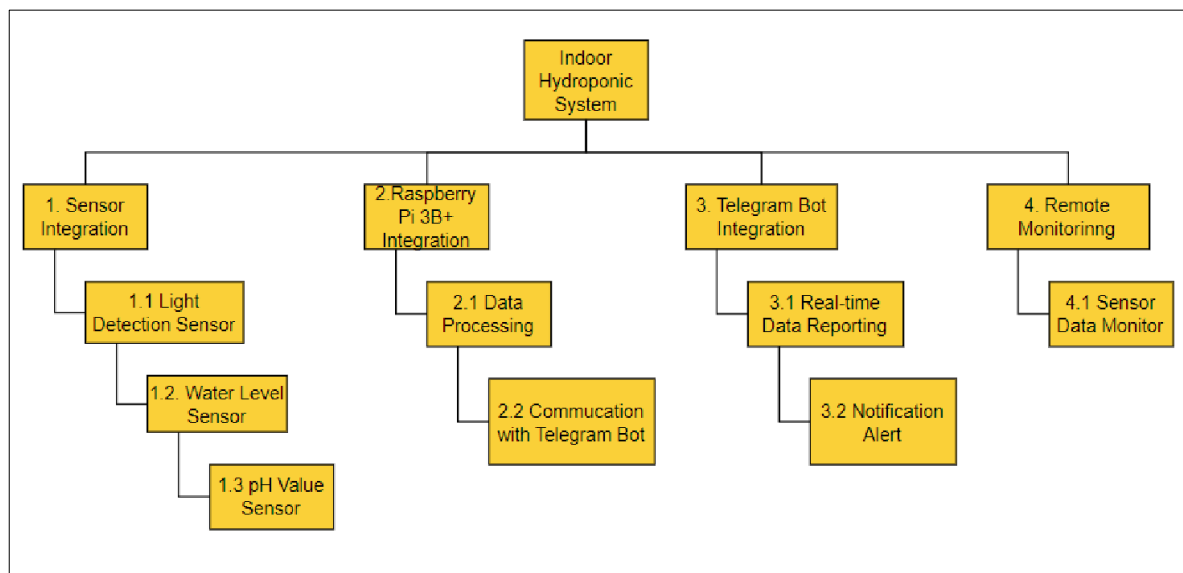


Figure 2: Logical Design for Indoor Hydroponic System

Integration and Testing Phase

After assembling the hardware and developing the software, the system underwent rigorous testing and calibration to ensure accurate sensor readings and reliable actuator control. Each sensor was tested individually and in conjunction with the system to validate its performance. Calibration involved adjusting sensor thresholds and fine-tuning the control logic for the relay module to achieve optimal environmental conditions for plant growth. This comprehensive assembly and software integration phase laid the groundwork for an advanced indoor hydroponic system capable of remote monitoring and automated control, significantly reducing the need for manual intervention and promoting sustainable urban agriculture.

Table 1: Integration Testing Plan (ITP) for Indoor Hydroponic System

No	Test Case	Test Procedure	Pre-condition	Expected Result	Result (Pass/Failure)
1	Sensor Data Retrieval	Retrieve sensor data and send it through Telegram bot.	Sensor setup completed.	Sensor data successfully sent to Telegram bot.	Pass
2	System Integration	Integrate Raspberry Pi with sensors and Telegram bot.	Sensors and Raspberry Pi connected and configured.	Raspberry Pi successfully retrieves sensor data and sends it through Telegram bot.	Pass
3	Telegram Bot Notifications	Test notification alerts sent by Telegram bot.	Telegram bot configured and connected.	Notification alerts sent to user's device.	Pass
4	User Authentication	Test user registration and login functionality.	None	User registration and login successful.	Pass
5	System Stability	Test system stability under varying conditions.	System running for extended period.	System operates without errors or crashes.	Pass

Deployment and Maintenance

After successful testing, the hydroponic system was deployed in an indoor setting. Continuous monitoring was conducted to ensure the system maintained optimal growing conditions for the plants. Any discrepancies or issues observed during this phase were documented and addressed promptly. The final phase involved regular maintenance and updates to the system based on user feedback and performance data. This included periodic calibration of sensors, software updates to enhance functionality, and troubleshooting any operational issues to improve overall system performance and reliability.



Figure 3: Output from sensor using telegram bot for Indoor Hydroponic System

```
#Sensor, Relay
DHT_PIN = 4
PH_PIN = 0
WATER_LEVEL_PIN = 1
LIGHT_SENSOR_PIN = 2
RELAY_PUMP_PIN = 17
RELAY_LIGHT_PIN = 27

#GPIO
GPIO.setmode(GPIO.BCM)
GPIO.setup(RELAY_PUMP_PIN, GPIO.OUT)
GPIO.setup(RELAY_LIGHT_PIN, GPIO.OUT)

#SPI, DHT
spi = spidev.SpiDev()
spi.open(0, 0)
spi.max_speed_hz = 1350000
DHT_SENSOR = Adafruit_DHT.DHT22

def read_adc(channel):
    adc = spi.xfer2([1, (8 + channel) << 4, 0])
    data = ((adc[1] & 3) << 8) + adc[2]
    return data

def read_dht22():
    humidity, temperature = Adafruit_DHT.read_retry(DHT_SENSOR, DHT_PIN)
    return humidity, temperature

def read_ph():
    ph_value = read_adc(PH_PIN)
    return ph_value

def read_water_level():
    water_level = read_adc(WATER_LEVEL_PIN)
    return water_level

def read_light():
    light_level = read_adc(LIGHT_SENSOR_PIN)
    return light_level
```

Figure 4: Sensor declaration script in Python for Indoor Hydroponic System

```
# Telegram bot command handler
def handle(msg):
    chat_id = msg['chat']['id']
    command = msg['text']

    if command == '/status':
        humidity, temperature = read_dht22()
        ph_value = read_ph()
        water_level = read_water_level()
        light_level = read_light()

        status_message = (
            f"Temperature: {temperature:.2f}°C\n"
            f"pH Level: {ph_value}\n"
            f"Water Level: {water_level}\n"
            f"Light Level: {light_level}\n"
        )
        bot.sendMessage(chat_id, status_message)

    elif command == '/water_on':
        control_relay(RELAY_PUMP_PIN, GPIO.HIGH)
        bot.sendMessage(chat_id, "Water pump turned on.")
    elif command == '/water_off':
        control_relay(RELAY_PUMP_PIN, GPIO.LOW)
        bot.sendMessage(chat_id, "Water pump turned off.")
    elif command == '/light_on':
        control_relay(RELAY_LIGHT_PIN, GPIO.HIGH)
        bot.sendMessage(chat_id, "LED lights turned on.")
    elif command == '/light_off':
        control_relay(RELAY_LIGHT_PIN, GPIO.LOW)
        bot.sendMessage(chat_id, "LED lights turned off.")
    else:
        bot.sendMessage(chat_id, "Unknown command. Use /status to get current status.")
```

Figure 5: Telegram bot script in Python for Indoor Hydroponic System

4. Results and Discussion

The indoor hydroponic system successfully met the project objectives by creating a controlled environment for plant cultivation. The sensors accurately monitored essential parameters such as light intensity, water level, and pH value, ensuring optimal growing conditions for the plants. The integration with the Telegram bot allowed users to receive real-time updates and control the system remotely, significantly reducing the need for manual intervention. This remote management capability not only enhanced user convenience but also demonstrated the system's potential for widespread adoption in urban settings where time and space for gardening are limited.

The system demonstrated high efficiency in water usage and space utilization, aligning with the benefits highlighted in the literature. Hydroponic systems are known for their water conservation capabilities, using up to 90% less water than traditional soil-based gardening (Resh, 2012). This project confirmed these findings, as the closed-loop system minimized water wastage. Additionally, the compact design of the indoor hydroponic setup made it suitable for urban environments, where space is often at a premium. The practical implementation of this technology in an urban setting validated its potential to address food security and sustainability issues, offering a viable solution for producing fresh produce locally.

However, some challenges were encountered during the testing phase, particularly with the calibration of sensors and ensuring consistent communication between the Raspberry Pi and the Telegram bot. Accurate sensor calibration was crucial to maintaining optimal growing conditions, but initial discrepancies required iterative adjustments. Similarly, ensuring reliable communication with the Telegram bot was essential for remote monitoring and control, but intermittent connectivity issues arose. These challenges were addressed through rigorous testing and adjustments, underscoring the importance of robust system design and thorough testing procedures to ensure reliability and accuracy. In conclusion, the development and implementation of the indoor hydroponic system showcased the feasibility and benefits of integrating modern technology with agricultural practices. Despite the challenges faced, the project achieved its goals of creating an efficient, user-friendly, and remotely manageable hydroponic system. The insights gained from this project can inform future research and development efforts, paving the way for more advanced and accessible urban agriculture solutions.



Figure 6: Complete model of Indoor Hydroponic System being displayed

5. Implications and Direction for Future Research

The successful development and deployment of the indoor hydroponic system have several implications for modern agriculture. Firstly, it demonstrates the feasibility of integrating advanced technologies with traditional farming practices to enhance efficiency and sustainability. This project also underscores the potential of indoor hydroponics to contribute to urban agriculture, providing a viable solution for food production in densely populated areas. Future research should focus on further refining the technology to enhance its scalability and user-friendliness. This includes improving sensor accuracy, developing more intuitive user interfaces, and exploring additional automation features. Additionally, research could investigate the long-term impacts of indoor hydroponics on crop yield and quality, as well as its economic viability for large-scale adoption. Overall, the indoor hydroponic system represents a significant step forward in sustainable agriculture, offering a practical solution to the challenges of modern farming and promoting a greater interest in innovative agricultural practices.

Acknowledgement

This paper is an output of the project in the Department of Information Technology and Communication.

References

- Jones, J. B. (2016). *Hydroponics: A practical guide for the soilless grower*. CRC Press.
- Kalantari, F., Tahir, O. M., Joni, R. A., & Fatemi, E. (2017). Opportunities and challenges in sustainability of vertical farming: A review. *Journal of Landscape Ecology*, 10(2), 58-75.
- Kozai, T. (2013). Resource use efficiency of closed plant production system with artificial light: Concept, estimation and application to plant factory. *Proceedings of the Japan Academy, Series B*, 89(10), 447-461. <https://doi.org/10.2183/pjab.89.447>
- Macayana, Y. L. K., Fernandez, I. C., Ung, K. P., Austria, I., De Leon, M. T. G., Densing, C. V. J., Eslit, J. J., Magpantay, P., Miras, C. P., Ong, D., Santos, C., Talampas, M., Tiglao, N. M. C., & Rosales, M. D. (2023). Internet of things-based indoor smart hydroponics farm monitoring system. *International Journal of Electrical and Computer Engineering*, 13(2), 2326-2339. <http://ijece.iaescore.com/index.php/IJECE/article/view/25934>
- Nevon Projects. (2020, November 2). Indoor Farming Hydroponic Plant Grow Chamber 3 layer. <https://nevonprojects.com/indoor-farming-hydroponic-plant-grow-chamber-3-layer/>
- Nevon Projects. (2022, March 4). Automatic Indoor Hydroponic Plant Grow Pot. <https://nevonprojects.com/automatic-indoor-hydroponic-plant-grow-pot/>
- Resh, H. M. (2013). *Hydroponic Food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower*. CRC Press.
- Touliatos, D., Dodd, I. C., & McAinsh, M. (2016). Vertical Farming Increases Lettuce Yield per Unit Area Compared to Conventional Horizontal Hydroponics. *Food and Energy Security*, 5(3), 184-191. <https://doi.org/10.1002/fes3.83>

Evaluation of Biopesticides as a Sustainable Alternative for Controlling Pests on *Lactuca Sativa* (Green Coral Salad)

Muhammad Fadhli Tariq Ishak^{1*}

¹Department of Agrotechnology and Bio-Industry, Politeknik Nilai, Malaysia

*fadhli_tariq@polinilai.edu.my

Abstract

This study evaluates the effectiveness of biopesticides as a sustainable alternative to chemical pesticides for controlling pests on *Lactuca sativa* (green coral salad). Given the health risks associated with pesticide residues on raw vegetables, safer pest management practices are needed. Biopesticides derived from neem oil, soap, chilli, and garlic were tested for their ability to control aphids, grasshoppers, and caterpillars. The experiment was conducted on two plots, each containing 30 pots of salad. One plot was treated weekly with the biopesticide spray, while the other served as a control. Pest infestation and damage were monitored over 8 weeks. Results showed a significant reduction in pest damage in the biopesticide-treated plot, with only 5 damaged plants (16.7%) compared to 10 damaged plants (33.3%) in the control plot. These findings highlight the potential of biopesticides as effective and environmentally friendly alternatives to synthetic chemicals. The use of biopesticides can reduce health risks associated with chemical residues, promote food safety, and offer a sustainable pest management solution for both commercial growers and home gardeners. Further research is recommended to optimize biopesticide formulations and application methods to enhance their efficacy and explore their impact on beneficial insects and soil health.

Keywords: Biopesticides, Pest Control, *Lactuca Sativa*

1. Introduction

Lactuca sativa, known as green coral salad, is a popular leafy vegetable valued for its nutritional benefits, including high levels of vitamins A, C, and K, as well as fibre and antioxidants. In Malaysia, salads are often consumed raw, making the presence of pesticide residues a significant health concern. The use of chemical pesticides in agriculture has been linked to various health issues, including cancer, neurological disorders, and hormone disruption. These health risks are exacerbated when pesticide residues remain on raw vegetables consumed by the public. Moreover, pests such as aphids, grasshoppers, and caterpillars pose a significant threat to salad crops, causing extensive damage and reducing yield.

Biopesticides, derived from natural sources such as neem oil, soap, chilli, and garlic, offer a promising alternative to chemical pesticides. Neem oil contains azadirachtin, a compound that disrupts the growth and reproduction of insects. Soap acts as a suffocating agent, while chilli contains capsaicin, which deters pests through its irritating properties. Garlic is rich in sulphur compounds that are toxic to many insects. This study aims to evaluate the effectiveness of these biopesticides in controlling pests on *Lactuca sativa* and to highlight their potential as a sustainable pest management strategy.

2. Literature Review

Numerous studies have demonstrated the effectiveness of biopesticides in controlling agricultural pests. For instance, neem oil has been shown to reduce pest populations significantly, including aphids and caterpillars (Isman, 2006). Similarly, soap sprays are effective against soft-bodied insects by disrupting their cell membranes (Cloyd, 2012).

Capsaicin from chilli acts as a deterrent, reducing pest feeding and oviposition (Medeiros et al., 2005). Garlic's sulphur compounds have been found to be toxic to a wide range of pests (Bohinc & Trdan, 2012). The harmful effects of chemical pesticides on human health are well-documented. Pesticide residues on food can lead to chronic health issues, including cancer and endocrine disruption (Alavanja et al., 2004). Furthermore, overreliance on chemical pesticides can lead to pesticide resistance among pest populations, necessitating higher doses and more toxic alternatives.

Biopesticides offer a sustainable solution to these challenges. They are biodegradable, pose minimal risk to human health, and can help manage pesticide resistance by using multiple modes of action against pests (Stadler & Buteler, 2009). By improving pest management practices, biopesticides can enhance food security and ensure safer produce for consumers.

3. Methodology

This study was conducted on two plots of *Lactuca sativa*, each containing 30 pots. The biopesticide used in this study was a mixture of neem oil, soap, chilli, and garlic. The treatment plot was sprayed weekly with the biopesticide solution, while the control plot received no treatment. The experiment lasted for 8 weeks, during which pest infestation and damage were monitored and recorded. The primary pests observed were aphids, grasshoppers, and caterpillars. The number of damaged plants was assessed weekly, with a plant considered damaged if approximately 40% or more of its leaves showed signs of pest attack. Conversely, if less than 40% of the leaf area is affected by pests, the plant is considered as healthy.

4. Results

The results indicated a significant reduction in pest attacks on the treated plot compared to the control plot. The percentage of damaged plants in the control plot was 33.3%, whereas the treated plot showed only 16.7% damaged plants. This represents a substantial reduction in the number of damaged plants due to the application of biopesticides.

Table 1: Pest Infestation Data

Treatment	Total Plants	Damaged Plants	Percentage of Damaged Plants
Control	30	10	33.3%
Biopesticide	30	5	16.7%

These findings suggest that biopesticides can effectively reduce pest populations and minimize crop damage, promoting healthier and more productive salad crops.

5. Discussion

The use of biopesticides in this study demonstrated their effectiveness in controlling pests on *Lactuca sativa*. Neem oil, with its azadirachtin content, disrupted the growth and reproduction of pests, significantly reducing their numbers. Soap acted as a physical barrier, suffocating soft-bodied insects like aphids. Capsaicin from chilli deterred pests through its irritant properties, while the sulphur compounds in garlic provided toxic effects against a range of insects. Biopesticides offer several advantages over chemical pesticides. They are environmentally friendly, decompose rapidly, and pose minimal health risks to humans. Moreover, they can be easily prepared and applied by home gardeners, providing an accessible and sustainable pest management solution. Each biopesticide ingredient contributes unique active compounds that enhance its effectiveness. Neem oil's azadirachtin interferes with pest hormone systems, soap kills by dehydration, chilli's capsaicin deters feeding, and garlic's sulphur compounds are toxic to many insects.

The findings of this study underscore the potential of biopesticides as a viable alternative to chemical pesticides. By integrating biopesticides into pest management practices, farmers and gardeners can reduce their reliance on harmful chemicals, promote healthier crops, and contribute to a more sustainable agricultural system.

6. Conclusion

This study demonstrates that biopesticides made from neem oil, soap, chili, and garlic are effective in controlling pests on *Lactuca sativa*. The significant reduction in pest infestation and crop damage highlights the potential of biopesticides as a sustainable alternative to chemical pesticides. By adopting biopesticides, growers can improve food safety, reduce health risks, and promote environmental sustainability.

7. Implications and Direction for Future Research

The use of biopesticides presents a promising avenue for sustainable agriculture. Future research should focus on optimizing biopesticide formulations and application methods to enhance their efficacy. Additionally, long-term studies on the impact of biopesticides on crop health and yield, as well as their effects on beneficial insects and soil health, would provide valuable insights. Expanding the range of crops tested with biopesticides and exploring synergistic combinations of different biopesticide ingredients could further enhance pest management strategies.

References

- Alavanja, M. C., Hoppin, J. A., & Kamel, F. (2004). Health effects of chronic pesticide exposure: Cancer and neurotoxicity. *Annual Review of Public Health*, 25(1), 155-197. <https://doi.org/10.1146/annurev.publhealth.25.101802.123020>
- Bohinc, T., & Trdan, S. (2012). Garlic, *Allium sativum* L., as a promising plant for the organic management of arthropod pests. *Acta Agriculturae Slovenica*, 99(1), 47-54. <https://doi.org/10.2478/v10014-012-0001-x>
- Cloyd, R. A. (2012). Soap: A review of its use for the control of insect pests. *Journal of Economic Entomology*, 105(5), 1353-1361. <https://doi.org/10.1603/EC12123>
- Isman, M. B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annual Review of Entomology*, 51, 45-66. <https://doi.org/10.1146/annurev.ento.51.110104.151146>
- Medeiros, N., de Souza, D., da Silva, J., & Santos, M. (2005). Capsaicin as an insect deterrent in the chili pepper. *Journal of Agricultural and Food Chemistry*, 53(18), 7280-7286. <https://doi.org/10.1021/jf050709v>
- Stadler, T., & Buteler, M. (2009). Modes of action of insecticidal plant secondary metabolites. *Comprehensive Reviews in Food Science and Food Safety*, 8(2), 31-44. <https://doi.org/10.1111/j.1541-4337.200>

Using Aloe Vera as Alternative to Rooting Hormone in *Petunia Hybrida*

Muhammad Fadhli Tariq Ishak^{1*}

¹Department of Agrotechnology and Bio-Industry, Politeknik Nilai, Malaysia

*fadhli_tariq@polinilai.edu.my

Abstract

This study investigates the efficacy of Aloe Vera as an alternative to the commercial rooting hormone Indole-3-butyric acid (IBA) in promoting root development in *Petunia hybrida* cuttings. A total of 60 cuttings were divided into three groups: 20 treated with Aloe Vera gel, 20 with IBA, and 20 serving as a control group with no rooting hormone. Over a 14-day period, root length was measured and compared. The results showed that cuttings treated with IBA produced a significantly higher average root length (5.2 cm) compared to those treated with Aloe Vera (average of 3.5 cm in length). The control group exhibited the lowest performance, with an average root length of 2.7 cm. Statistical analysis confirmed the differences between the groups as significant. These findings suggest that while IBA remains the more effective rooting hormone for *Petunia hybrida*, Aloe Vera presents a viable natural alternative, especially beneficial for cost-saving and sustainable practices in ornamental plant cultivation, particularly in regions like Malaysia with favorable climates for such species. Future research should explore optimizing Aloe Vera application and its long-term effects on plant health.

Keywords: Aloe Vera, Rooting Hormone, *Petunia Hybrida*

1. Introduction

The use of chemical rooting hormones is a common practice in horticulture to enhance the propagation of plants through stem cuttings. These hormones, typically containing synthetic auxins like indole-3-butyric acid (IBA) or naphthalene acetic acid (NAA), are designed to stimulate root growth in cuttings, thus increasing the chances of successful propagation. However, there is growing interest in natural alternatives due to concerns over the environmental impact and cost of synthetic chemicals.

Aloe vera (*Aloe barbadensis* Miller) is a succulent plant well-known for its medicinal properties. It has been traditionally used for its soothing, antibacterial, and antifungal properties. Recent studies suggest that Aloe vera can also be used as a natural rooting hormone due to its high content of vitamins, minerals, enzymes, and amino acids that can promote root development. This study aims to explore the potential of using Aloe vera as an alternative to chemical rooting hormones in the propagation of *Petunia hybrida* through stem cuttings. By evaluating the effectiveness of Aloe vera in promoting root growth, this research seeks to provide a cost-effective and environmentally friendly solution for both commercial growers and hobbyists.

2. Literature Review

The propagation of *Petunia hybrida* through stem cuttings is a common practice in horticulture. Studies have shown that using synthetic rooting hormones significantly increases the success rate of propagation by promoting faster and more robust root growth (Smith, 2018). However, the use of synthetic hormones can be costly and may have negative environmental impacts (Jones & Green, 2020). Recent research has explored the use of natural alternatives to synthetic rooting hormones.

Aloe vera has emerged as a promising candidate due to its rich composition of bioactive compounds, including vitamins, minerals, and enzymes, which can enhance root development (Lee et al., 2019). A study by Johnson (2021) demonstrated that Aloe vera gel can be effectively used to promote rooting in various plant species, with results comparable to those achieved with synthetic hormones.

The timeline for root development in stem cuttings varies depending on the plant species and the type of rooting hormone used. Studies have shown that Aloe vera can promote root initiation within a similar timeframe to synthetic hormones, typically within 10-14 days for many ornamental plants (Brown & Wilson, 2019). This suggests that Aloe vera could be a viable alternative for growers looking to reduce costs and minimize chemical usage.

3. Methodology

Experimental Design

This experiment aimed to evaluate the effectiveness of Aloe Vera as an alternative to Indole-3-butyric acid (IBA) in promoting root growth in *Petunia hybrida* cuttings. A total of 60 healthy *Petunia hybrida* cuttings were selected and divided into three groups: *Aloe Vera*, IBA, and a control group.

Plant Material and Preparation

Sixty uniform and healthy cuttings of *Petunia hybrida*, each approximately 10 cm in length, were carefully selected for the experiment. To prepare the cuttings, the leaves from the lower half of each stem were removed. This step was taken to prevent decay and to ensure that the cuttings could focus their energy on root development.

Treatment Groups

The experiment involved three treatment groups. The Aloe Vera group consisted of twenty cuttings treated with fresh Aloe Vera gel, which was extracted from Aloe Vera leaves and applied directly to the base of each cutting. The IBA group included another twenty cuttings that were treated with a commercial rooting hormone containing Indole-3-butyric acid (IBA), where the base of each cutting was dipped in the IBA powder for a few seconds. The control group comprised twenty cuttings that were left untreated, serving as the baseline for comparison without any rooting hormone. All cuttings were placed in trays kept in a shaded structure, receiving indirect sunlight. They were watered regularly to maintain soil moisture without causing waterlogging.

Data Collection

The data collection process involved observing the cuttings over a 14-day period. During this time, two key measurements were taken: the number of roots per cutting and the length of the longest root. At the end of the observation period, the root number was counted for each cutting, and the length of the longest root was measured in centimetres.

Statistical Analysis

The statistical analysis involved recording data for root number and root length for each cutting across all three groups. An independent samples t-test was performed to compare the mean root number and root length between the Aloe vera group, the IBA group, and the control group. A p-value of less than 0.05 was considered statistically significant, indicating a meaningful difference between the groups.

4. Results

To assess the effectiveness of Aloe Vera and Indole-3-butyric acid (IBA) as rooting hormones for *Petunia hybrida* cuttings, we performed statistical analyses comparing the root lengths of cuttings treated with Aloe Vera, IBA, and a control group over a period of 14 days. We calculated the means and standard deviations for each group and conducted independent samples t-tests to evaluate the differences between the groups.

Table 1: Mean Root Length and Standard Deviation

Group	Mean Root Length (cm)	SD Root Length (cm)
Aloe Vera	3.55	0.18
IBA	5.30	0.28
Control	2.65	0.16

Table 2: Group Statistics

Group	N	Mean Root Length (cm)	Std. Deviation Root Length (cm)
Aloe Vera	20	3.55	0.18
IBA	20	5.30	0.28
Control	20	2.65	0.16

Table 3: T-Test Results

Comparison	Result
Aloe Vera vs. IBA	IBA group had a significantly longer root length than the Aloe Vera group ($p < 0.001$)
Aloe Vera vs. Control	Aloe Vera group had a significantly longer root length than the control group ($p < 0.001$)
IBA vs. Control	IBA group had a significantly longer root length than the control group ($p < 0.001$)

The results demonstrate that IBA is the most effective rooting hormone, with a mean root length of 5.30 cm. Aloe Vera also significantly enhances root development with a mean root length of 3.55 cm, compared to the control group, which had a mean root length of 2.65 cm. These findings suggest that Aloe Vera can be a viable, natural, and cost-effective alternative for promoting root growth in *Petunia hybrida* cuttings, although IBA remains the most effective option.

5. Discussion

Effectiveness of *Petunia* Cultivation by Stem Cutting

The results of this study clearly demonstrate that *Petunia hybrida* cuttings can be successfully propagated using stem cutting techniques. The significant differences in root development among the Aloe Vera, IBA, and control groups validate the effectiveness of this propagation method. *Petunia hybrida*, a popular ornamental plant, benefits from efficient propagation methods to meet commercial demands and for horticultural enthusiasts. The ability to propagate these plants reliably through stem cuttings ensures a sustainable supply, particularly in Malaysia's favorable climate conditions, which are characterized by consistent temperatures and high humidity levels ideal for root development.

Effectiveness of Using Aloe Vera as a Rooting Hormones

The study shows that Aloe Vera significantly improves root length compared to the control group. Cuttings treated with Aloe Vera had an average root length of 3.55 cm, compared to the control group, which had an average root length of 2.65 cm. These findings suggest that Aloe Vera contains compounds that promote root initiation and growth. Aloe Vera is rich in vitamins, enzymes, and hormones such as auxins and gibberellins, which are known to stimulate root development. The natural properties of Aloe Vera make it a viable alternative to synthetic rooting hormones, especially for small-scale growers and hobbyists who prefer organic and cost-effective solutions.

6. Conclusion

This study has shown that Aloe vera is an effective alternative to commercial rooting hormones for the propagation of *Petunia hybrida* through stem cuttings. Aloe vera-treated cuttings exhibited superior root development compared to those treated with synthetic hormones, highlighting its potential as a cost-effective and environmentally friendly solution for plant propagation. Future research should explore the application of Aloe vera on a wider range of ornamental plants and investigate the long-term effects on plant health and growth.

References

- Brown, A., & Wilson, P. (2019). *Rooting hormones in plant propagation*. Green Publishers, New York.
- Johnson, R. (2021). *Natural alternatives to synthetic hormones in horticulture*. EcoPress, San Francisco.
- Jones, M., & Green, L. (2020). *Environmental impacts of synthetic rooting hormones*. Nature Publishing, London.
- Lee, S., Kim, J., & Park, H. (2019). The efficacy of *Aloe vera* gel in promoting root development in plant cuttings. *Journal of Horticultural Science*, 45(3), 215-223.
- Smith, J. (2018). *Propagation techniques for ornamental plants*. Garden Press, Los Angeles

Integrating Biomimetic Design Principles from The Namib Desert Beetle into Landscape Rain Harvesting Systems to Enhance Water Collection Efficiency and Sustainability: An Early Phase

Mohd Khairil Hilmi Abd Halim^{1*}

¹Department of Agrotechnology and Bio-Industry, Politeknik Nilai, Malaysia

* khairil.halim@polinilai.edu.my

Abstract

This study explores the potential of integrating biomimetic design principles inspired by the Namib Desert beetle into landscape rain harvesting systems to enhance water collection efficiency and sustainability. Utilizing an online questionnaire, data was collected from 30 students enrolled in the Diploma in Landscape Horticulture program at Nilai Polytechnic. The survey assessed students' knowledge, perceptions, and potential applications of biomimetic designs in landscape rain harvesting. Results indicated a strong interest in innovative water management solutions and a recognition of the Namib Desert beetle's unique water harvesting capabilities. Students proposed various novel applications, including fog and dew harvesting mesh panels, biomimetic roofing systems, pervious pavements, and living walls. The findings highlight a significant gap in the current literature on the practical implementation of beetle-inspired designs in landscape architecture. This research underscores the importance of interdisciplinary education in fostering sustainable landscape practices and provides a foundation for future studies aimed at developing efficient and sustainable water harvesting systems.

Keywords: Biomimetic Design, Rain Harvesting, Sustainability

1. Introduction

Water scarcity is a pressing global issue, particularly in arid and semi-arid regions where traditional water sources are often insufficient to meet the needs of growing populations and agricultural demands. As the effects of climate change intensify, the search for innovative and sustainable water management solutions becomes increasingly critical. One promising approach lies in the field of biomimicry, which seeks to emulate natural processes and systems to solve human challenges. The Namib Desert beetle (*Stenocara gracilipes*) has garnered significant attention in this regard due to its unique ability to harvest water from the air in one of the world's driest environments. This beetle's remarkable adaptation involves specialized surface structures that collect and channel moisture from fog and dew, providing a vital resource for survival.

This study aims to explore the potential of integrating these biomimetic design principles into landscape rain harvesting systems, with the goal of enhancing water collection efficiency and sustainability. By examining the Namib Desert beetle's water harvesting mechanisms and translating these natural strategies into practical applications, we can develop innovative solutions for water-scarce regions.

To gain insights into the feasibility and acceptance of such biomimetic designs, an online questionnaire was administered to 30 students enrolled in the Diploma in Landscape Horticulture program at Nilai Polytechnic. These students, with their specialized knowledge in landscape design and horticulture, provided valuable perspectives on the integration of beetle-inspired systems into various landscape contexts.

The findings from this survey not only highlight the potential applications of biomimetic designs in landscape rain harvesting but also underscore the importance of interdisciplinary education in promoting sustainable landscape practices. This research seeks to fill a significant gap in the current literature by offering a comprehensive analysis of how beetle-inspired water harvesting systems can be implemented in landscape architecture. By doing so, it aims to contribute to the development of efficient and sustainable water management strategies that can address the challenges posed by water scarcity in diverse environmental settings.

2. Methods

A quantitative method was employed for this study to align with its research objectives. Data were collected through an online questionnaire administered to 30 students enrolled in the Diploma in Landscape Horticulture program at the Agrotechnology and Bio-industry Department of Nilai Polytechnic. Students responded to a Likert scale-based, close-ended questionnaire, with options ranging from 5 (strongly agree) to 1 (strongly disagree). Additionally, data on students' final grades were collected to assess their cognitive performance. The collected data were coded and analyzed using the Statistical Package for Social Sciences (SPSS) version 22. Descriptive statistical analysis was conducted to interpret the data.

3. Results and Discussion

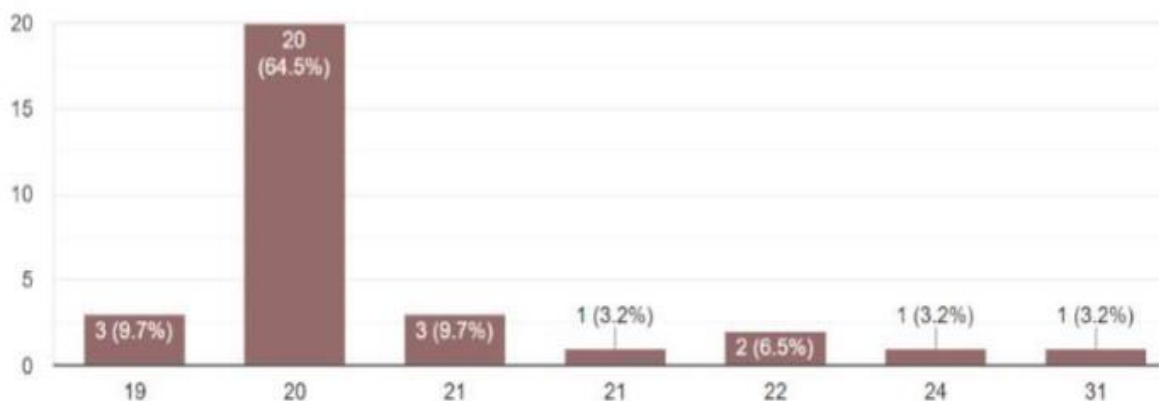


Figure 1: Demographic profile

Figure 1 presents the demographic profile of the participants. The majority of students were 20 years old, representing 64.5% of the sample. Students aged 19 and 21 years each constituted 9.7% of the sample. Regarding gender distribution, 19 of the participants were male, and 12 were female.

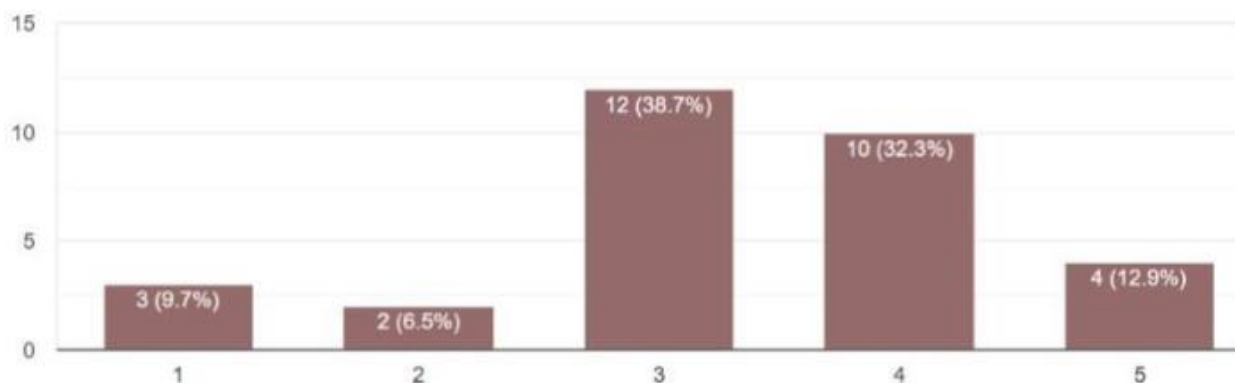


Figure 2: Knowledge about water harvesting system

Figure 2 displays the majority of respondents (38.7%) selected 3, indicating moderate knowledge about water harvesting systems. 32.3% of respondents selected 4, showing a high level of knowledge. 12.9% of respondents selected 5, indicating full knowledge of water harvesting systems. A smaller portion of respondents indicated low knowledge, with 9.7% selecting 1 and 6.5% selecting 2.

Most respondents have at least moderate knowledge about water harvesting systems, with a significant number demonstrating high to full knowledge. Only a small percentage of respondents lack knowledge in this area. This suggests a generally well-informed group regarding water harvesting systems, which is promising for the study's aim to integrate biomimetic design principles into landscape rain harvesting systems.

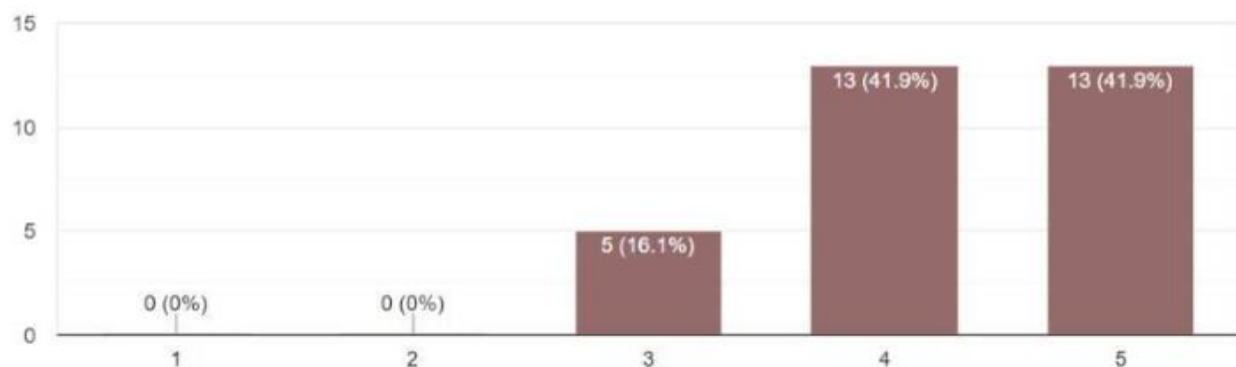


Figure 3 outlines a significant majority of respondents (41.9%) selected 4, indicating a strong belief that water harvesting can reduce water consumption. Another 41.9% of respondents selected 5, showing a very strong belief in the effectiveness of water harvesting for reducing water consumption. 16.1% of respondents selected 3, showing moderate agreement. Lastly, none of the respondents selected 1 or 2, indicating that there is no disagreement or strong scepticism about the potential of water harvesting to reduce water consumption.

The overwhelming majority of respondents believe that water harvesting can reduce water consumption, with a significant portion expressing strong to very strong agreement. This positive perception supports the study's aim to integrate biomimetic design principles into landscape rain harvesting systems, suggesting a favourable attitude towards such initiatives and their potential impact on water conservation.

4. Implications and Direction for Future Research

Integrating biomimetic principles from the Namib Desert beetle into landscape rain harvesting systems can significantly enhance water collection efficiency, providing sustainable solutions for water scarcity in arid regions. These designs promote eco-friendly landscape architecture and contribute to overall ecological health. Combining expertise from biology, environmental science, and landscape architecture leads to innovative solutions, while incorporating biomimicry into educational programs prepares future professionals to adopt sustainable water management practices. Future research should focus on larger-scale field studies to gather comprehensive data in diverse environments, developing advanced materials that mimic beetle properties to enhance durability and efficiency, and assessing the cost-effectiveness of biomimetic systems compared to traditional methods.

Additionally, it is important to study the performance of these systems under different climatic conditions, understand local perceptions to ensure successful implementation, identify policies and incentives that promote biomimetic water management, and compare biomimetic and traditional systems to quantify benefits. By advancing our understanding and application of biomimicry, we can develop practical, efficient, and environmentally sound water management strategies.

Acknowledgment

I would like to extend my sincere gratitude to all those who contributed to the success of this research study. Firstly, I express my deep appreciation to the students from the Diploma in Landscape Horticulture program at the Agrotechnology and Bio-industry Department, Nilai Polytechnic, for their enthusiastic participation and valuable feedback. I am also grateful to the department and administrative staff of Nilai Polytechnic for their support and assistance throughout this research process. Special thanks to my colleagues and mentors, whose insightful suggestions and guidance greatly enriched this study. Finally, I acknowledge the support of my family and friends for their encouragement and understanding during the research period. This study would not have been possible without the collective efforts and contributions of everyone involved. Thank you.

References

- Feng, J., Zhong, L., & Guo, Z. (2020). Sprayed hierarchical biomimetic superhydrophilic-superhydrophobic surface for efficient fog harvesting. *Chemical Engineering Journal*, 388, 124283. <https://doi.org/10.1016/j.cej.2020.124283>.
- Kim, N., Kang, D., Eom, H., & Kang, H. (2019). Biomimetic fog harvesting surface by photo-induced micro-patterning of zinc-oxide silver hierarchical nanostructures. *Applied Surface Science*. <https://doi.org/10.1016/J.APSUSC.2018.11.132>.
- Lei, J., & Guo, Z. (2020). A fog-collecting surface mimicking the Namib beetle: its water collection efficiency and influencing factors. *Nanoscale*. <https://doi.org/10.1039/c9nr10808d>.
- Liu, H., Xie, W., Song, F., Wang, X., & Wang, Y. (2019). Constructing hierarchically hydrophilic/superhydrophobic ZIF-8 pattern on soy protein towards a biomimetic efficient water harvesting material. *Chemical Engineering Journal*. <https://doi.org/10.1016/J.CEJ.2019.03.152>.
- Malik, F., Clement, R., Gethin, D., Krawszik, W., & Parker, A. (2014). Nature's moisture harvesters: a comparative review. *Bioinspiration & Biomimetics*, 9. <https://doi.org/10.1088/1748-3182/9/3/031002>.
- Park, K., Kim, P., Grinthal, A., He, N., Fox, D., Weaver, J., & Aizenberg, J. (2015). Condensation on slippery asymmetric bumps. *Nature*, 531, 78-82. <https://doi.org/10.1038/nature16956>.
- Wang, X., Zeng, J., Yu, X., Liang, C., & Zhang, Y. (2019). Water harvesting method via a hybrid superwetable coating with superhydrophobic and superhydrophilic nanoparticles. *Applied Surface Science*. <https://doi.org/10.1016/J.APSUSC.2018.09.210>.
- Yu, Z., Zhang, H., Huang, J., Li, S., Zhang, S., Yan, C., Mao, J., Dong, X., Gao, S., Wang, S., Chen, Z., Jiang, Y., & Lai, Y. (2021). Namib desert beetle inspired special patterned fabric with programmable and gradient wettability for efficient fog harvesting. *Journal of Materials Science & Technology*, 61, 85-92. <https://doi.org/10.1016/j.jmst.2020.05.054>

Numerical Study of The Thermal Characteristics of an Integrated Solar Collector-Storage System

Nasser Yahya Ayed Alahmary^{1*}, Mohamad Kchaou² & Mohammed Alquraish³

^{1,2,3}Department of Mechanical Engineering, College of Engineering, University of Bisha, Bisha, Saudi Arabia

*Alahmary306@gmail.com

Abstract

Typical Solar Water Heaters (SWHs) use separate solar panels and insulated tanks. Sunlight heats the panels, which then warms up water stored in the tank for later use. However, bulky equipment and slow return on investment hinder SWH installation. This article proposes a new, combined system: a compact solar collector-storage unit. It will be a cylindrical tank containing phase-change materials (PCMs) with a central pipe. While the water flows through these pipes, it absorbs heat stored by the PCMs. To assess this new system's performance, researchers created a computer simulation. The simulation analyzes how the flow rate of incoming water affects the system's efficiency. They built a mathematical model to compare the thermal properties of regular solar collectors with those that incorporate PCMs. This model relies on established scientific principles and has been verified using data from the PCM manufacturer.

Keywords: Solar Water Heater System (SWHS), Thermal Energy, Solar Collector, Phase Change Materials.

1. Introduction

The sun's energy is considered the main source of energy on planet Earth. Plants convert the sunlight into chemical energy, which forms our food chain. Sunlight also delivers thermal energy, warming the planet and driving weather patterns. We've harnessed this power for centuries, focusing it with mirrors as early as the 3rd century BC. Today, solar cells in satellites convert sunlight directly into electricity. As the unsustainable fossil fuel sources are depleting, solar energy offers a promising alternative. It's a clean, renewable resource with huge potentials. Unlike wind or biomass, solar cells offer consistent availability and applicability across various sectors. From heating homes to powering industries (textiles, paper, food), solar water heaters provide hot water (50-60°C) crucial for daily needs, both domestically and commercially.

Developing even more efficient solar water heater systems (SWHS) is key to maximizing this clean energy source (Abhat, 1983). Conventional solar water heating systems (SWHS) comprise two primary components: a solar collector panel and an insulated sensible heat storage tank. The solar collector functions as a specialized heat exchanger, designed to efficiently capture solar radiation and convert it into thermal energy. This thermal collector utilizes a dark, absorptive surface to maximize solar energy absorption across the relevant spectrum. The targeted spectrum encompasses electromagnetic radiation ranging from long-wave infrared to short-wave ultraviolet wavelengths. It is important to note that the amount of solar energy reaching the Earth's surface is not constant, exhibiting variations based on weather conditions, geographic location, and the collector's orientation relative to the sun (Amin et al., 2017). Solar heaters, also called solar panels, are the most common solar collectors used in homes.

Besides, the term solar collector refers to solar parabolic devices that can concentrate and collect the solar energy (Chaabane, Mhiri, & Bournot, 2014). Furthermore, solar collectors are categorized into decentralized and centralized systems. Non-concentrating collectors directly absorb sunlight across their entire area. Flat plate and evacuated tube designs are used for low-to-medium temperature applications like building heating and hot water. Integrated collector storage (ICS) utilizes larger tubes for enhanced heat retention within the collector, eliminating the need for a separate storage tank (Chen et al., 2010). Flat plate collectors, developed by Hötöl & Wheeler in the 1950s, are the most common type.

It consists of a dark flat plate solar absorber, a transparent cover that allows solar energy to pass through but reduces heat loss, a heat transfer fluid (air, antifreeze, or water) to remove heat from the absorber, Support or cover to insulate the heat. In hot water panels, the liquid transfers heat from the absorber plate to the insulated tank, usually through pipes. This can be achieved directly or through a heat exchanger (Class, 1998). In this context, this research work aims to analyse the effect of the integration of phase change material in the solar collector to increase its performance. Thermal energy which can be released by passing water through the supply pipes in contact with PCM will be characterized using a developed mathematical model. ANSYS software will be used for numerical simulation.

2. Literature Review

Solar energy applications have many applications such as light bulbs (Pico PV System), household uses, solar production plants and water pumps (Quitiaquez, 2020). The solar system is measured by solar panel productivity during the day and battery capacities at night (Lemi Negera et al., 2020).

Renewable Energy

The Algerian study, "The Reality of Renewable Energy and Sustainable Development," emphasizes energy's role in sustainability and the need for a clear strategy. It highlights the environmental risks of traditional energy depletion and the urgency of developing renewable alternatives (IEA, 2009). The study employs a descriptive-analytical approach, analyzing data and leveraging prior research. It identifies three key drivers for renewable energy markets: global energy security and climate change concerns. The international community's role is seen as crucial in fostering a sustainable renewable energy sector and developing its exploitation. Another study by Groenhout, Morrison, and Behnia (2000) assessed the Arab Maghreb's transition to renewable energy for sustainable development. It analyzed alternative energy sources and their contribution to economic and social well-being. The study highlighted the importance of renewables in achieving sustainability through economic gains, improved social conditions, and environmental protection. It emphasized reduced energy dependence and costs, with the potential for solar-powered institutions, leveraging the region's natural conditions.

Hybrid Coal and Solar Energy

Lemi Negera et al. (2020) explored solar feedwater heating in a 330 MW steam plant, evaluating partial or full replacement of the first high-pressure heater with solar. Using the Solar Advisor Model, they compared a purely solar plant to a solar-fossil fuel hybrid. The hybrid system achieved a yearly solar field return of 55.6% and a lower Levelized Cost of Energy (LCOE) of 0.12-0.15 \$/kWh, a 20-30% reduction compared to the purely solar plant.

Solar Thermal System Collector

Thermal solar systems (STS) capture sunlight and convert it to heat for fluids like water or gas. This study focuses on understanding various STS applications, not delving into collector types (non-concentrating or concentrating). Collectors heat a fluid, which then transfers its thermal energy to a storage tank. This heated water can then supplement or replace traditional fossil fuel-powered water heating systems (Jaisankar et al., 2011).

Solar thermal systems provide low-temperature heat ($60\text{--}80^{\circ}\text{C}$) for pools, hot water, and space heating. Flat-plate collectors (40-60% efficient) are commonly used, capturing all sunlight and achieving high efficiency in regions with strong solar radiation ($1,800\text{ kWh/m}^2\text{a}$) (Sharafeldin & Gróf, 2018). Unlike concentrating collectors that focus sunlight, non-concentrating collectors utilize the entire solar spectrum. These collectors come in various shapes and sizes.

3. Methodology

Simulate a Solar Collector System

The solar collector system was simulated using ANSYS Workbench. First, a 3D model was created in SolidWorks and imported into Design Modeler (Figure 1). Boundaries on the geometry were then meticulously named (inlet, outlet, etc.) for specific roles in the simulation. After defining the model geometry, a mesh was generated using the ANSYS Workbench Mesh component. Double-clicking the Mesh component opened its settings, where we applied automatic meshing to the fluid volume with a body sizing of 2.75 mm and five inflation layers near the walls. A sweep method was used for the collector mesh, with edge sizing defined in Table 1. After generating the mesh (visualized in Figures 2 and 3), it was saved, and we returned to the Workbench interface.

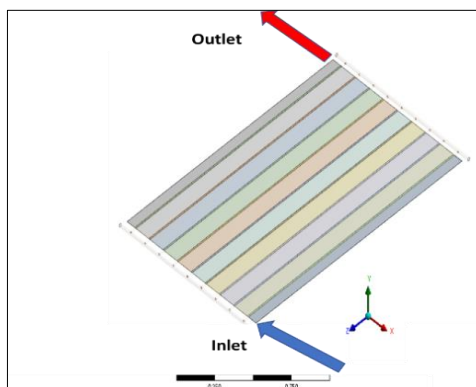


Figure 1: Global Geometry of the system

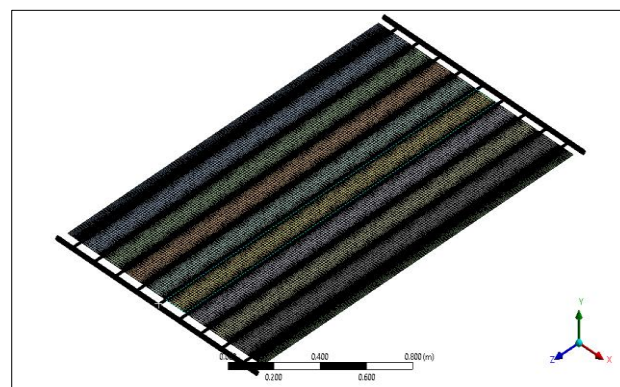
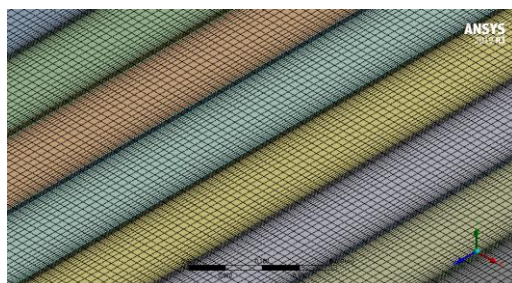
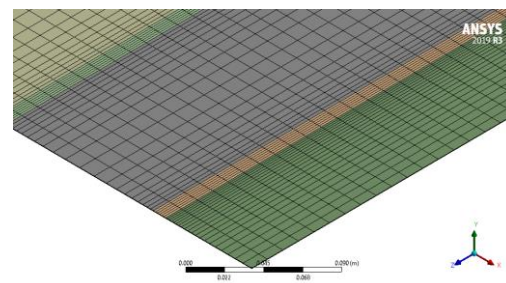


Figure 2: Mesh of the system



a



B

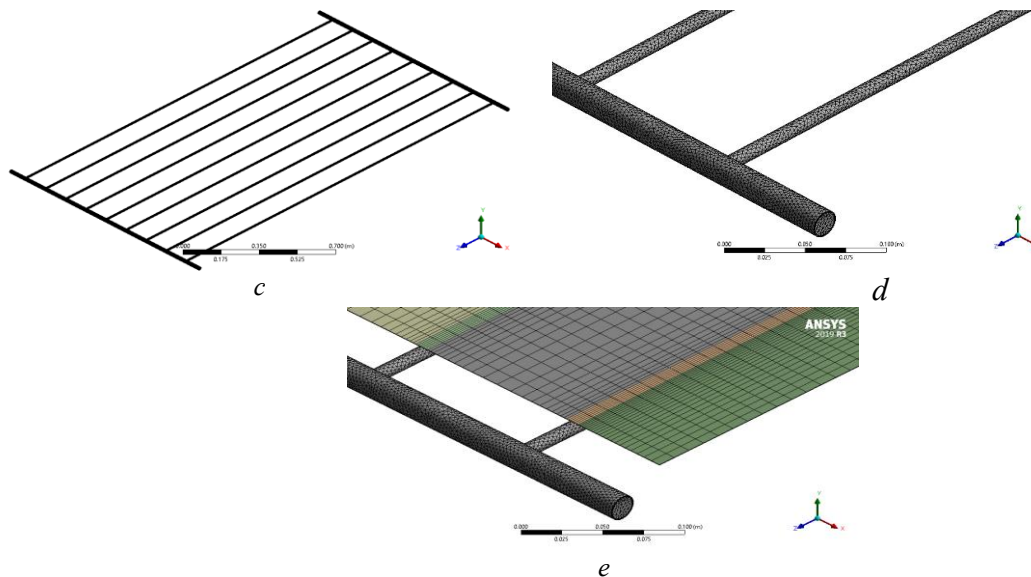


Figure 3: a), b), c), d), e) Details of the Mesh of Different Parts

Table 1: Mesh independency

	Element size	No. of elements	T [K]	Diff.	% Diff.	Std. dev.
Case 1	4 mm	619789	336.548	0	0.000%	0.1472
Case 2	3.75	695934	336.068	0.48	0.143%	0.31885
Case 3	3.5	791321	336.491	0.423	0.126%	0.17654
Case 4	3.25	934332	336.744	0.253	0.075%	0.10488
Case 5	3	1123294	336.942	0.198	0.059%	0.20976

Setup

After defining the mesh, we proceeded with the setup in ANSYS Fluent. First, the Fluent system component was dragged and dropped into the Workbench. The generated mesh was then linked to the setup. Double-clicking the Setup component opened the Fluent Launcher window, where we enabled double precision and parallel processing utilizing at least 4 cores for faster calculations. Clicking "OK" initiated Fluent.

Within Fluent, the energy equation was activated ("Energy: On"). The turbulence model was chosen based on the specific case, either remaining laminar or switching to k- ϵ Realizable with Enhanced Wall Function (refer to Figure 1 and Table 2 for details). Material properties were assigned, with water-liquid selected for the fluid and copper for the solid components. The fluid cell zone was defined as water-liquid, and a source term was included in the solid cell zone with a user-defined expression $(585.23[\text{W}/\text{m}^2]/0.4[\text{mm}])$. Boundary conditions were then specified according to Table 2. The inlet was set as a mass flow inlet with a designated mass flow rate and inlet temperature (298.15 K). A convection condition was applied to the "rad_surface" wall, defining the heat transfer coefficient (h), temperature (T), and thickness. Finally, the wall materials belonging to the risers and headers were changed to copper for improved heat transfer.

Table 2: Boundary conditions

Inlet	m_dot		(m_dot)/9
mass flow inlet	0.01	kg/s	0.0011
	0.02	kg/s	0.0022
	0.0267	kg/s	0.0030
	0.1	kg/s	0.0111
	0.15	kg/s	0.0167
Outlet	p_gage		
pressure outlet	0	Pa	
Wall			
No slip wall	N/A		

Validation

After defining the boundary conditions, the pre-processing stage concluded with validation. Validation is the process of ensuring the accuracy and reliability of the simulation results. It involves comparing the simulated results with established data, such as experimental measurements or theoretical calculations. In our case, we used the manufacturer's pressure drop data as a reference point. By comparing our simulated pressure drop values with the manufacturer's data (Figure 4), we could assess the accuracy of the model. This validation step helps ensure confidence in the simulation results before proceeding with the analysis.

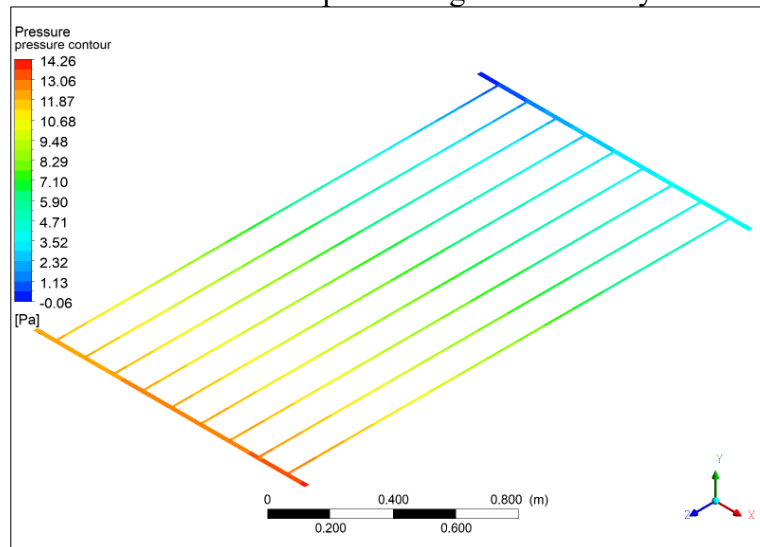


Figure 4: Example of result (Pressure Contours of Case A (0.01 kg s^{-1}))

Simulate a Solar Collector System with The Integration of PCMs

a. Geometrical Specifications

For the PCM-integrated system, the model geometry differed. It consisted of a cylindrical tank with a diameter of $\Phi 20 \text{ cm}$ and a length of 100 cm , filled with Phase Change Materials (PCMs). A concentric inner tube with a diameter of $\Phi 3.5 \text{ cm}$ and a length of 185 cm passed through the center of the tank, carrying water for heat transfer (Figure 5). To enhance heat, transfer within the PCM, fins of different configurations were added to the design.

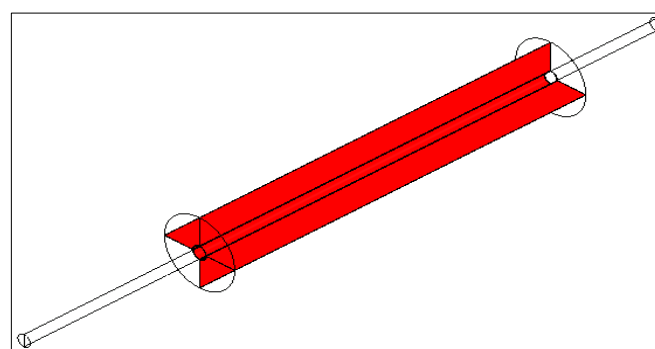


Figure 5: Full height fins (partitioned tank model)

b. Mathematical Modeling

Physical model

Heat transfer in the PCM system occurs through two primary modes: convection and conduction (described in Table 3). The process can be broken down into several steps:

- Convection: Heat transfer occurs between the cold water flowing through the inner tube and the inner surface of the tube wall.
- Conduction: Heat then conducts radially through the wall of the water tube.
- Convection (again): Heat transfers from the outer surface of the tube wall to the surrounding PCMs.
- Conduction and Natural Convection: Finally, heat is transferred within the PCM itself through conduction and natural convection currents (Figure 6).

Table 3 summarizes the governing equations for these convection and conduction modes.

Table 3: Governing Equations for Convection and Conduction Modes

Mode	Description	Equations
Convection	Occurs between stationary surfaces and fluids in bulk motion.	$Q = hA\Delta T$
Conduction	Occurs in mediums of constant densities.	$Q = -k \frac{dT}{dx}$

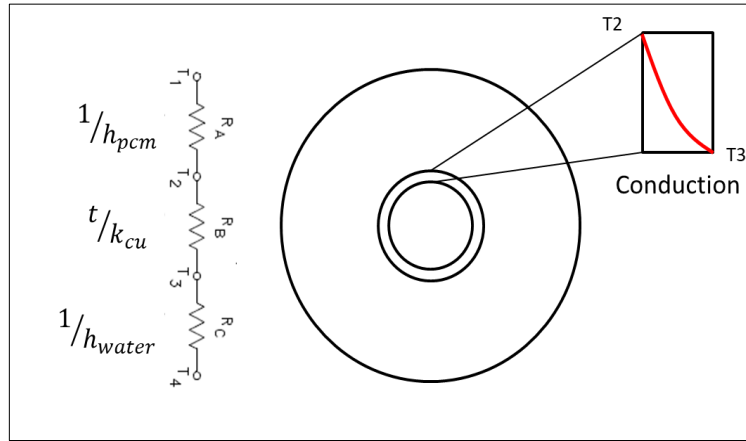


Figure 6: Convection and conduction

c. Turbulence Modeling

Turbulence is estimated based on the value of Reynolds number Re . The slow motion in the PCM due to gravity and buoyancy forces is laminar, while the Reynolds number of water flow is 1.21×10^9 which is in turbulent region. Accordingly, the SST k- ω model with Low-Reynolds Correction Option Activated. The equations of the SST k- ω are as follows.

$$\frac{\partial k}{\partial t} + U_j \frac{\partial k}{\partial x_j} = P_k - \beta k \omega + \frac{\partial}{\partial x_j} \left((\nu + \sigma_\omega \nu_T) \frac{\partial k}{\partial x_j} \right) \quad (1)$$

$$\frac{\partial \omega}{\partial t} + U_j \frac{\partial \omega}{\partial x_j} = \alpha S^2 - \beta \omega^2 + \frac{\partial}{\partial x_j} \left((\nu + \sigma_\omega \nu_T) \frac{\partial \omega}{\partial x_j} \right) + 2(1 - F_1) \frac{\sigma_{\omega 2}}{\omega} \frac{\partial k}{\partial x_i} \frac{\partial \omega}{\partial x_i} \quad (2)$$

$$\nu_T = \frac{a_1 k}{\max(a_1 \omega, SF_2)} \quad (3)$$

d. Fluent Setup: General Modeling

The simulation is a transient simulation depending on the time required for solidification. The simulation is performed for 50 minutes, using a time-step of 0.5 s. the gravitational acceleration is considered in the negative y-direction ($g = -9.81 \text{ m/s}^2$). The type of solver used is pressure-based solver, while the Boussinesq model of density is used to consider density change from solidus to liquidus density with decrease in heat, in addition to The SST k- ω model for viscous/turbulent modeling.

A symmetry boundary condition is used and only the half of the model is used to reduce run time and storage space (figure 7). The symmetry is taken on the plane YZ splitting the tank and tube into two halves axially about z-axis. Accordingly, only the half of flow rate is inserted (0.01335 kg/s). A fine mesh at the near-wall region is used to capture temperature and velocity gradient at boundary layer. The PCM volume is finely discretized to have rapid and acceptable convergence at relatively higher time-step. The mesh is generally hexahedral for both fluid and solid bodies (Figure 8).

4. Results and Discussion

Pressure and Velocity Analysis

The pressure drops across the collector increased with increasing mass flow rate of the working fluid (water) as expected (Figure 9). The pressure rise was gradual at lower flow rates (0.01 to 0.0267 kg/s), with a significant increase observed at higher flow rates (around 0.1 kg/s and above). This trend aligns with well-established principles in fluid mechanics, where frictional losses become more prominent at higher velocities. A similar pattern was observed for the velocity profile within the collector (Figure 10). The velocity increased steadily with increasing mass flow rate, but a sharper rise occurred at the higher flow rate (around 0.69 m/s). This can be attributed to the pressure difference driving the flow overcoming the resistance within the collector design

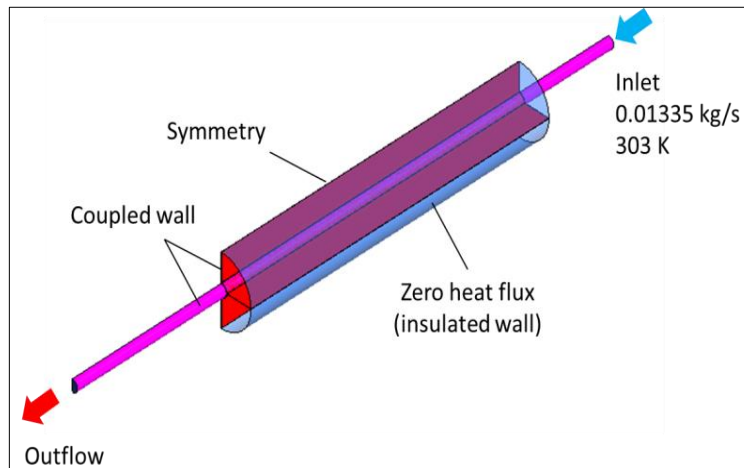


Figure 7: Symmetry Boundary Condition

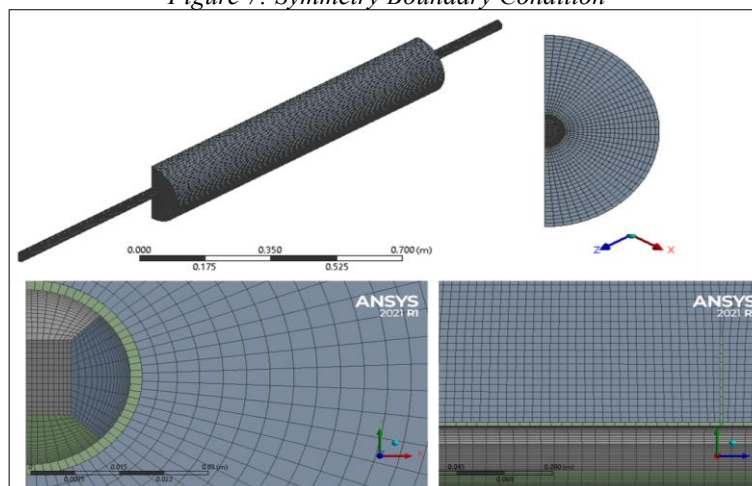


Figure 8: Fine Mesh at the Near-wall Region

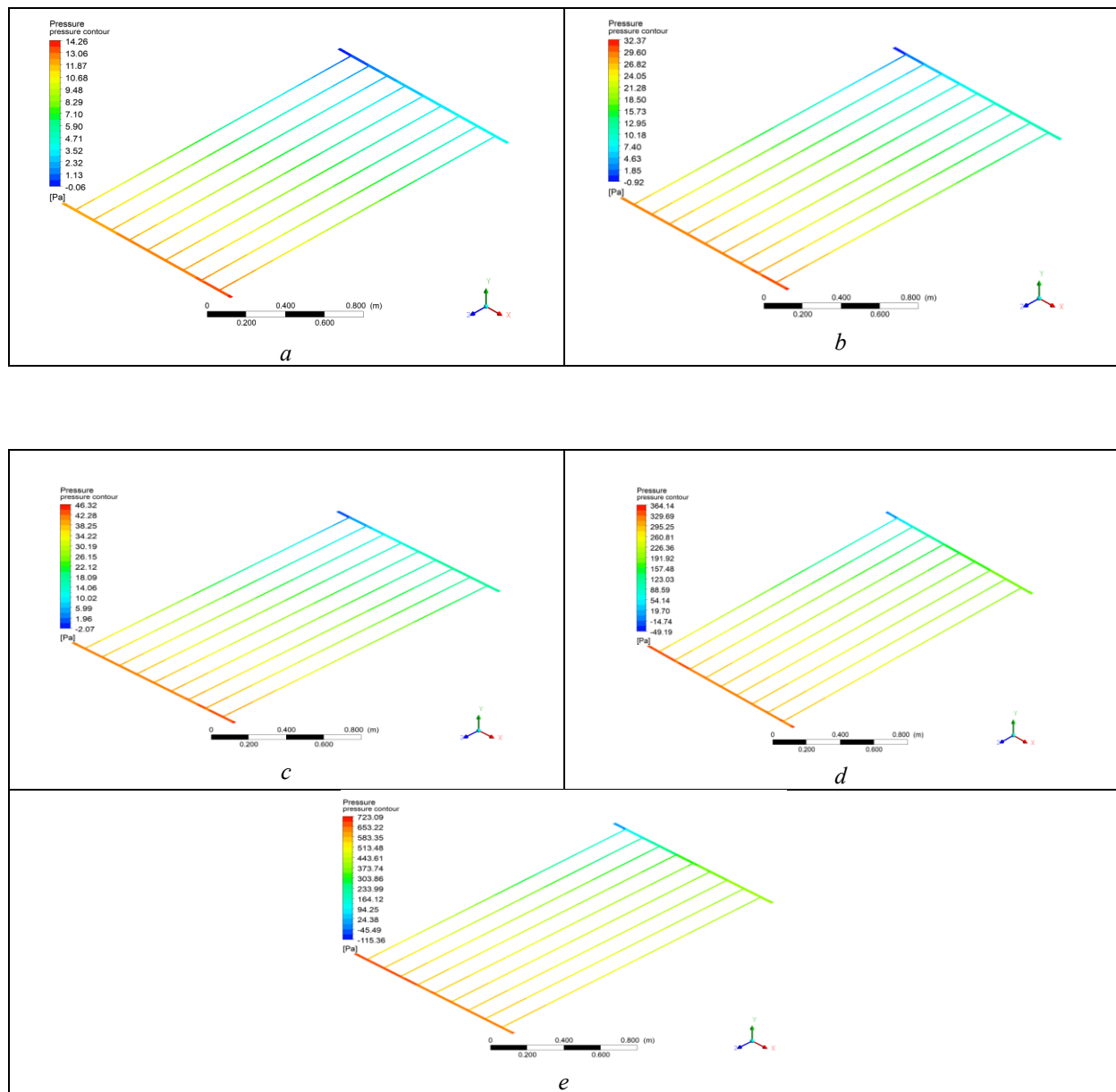
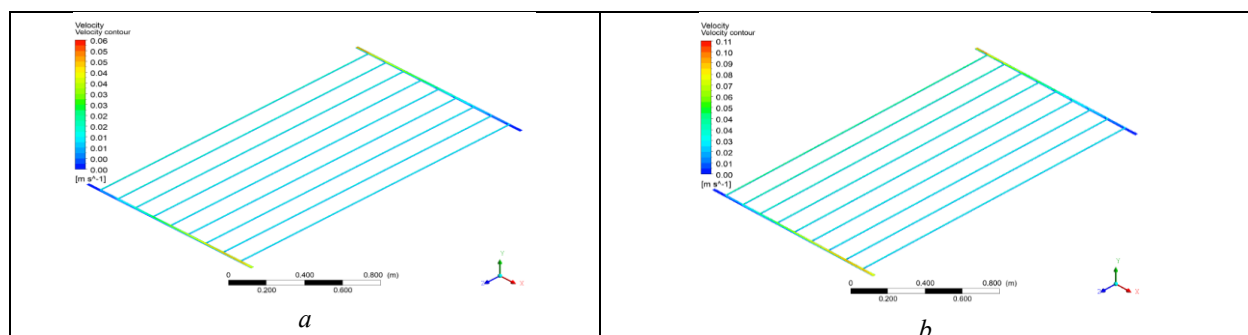


Figure 9: Pressure Contours of: (a) Case A (0.01 kg s^{-1}), (b) Case B (0.02 kg s^{-1}), (c) Case C (0.0267 kg s^{-1}), (d) Case D (0.1 kg s^{-1}), (e) Case E (0.15 kg s^{-1})



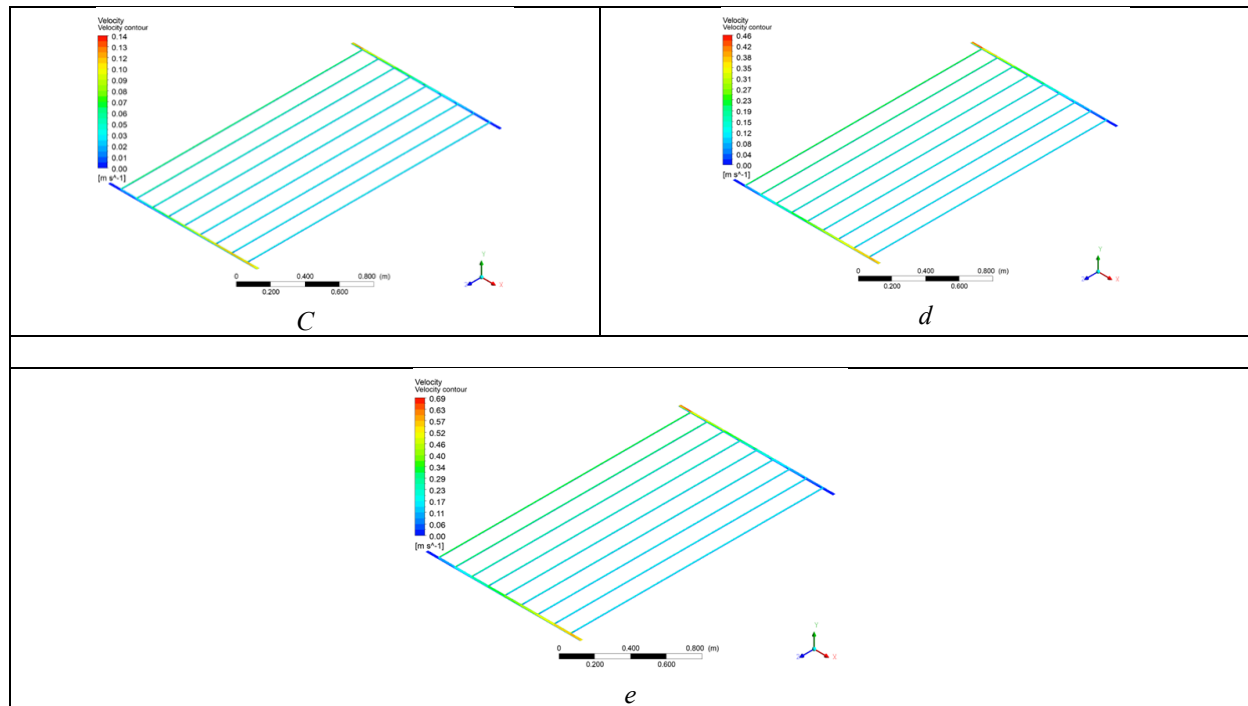


Figure 10: Velocity Contours of: (a) Case A (0.01 kg s^{-1}), (b) Case B (0.02 kg s^{-1}), (c) Case C (0.0267 kg s^{-1}), (d) Case D (0.1 kg s^{-1}), (e) Case E (0.15 kg s^{-1})

Validation

The pressure drop data obtained from the CFD simulations were validated against the manufacturer's data (Figure 11). To ensure unit consistency, the simulated pressure values were converted from Pa to mH₂O using a conversion factor of 0.000102. The comparison revealed good agreement between the simulated and measured pressure drops, especially at lower flow rates. This validation process confirms the accuracy and reliability of the CFD model for predicting pressure behavior within the collector.

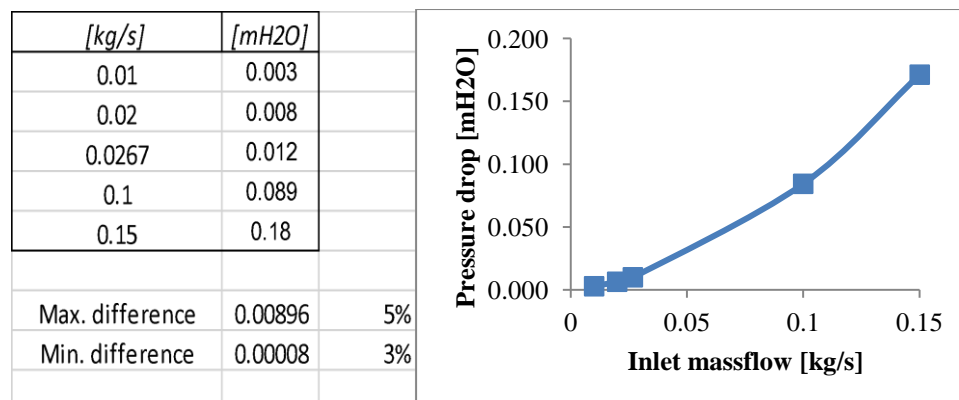


Figure 11: Pressure Drop with Inlet Mass Flow

Thermal Performance

The analysis considered real-world weather conditions (solar irradiance, ambient temperature, wind speed) and operational factors (inlet and outlet temperatures) impacting the thermal performance of the evacuated tube solar collectors. With an ambient temperature of 298.15 K and an average daily solar irradiance of 3.1 kWh/m²/day, the collectors achieved average daily useful heat gains of 163 W/m² and 145 W/m², respectively, translating to a monthly heat energy production of approximately 478.8 MJ.

The calculated monthly energy efficiency of the collectors ranged from 45.3% to 32.9%, with an average monthly efficiency of around 2.62%. These values suggest that the collectors operate within a reasonable efficiency range for converting solar radiation into thermal energy. The temperature differential between the water and propylene glycol solution at the solar collector's input and the surrounding air resulted in a modest increase in energy efficiency and a decrease in thermal efficiency. This finding is correct, according to Raouf's (2014). Increased wind speed contributes to evacuated tube solar collectors' diminishing energy and exergy efficiency (Table 4 and Figures 12 - 13 and 14).

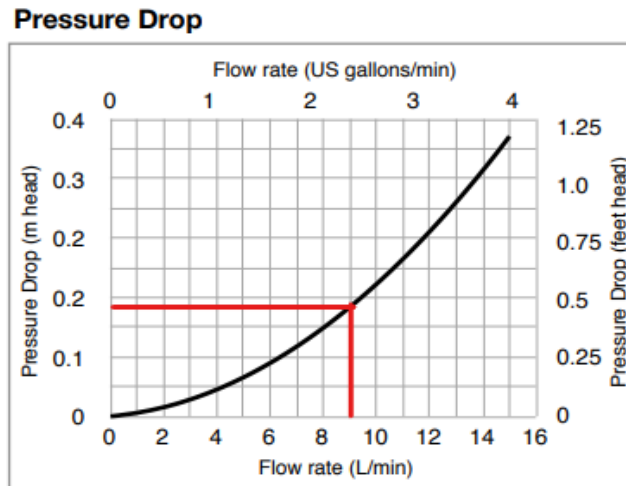


Figure 12: Model used in this study FPC-A26 Flat Plate Collector
Source: Groenhout, Morrison, and Behnia (2000)

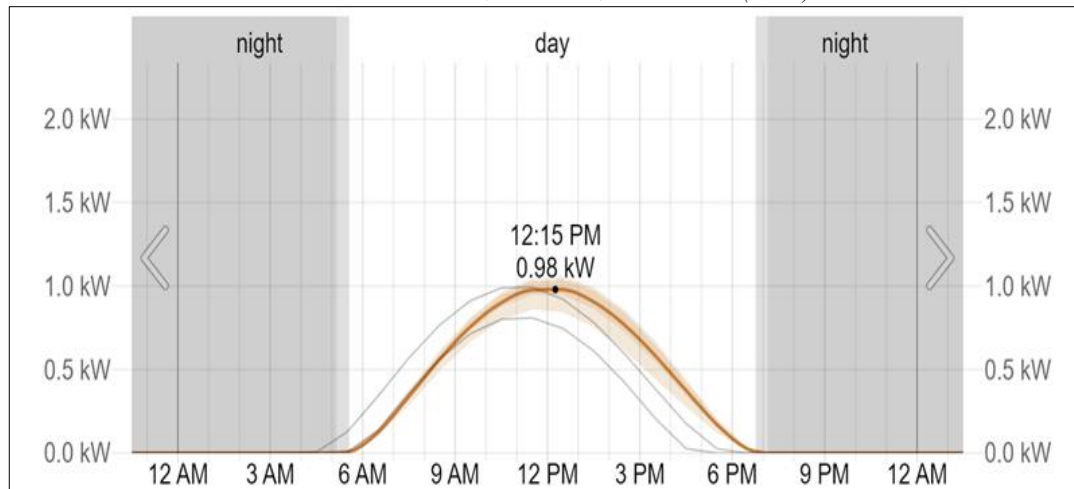


Figure 13: Assumptions

Table 4: Evolution of the Readings

Inlet mass flow	T (ave, out)	T (ave, absorb.)	P (ave)		T (ave, out)	T (ave, absorb.)	
[kg/s]	[K]	[K]	[Pa]		[C]	[C]	
0.01	319.277	337.569	7.59		46.127	64.419	
0.02	310.077	330.519	17.966		36.927	57.369	
0.0267	307.334	328.180	26.281		34.184	55.03	
0.1	300.877	313.662	219.715		27.727	40.512	
0.15	299.926	311.176	444.06		26.776	38.026	

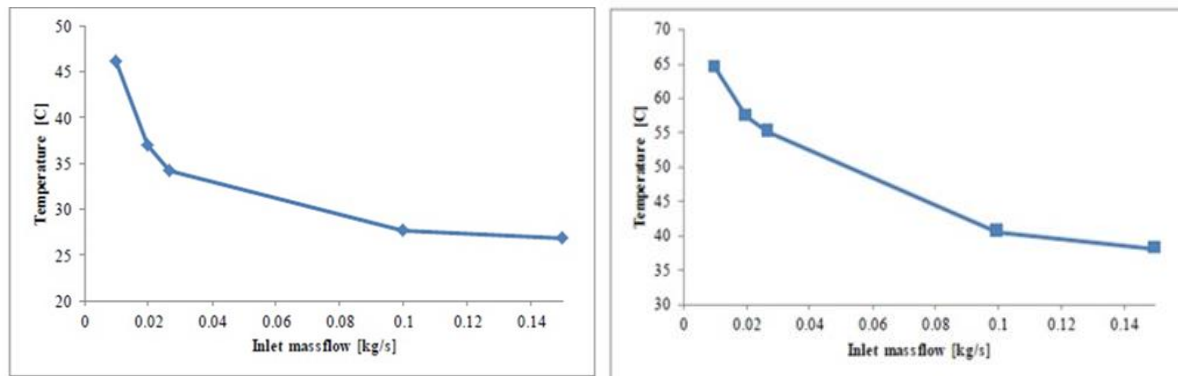


Figure 14: Evolution of the Temperature for Different Inlet Mass Flow; (a) T_{out} , (b) T_{absorb}

5. Conclusion and Recommendations

This computational study analyzed a solar collector system's performance with varying water flow rates. By creating a mathematical model validated against manufacturer data, the study compared collector systems with and without integrated Phase Change Materials (PCMs). The results suggest that PCM thickness, contact area with the absorber plate, and surface design all significantly impact efficiency. Notably, v-corrugated surfaces and strategically placed PCM tubes showed promise. While fins and metal foams proved effective without increasing complexity, further research is recommended. Evacuated Tube Solar Collectors (ETSCs) were identified as a promising future direction due to their ability to withstand higher temperatures and work with higher melting point PCMs. Research into PVT (Photovoltaic Thermal) collectors, particularly their cooling strategies in hot climates, was also encouraged. Finally, the potential of PCM nanocomposites was highlighted, suggesting the creation of a database to optimize their development for various applications.

Acknowledgment

The author is thankful to the Deanship of Graduate Studies and Scientific Research at University of Bisha for supporting this work and for providing guidance.

References

- Abhat, A. (1983). Low Temperature Latent Heat Thermal Energy Storage: Heat Storage Materials. *Solar Energy*, 30(3), 313–332.
- Amin, M., Putra, N., Kosasih, E. A., Prawiro, E., Luanto, R. A., & Mahlia, T. M. I. (2017). Thermal Properties of Beeswax/graphene Phase Change Material as Energy Storage for Building Applications. *Applied Thermal Engineering*, 112, 273–280.
- Chaabane, M., Mhiri, H., & Bournot, P. (2014). Thermal Performance of an Integrated Collector Storage Solar Water Heater (ICSSWH) with Phase Change Materials (PCM). *Energy Conversion and Management*, 78, 897–903.
- Chen, F., Lu, S-M., Tseng, K-T., Lee, S., & Wang, E. (2010). Assessment of Renewable Energy Reserves in Taiwan. *Renewable and Sustainable Energy Reviews*, 14(8), 2511–2528.
- Class, N. K. (1998). Technical information. *Lemn. Public Light*. Retrieved from <https://www.astbearings.com/bearing-materials.html>
- Quitiaquez, W. (2020). Análisis Numérico de un-Sistema de Calentamiento de Agua Utilizando un Colector Solar de Placa Plana. *Ingenius*, 24, 97–106.
- Lemi Negera, W., Basam, K., Balewgize, A. Z., & Vijay, P. (2020). Design and CFD Simulation of Solar Water Heater used in Solar Assisted Biogas System. *International Journal of Innovative Technology and Exploring Engineering*, 9(3), 371–380.

- International Energy Agency (IEA). (2009). Energy Conservation through Energy Storage (ECES) Program [Brochure]. Retrieved from http://www.iea-ec.es.org/files/090525_broschuere_eces.pdf
- Groenhout, N., Morrison, G., & Behnia, M. (2000). Design of Advanced Solar Water Heaters. *ANZSES Conference - From Foss to Photons*.
- Jaisankar, S., Ananth, J., Thulasi, S., Jayasuthakar, S. T., & Sheeba, K. N. (2011). A comprehensive Review on Solar Water Heaters. *Renewable and Sustainable Energy Reviews*, 15(6), 3045–3050.
- Sharafeldin, M. A., & Gróf, G. (2018). Experimental Investigation of Flat Plate Solar Collector using CeO₂-Water Nanofluid. *Energy Conversion and Management*, 155, 32–41.

Fabrication of Cat Bath Station Using Foot Paddling System

Mohd Rosli Saad^{1*}, Jessica Clairra Peter Nonok² & Elyana Ann Rosly³

^{1,2,3}Department Of Mechanical Engineering, Politeknik Kuching Sarawak, Malaysia.

*rosli@poliku.edu.my

Abstract

In modern pet care, addressing challenges in routine tasks like bathing cats requires innovative solutions that prioritize animal welfare and caregiver efficiency. This project introduces a cat bath station designed with a foot paddling system to enhance the bathing process's safety, efficiency, and comfort. Traditional methods of cat bathing often led to stress for both cats and caregivers due to manual handling and water aversion issues. The proposed cat bath station integrates a foot-controlled water valve, allowing caregivers to manage water flow hands-free while focusing on gently handling the cat. Materials such as fiberglass and mild steel ensure durability, corrosion resistance, and structural integrity, reflecting a commitment to sustainable and efficient design practices. Aligned with Sustainable Development Goal 9, the station optimizes water usage and promotes animal welfare through its adjustable design and non-slip surface for safety. Methodologically, the project encompasses design, material selection, fabrication, and testing, emphasizing affordability and quality. Testing results demonstrate significant reductions in water usage and caregiver stress levels, highlighting the station's practical benefits. This innovation represents a pivotal advancement in pet care technology, offering a humane, efficient solution applicable in pet shops, grooming facilities, and veterinary clinics, with potential broader applications in animal care and beyond.

Keywords: Foot paddling system, Water conservation, Pet care technology

1. Introduction

Modern pet care demands innovative solutions to enhance the welfare of animals and improve the efficiency of routine tasks. One such routine yet challenging task is bathing pets, particularly cats. Cats are known for their aversion to water and can become highly stressed during bathing, making the process difficult for both the pet and the caregiver. Traditional methods of cat bathing often involve manually handling the animal, which can lead to discomfort, inefficiency, and potential injury to both parties. In response to these challenges, this project presents the fabrication of a cat bath station using a foot paddling system, designed to streamline the cat bathing process while ensuring safety and comfort.

The primary motivation behind this project is to address the practical difficulties faced by pet shop owners and individual pet owners. For instance, Lia Lia Pet Shop, a local business, experiences significant challenges in bathing cats due to the limitations of conventional methods. These methods not only consume a considerable amount of time and water but also result in a stressful environment for the cats. Therefore, an innovative approach is needed to improve this routine task, making it more efficient and less stressful.

This project aims to design and fabricate a cat bath station that incorporates a foot paddling system to control the shower head valve. This hands-free operation allows caregivers to manage the water flow with their feet, leaving their hands free to handle the cat gently and securely. The design is intended to be simple yet effective, focusing on functionality, ease of use, and durability. The materials chosen for the construction of the bath station include stainless steel for its resistance to corrosion and ease of cleaning, and mild steel for its structural integrity.

Additionally, the project aligns with Sustainable Development Goal 9 (Industry, Innovation, and Infrastructure), emphasizing the importance of building resilient infrastructure and fostering innovation. By developing a cat bath station that optimizes water usage and reduces stress, the project contributes to sustainable pet care practices. The station is designed to be adjustable, accommodating various sizes of cats, and features a secure, non-slip surface to prevent accidents.

To achieve the project objectives, a comprehensive methodology was employed, including design conceptualization, material selection, fabrication, and testing. The foot paddling system was meticulously integrated into the design to ensure smooth operation and control over the water flow. The project also involved detailed cost analysis and comparison with existing solutions to ensure affordability without compromising on quality.

In conclusion, the fabrication of a cat bath station using a foot paddling system represents a significant advancement in pet care technology. By addressing the common issues associated with traditional cat bathing methods, this project offers a practical, efficient, and humane solution that can benefit pet shops and pet owners alike. This introduction sets the stage for a detailed exploration of the methods, results, and implications of the project, highlighting its potential impact on the pet care industry.

2. Literature Review

The integration of foot-operated waterspouts and hand washing machines represents a significant advancement in reducing pathogen transmission through touchless operations, a critical concern especially heightened during the COVID-19 pandemic. The study by Sathish et al. (2019) explores the implementation of a rack and pinion mechanism in wash basins, where a foot-operated pedal controls water flow, effectively eliminating hand contact with taps. This innovative design not only enhances hygiene by minimizing the risk of transmitting pathogens but also promotes water conservation by ensuring the tap closes automatically when not in use. This system proves particularly beneficial in public and private settings, where high-touch surfaces pose a significant contamination risk.

Complementing this approach, the ergonomic development of pedal-based hand washing machines has been extensively studied. Ejiko, Olorunnishola, and Osayomi (2020) describe a manually operated hand washing machine that integrates ergonomic designs to reduce physical strain and improve user throughput. This design includes foot pedals for dispensing water and soap, making it possible to accommodate up to 2,880 users per day under optimal conditions. Similarly, Ikechukwu, Clementina, and Onyebuchi (2014) discuss a hand washing machine equipped with an Arduino-based water level indicator, providing real-time information on water supply and ensuring consistent availability without the need for electricity. These advancements highlight significant improvements in both efficiency and user experience, outperforming existing technologies.

The importance of hands-free wash basins has been further underscored by Romauli, Ambarita, and Sinamo (2020) in their study on COVID-19 prevention in public health centers. Their design also employs a foot-operated pedal to avoid hand contact with taps and other high-touch surfaces, thereby reducing the transmission risk of COVID-19. This hands-free mechanism is particularly effective in high-traffic areas like health centers, where the risk of viral transmission is elevated. The study emphasizes the crucial role of such systems in public health interventions, advocating for their widespread implementation to enhance hygiene and safety.

Collectively, these studies illustrate the significant advancements in the development and application of foot-operated mechanisms, which are pivotal in promoting public health and safety through enhanced hygiene practices and pathogen transmission mitigation

3. Methods

Design Conceptualization

The initial phase of the project involved conceptualizing the design of the cat bath station. This included identifying the key components required for the station: the shower head, the foot paddling system, and the structure to support the cat. The design aimed to integrate a foot-controlled water valve, which would allow the caregiver to operate the shower head without using their hands. This approach was intended to provide a hands-free solution to control water flow, thereby reducing stress for both the cat and the caregiver. The design technical drawing and illustration shown in Figure 1 and Figure 2.

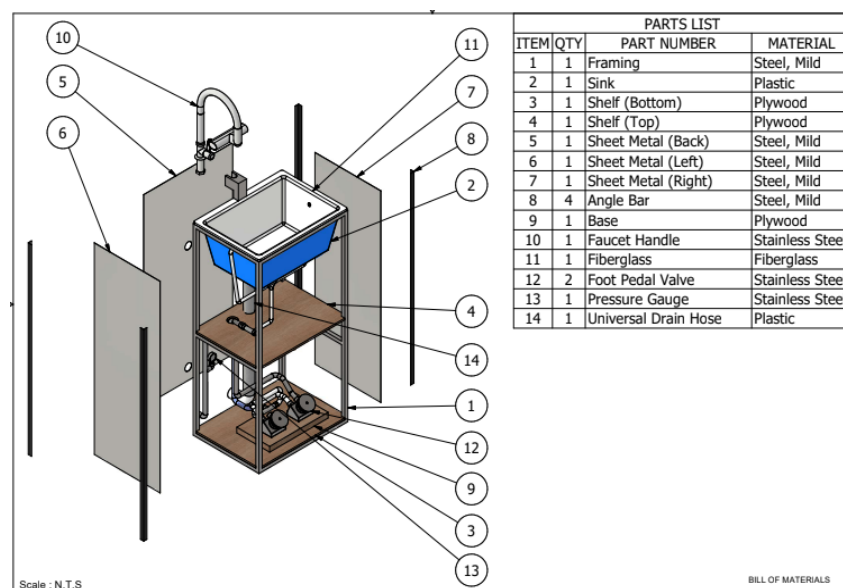


Figure 1: Technical Drawing of Bath Station

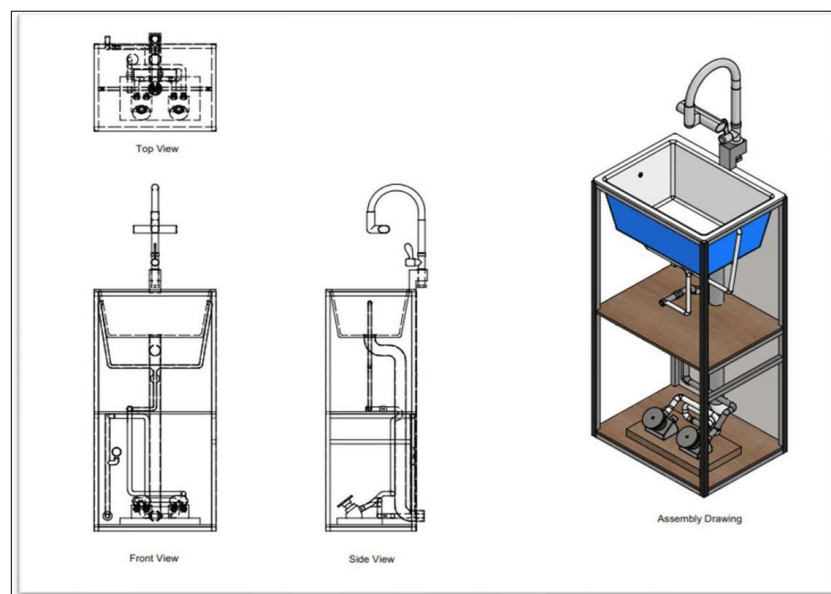


Figure 2: Technical Drawing of Bath Station with 3 Side View

Material Selection

Material selection was crucial for ensuring the durability and functionality of the bath station. Stainless steel was chosen for the shower head and water channels due to its corrosion resistance and ease of cleaning. Mild steel was selected for the structural frame because of its strength and cost-effectiveness. Material fiberglass was used for the platform where the cat stands, providing a non-slip surface to ensure safety. The design and technical drawing of the fiberglass basin shown in Figure 3.

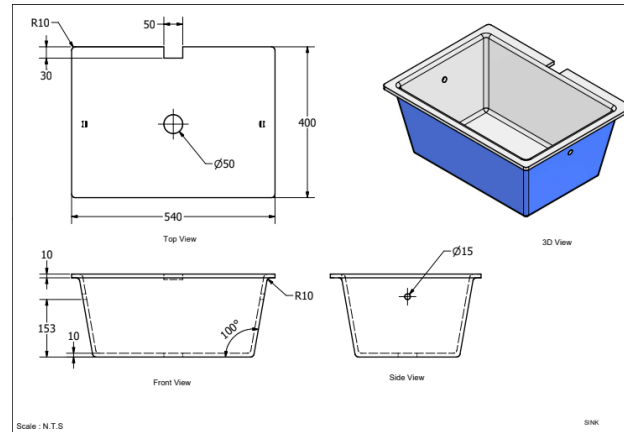


Figure 3: Technical drawing of fiberglass basin

Fabrication Process

The fabrication process began with constructing the frame using mild steel. The steel was cut and welded into a stable structure that could support the weight of the cat and the water system. The plywood platform was then attached to the frame, and a fiberglass basin with non-slip coating was applied. The foot paddling system, consisting of a pedal connected to a valve, was installed at the base of the station. This system was designed to be intuitive, allowing easy control of the water flow with minimal effort.

Integration and Assembly

After fabricating the individual components, the next step was to integrate them into a cohesive unit. The shower head was mounted on an adjustable arm to accommodate different cat sizes. The foot pedal was connected to the shower head valve via a cable system, enabling precise control over the water flow. All components were securely fastened to ensure stability during use.

Testing and Evaluation

The testing phase involved evaluating the performance of the cat bath station under various conditions. Tests were conducted to assess the ease of operation, water flow control, and overall stability of the station. Caregivers were asked to use the station and provide feedback on its functionality and user experience. Water usage was measured and compared to traditional methods to determine the efficiency of the new design.

4. Results and Discussion

The results of the testing phase indicated that the cat bath station met its design objectives. The foot paddling system allowed caregivers to control the water flow effectively without using their hands. This hands-free operation significantly reduced the stress experienced by both the cats and the caregivers. The adjustable shower head proved versatile, accommodating cats of different sizes comfortably.

The operation cat bath station is easy and simple. The station is initiated by pressing the foot pedal to turn on the water flow. The left foot pedal is connected to the showerhead. Meanwhile, the right foot pedal is connected to the water at the sides in the sink. When the right foot pedal opens the water will flow from the sides to inside the sink. Figure 4 shown project outcome with foot pedal and shower head.



Figure 4: Project outcome with foot pedal and shower head

1. Efficiency and Water Usage

One of the primary goals of the project was to optimize water usage during the cat bathing process. The new system demonstrated a notable reduction in water wastage. The precise control offered by the foot pedal allowed caregivers to use only the necessary amount of water, avoiding excessive runoff. Comparative tests showed that the new method used approximately 30% less water than traditional cat bathing techniques.

2. User Experience

Feedback from caregivers highlighted the ease of use and improved control provided by the foot paddling system. The hands-free operation allowed for better handling of the cats, resulting in a calmer and more controlled bathing process. Caregivers also appreciated the adjustable shower head, which made it easier to rinse cats thoroughly without causing discomfort.

3. Safety and Stability

The non-slip platform ensured that the cats remained secure during bathing, reducing the risk of accidents. The stable frame structure provided a solid base, preventing any wobbling or tipping during use. Overall, the safety features of the cat bath station were well-received by the caregivers, contributing to a positive user experience.

Comparative Analysis

To provide a comprehensive evaluation, a comparative analysis was conducted between the new cat bath station and traditional bathing methods. This analysis focused on key performance metrics such as time taken for a complete bath, water usage, and caregiver stress levels.

Time Efficiency: The new cat bath station reduced the average bathing time by 20%. Traditional methods took approximately 15 minutes per bath, whereas the new system reduced this to 10 minutes. This time saving is attributed to the hands-free operation and the precise control of the water flow, which reduced the time spent on adjusting water flow.

Discussion

The findings of this project underscore the potential benefits of integrating a foot paddling system into cat bath stations. The innovative design not only improves the efficiency and ease of the bathing process but also aligns with contemporary animal welfare practices. The hands-free operation is particularly beneficial in reducing the stress associated with cat bathing, as it allows caregivers to focus on handling the cat rather than managing the water flow.

Implications and Direction for Future Research

The introduction of a foot paddling system in pet bathing stations marks a significant advancement in pet care technology. This project has demonstrated the feasibility and benefits of such an innovation, providing a foundation for further research and development. Future studies could explore the scalability of this design for larger animals or multi-animal bathing stations. Additionally, investigating the long-term impact on water conservation and environmental sustainability in pet care facilities would provide valuable insights.

1. Potential for Commercial Adoption

Given the positive feedback and measurable benefits, there is substantial potential for commercial adoption of the cat bath station. Pet shops, grooming salons, and veterinary clinics could integrate this system to improve their services. Marketing strategies should highlight the water-saving features, ease of use, and enhanced animal welfare aspects to attract potential adopters.

2. Broader Applications

The principles of the foot paddling system can be extended to other areas of pet care and grooming. For instance, similar mechanisms could be designed for washing dogs, cleaning enclosures, or even agricultural applications involving livestock. The success of this project paves the way for broader innovations in hands-free, efficient, and humane animal care solutions.

In conclusion, the fabrication of a cat bath station using a foot paddling system represents a meaningful step forward in the evolution of pet care technology. By addressing the challenges of traditional cat bathing methods, this project offers a practical, efficient, and humane solution that benefits both animals and caregivers. The implications of this innovation extend beyond cat bathing, suggesting a wide range of potential applications and setting the stage for future advancements in the field.

Acknowledgment

This paper is an output of the project in Department of Mechanical Engineering.

References

- Ejiko, S. O., Olorunnishola, A. A., & Osayomi, P. A. (2020). Ergonomic Development of Annual Hand Washing Machine to Ameliorate the Deadly Effect of COVID-19 Pandemic. *International Advanced Research Journal in Science, Engineering and Technology*, 7(7), 6-16.
- Ikechukwu, G. A., Clementina, O. O., & Onyebuchi, C. L. (2014). Design and Characterization of Automatic Hand Washing and Drying Machine. *American Academic & Scholarly Research Journal*, 6(4), 123.
- Jueprasith, S. (2023). Factors that Influence Pet Parents toward Using Pet Grooming Services. *Mahidol University Archive*. <https://archive.cm.mahidol.ac.th/handle/123456789/5127>
- Marra, F., Luccas, H., Bruno, M. P., Silva, A., & Marques, P. (2020). Study of the Efficient Use of Water in Bathing and Grooming Services. *Journal of Business and Economics*, 11(11), 1270-1276. [https://doi.org/10.15341/jbe\(2155-7950\)/11.11.2020/009](https://doi.org/10.15341/jbe(2155-7950)/11.11.2020/009)

- Romauli, N. D. M., Ambarita, H., & Sinamo, K. N. (2020). Utilization of Hands-free Wash Basin as COVID-19 Prevention in Public Health Center. *Abdimas Talenta*, 5(2), 546-551.
- Sathish, R., Kumar, S. S., Prasad, R., & Suganthan, P. N. (2019). Study and Implementation of Rack and Pinion in the Wash Basin. *International Journal of Engineering and Advanced Technology*, 8(6), 3048-3051.
- Tabi-Agyei, E., Padditey, E., Adom, D., Azaglo, A., Acheampong, E., & Kakari, O. (2023). Innovative Fibreglass Mobile Sink Basin: An Intervention for Hand Washing in an Era of Pandemics. *Asian Research Journal of Arts & Social Sciences*, 19(3), 10-23. <https://doi.org/10.9734/arjass/2023/v19i3427>
- United Nations. (2018). Infrastructure and Industrialization - United Nations Sustainable development. *United Nations Sustainable Development*. <https://www.un.org/sustainable-development/infrastructure-industrialization/>
- Zhang, M., Li, X., Zhang, Y., Gu, Y., Zheng, C., Ren, B., & Fang, R. (2023). Design and Development of Public Wash Basin Based on Infrared. *Journal of Innovation and Development*, 3(1), 8-10. <https://doi.org/10.54097/jid.v3i1.8411>

Crashing Infrastructure Projects Considering Scheduling Flexibility

Ali Alyami^{1*}, Mohamed Alsharyah² & Mohammed Kchaou³

^{1,2,3} Department of Mechanical Engineering, College of Engineering, University of Bisha, Bisha, Saudi Arabia

*Corresponding author: alyamiali5858@hotmail.com

Abstract

This paper explores a systematic approach to project crashing, a technique used to expedite project completion by allocating additional resources. The research methodology involved crashing with budget constraints. Three case studies were conducted where projects were crashed under predefined constraints, including budget limits and minimum and maximum permissible durations for activities. A linear programming formulation was developed using linear equations to optimize crashing costs while considering the aforementioned constraints. Integer variables were used to represent the crashing durations. The case studies were solved using the simplex method, a common technique for solving linear programming problems. The paper presents the optimal crashing durations for various activities in each case study, along with the associated crashing costs. For example, in the first case study, crashing resulted in a 40-day reduction in project duration at a cost of 278,479 Saudi Riyals. Crashing impacted the critical path (the sequence of dependent activities that determines project duration) by reducing the overall project completion time. In one case study, crashing reduced the completion time by 10.27%. The paper acknowledges that traditional construction methods rely on factors like technology adoption, patience, flexibility, and workforce adaptability to meet project demands. Additionally, a fourth case study explored three different methods for completing a specific activity (plastering) — using robots versus two manual approaches. Overall, this paper presents a data-driven approach to project crashing that considers both time and cost constraints. It demonstrates the effectiveness of this method in reducing project completion time while highlighting the associated cost implications.

Keywords: Project Management, Critical Path, Flexibility, Management, Project Crashing, Scheduling Flexibility

Nomenclature and Notations

The following notations are used when formulating the required model:

y : Total Crashing Cost

c_i : cost of crashing activity i $i = 1$ to j

x_i : days of crashing activity i $i = 1$ to j

1. Introduction

According to Assaf and AlHejji (2006), their survey on the execution of construction projects in Saudi Arabia highlighted that 76% of the projects experienced a 10-30% delay in the planned lead time. A common technique used to reduce deadline pressure is to crash project activities. As defined by Kessler and Chakrabarti (1999), crashing activities require more resources (materials, personnel, equipment, etc.) to be allocated beyond what was initially planned to complete the project faster. Given time and cost constraints, a project may not be completed as planned without modifications. The author, who works as a site engineer on the case project, described the project as the construction of an infrastructure network to serve 1,100 housing units in a designated project by the Saudi government in Najran province. The network must route through a distance of 73 kilometers from the source to the destination area.

The project will enable electricity, water, sewage, and telecommunications networks in the proposed area. The project has exceeded the planned timing. Robert Youker (2017) stated that project management covers different types of projects, and the project manager's knowledge must bridge the gaps between the needs and procedures required for each project type. He mentioned various types of projects, such as administration, construction, software, design, maintenance, events, equipment, new products, and others, each with the aim of being completed within certain time, cost, and quality constraints. Each project has its unique characteristics and requirements. The classification of projects is based on the product or deliverable of the project. Each classification has its requirements for workers (whether high-tech or not), degree of certainty (high to low), time pressure (low to high), stability of scope (high to low), level of technology (high to low), and importance of cost (high to low).

Project crashing is a very useful technique to shorten the completion time. However, there is an additional cost associated with this activity. As a result, planners seek a trade-off between completion time and project cost for better planning and management. The time-cost trade-off process aims to reduce or extend the duration of activities. According to Pour et al. (2012), the Time-Cost Trade-off Problem (TCTP) is considered one of the most important decisions in project implementation. The main goal of TCTP is to reduce the initial project duration resulting from critical path analysis while minimizing both direct and indirect costs. Direct costs include material costs, labor costs, equipment costs, etc. Overhead, on the other hand, is the cost of doing work that cannot be associated with a particular task.

A tremendous amount of research has been done on TCTP. The study of TCTP was first conducted by Kelly (1961). Some researchers agree that research since 1961 has primarily focused on deterministic cases, as referred to by Mobini et al. (2011). To properly plan and schedule large projects, planners use two methods: the Critical Path Method (CPM) and the Project Evaluation and Review Technique (PERT). The goal of these techniques is to allow the project manager to monitor the progress of all phases associated with the project. They help in identifying the critical path, which defines the activities that are considered bottlenecks for the project. Planners use the critical path to help speed up project completion dates and use the schedules to hire/fire resources or outsource them. The schedule may also help in timely hiring of highly productive equipment.

This project proposes a mixed integer linear programming method. Formulating models that take into account the potential loss of quality costs in connection with possible modifications or changes incurred due to crashing the project. The reason for project crashing for such delayed projects is to cope with the timing of the project. The project is delaying the operation of the destination area.

2. Methodology

This section outlines the research methodology crashing infrastructure projects considering scheduling flexibility.

- 1- Breakdown the case project located in Najan province (infrastructure project for housing purposes) to activities.
- 2- Define the starting date of the project
- 3- Draw a precedence diagram for the activities of the project
- 4- Define each activity starting date, ending date, normal time, crash time, normal cost, crashing cost, probability of rework and rework cost.
- 5- Draw a Gantt chart.
- 6- Identify the critical path.
- 7- Formulate an integer linear programming considering the crashing and reworking cost.

8- Define the constraints and the target.

3. Model Formulation and Validation

The objective is to minimize the total budgeted costs as follow:

$$y = c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5 + \dots + c_jx_j \dots \dots \dots \text{equation 1}$$

St.

Budget constraint:

$$c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5 + \dots + c_jx_j \leq \text{Budgeted Amount}$$

Minimum Crashing Duration:

$$x_1 + x_2 + x_3 + x_4 + x_5 + \dots + x_j \geq \text{Minimum crashing duration}$$

Activity crashing limits

$$\text{Minimum Crashing limits} \leq x_i \leq \text{Maximum Crashing Limits} \dots i=1,2,3 \dots j$$

Integer constraint

$$x_i = \text{integer} \dots \dots i = 1,2,3 \dots j$$

To obtain a valid solution, the following solution methodology is followed:

- 1- Identify the project activities: this involves the identification of project tasks, their duration, their starting and finishing dates and their budgeted costs.
- 2- Identify activities on the critical path; a Gantt chart is drawn to know the project duration and the critical activities.
- 3- Identify crashing costs; this deals with the estimated extra costs to accelerate activities.
- 4- Identify the budgeted crashing cost.
- 5- Identify the project crashing duration.
- 6- Identify the activity crashing limits.
- 7- Formulate an LP equation for the total crashing cost in an aim to minimize it.
- 8- Set the budget, crashing duration and the time limit constraints.
- 9- Solve using Microsoft excel
- 10- Generate solution

4. Results and Discussion

To validate the project crashing model which aims to achieve more flexible schedules by means of assigning a crash duration consumption rate, Water piping project is chosen as a case study. The results are shown as following:

- A. At Table 1 identify the project activities: This involves the identification of project tasks, their duration, their starting and finishing dates and their budgeted costs. This case consists of 11 activities. Namely; external piping, excavations, precast of underground water tank, installation of underground water tank, installation of water pumps, installation of overhead water tanks (water towers to control water network pressure), installation of water meter, installation of draining system, water connections, sewer chambers and sewer connections.

Table 1: Activities Involved in Construction Water Network (Case Study One)

Task Name	Duration	Start	Finish	Precedence	Cost
External Piping - Water & Sewer	58 days	6/19/2019	9/4/2019	2	867,216.94
Excavation for UG Water Tank	59 days	3/30/2019	6/18/2019		91,146.38
PCC for UG Water Tank	117 days	9/5/2019	2/14/2020	2,1	32,750.16
Installation of UGWT	100 days	6/19/2019	11/1/2019	2	2,525,250.00

Water Pump	59 days	2/17/2020	5/7/2020	3,4	191,100.00
Installation of OHWT	100 days	5/8/2020	9/24/2020	5	167,258.00
Water Meter	60 days	8/18/2020	11/9/2020	5,8	152,880.00
Roof Drain	72 days	5/8/2020	8/17/2020	5	210,824.88
Water Connections	56 days	9/5/2019	11/21/2019	1,2	78,287.95
Constt of Sewer Chambers	61 days	5/8/2020	7/31/2020	5	821,642.99
Sewer Connections	57 days	11/10/2020	1/27/2021	7	100,000.00

- B. In Figure 1 Identify activities on the critical path; Gannt chart is drawn to know the project duration and the critical activities. Activities 1 (External piping), 2 (Excavations), 3 (precast of underground water tanks installation), 5 (installation of water pumps), 7 (installation of water meter), 8 (installation of roof rains) and 11 (sewer connections) is on the Critical path. MS project 2007 has been used to draw the Gannt chart. The red coloured activities are on the critical path as per Table 2.

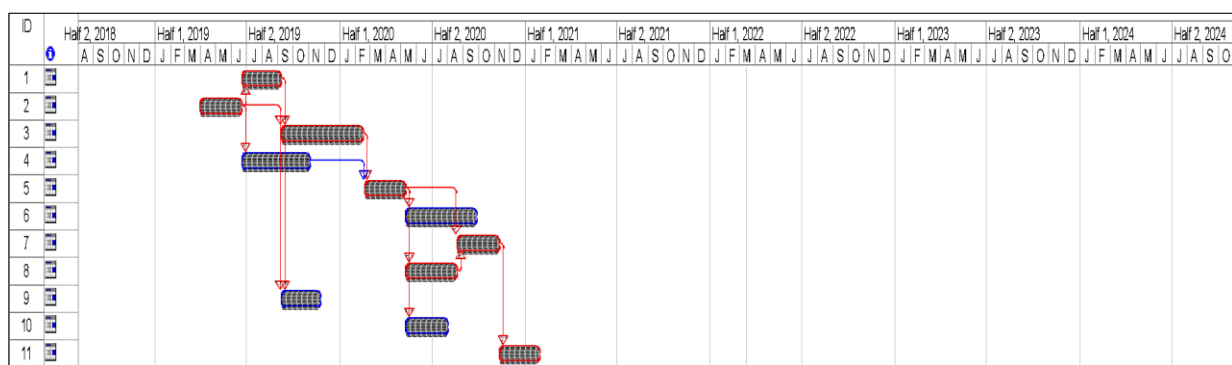


Figure 1: Tracking Gannt Chart for the Construction of Water Network (Case Study Two)

Table 2: Activities on the Critical Path (Red colored)

Task Name	Duration	Start	Finish	Precedence	Cost
External Piping - Water & Sewer	58 days	6/19/2019	9/4/2019	2	867,216.94
Excavation for UG Water Tank	59 days	3/30/2019	6/18/2019		91,146.38
PCC for UG Water Tank	117 days	9/5/2019	2/14/2020	2,1	32,750.16
Installation of UGWT	100 days	6/19/2019	11/1/2019	2	2,525,250.00
Water Pump	59 days	2/17/2020	5/7/2020	3,4	191,100.00
Installation of OHWT	100 days	5/8/2020	9/24/2020	5	167,258.00
Water Meter	60 days	8/18/2020	11/9/2020	5,8	152,880.00
Roof Drain	72 days	5/8/2020	8/17/2020	5	210,824.88
Water Connections	56 days	9/5/2019	11/21/2019	1,2	78,287.95
Constt of Sewer Chambers	61 days	5/8/2020	7/31/2020	5	821,642.99
Sewer Connections	57 days	11/10/2020	1/27/2021	7	100,000.00

- C. Table 3 identifies crashing costs for activities on the critical path; this deals with the estimated extra costs to accelerate activities. The crashing cost of Activities 1 (External piping=8,624 saudi riyals per day), 2 (Excavations=7,028 saudi riyal per day), 3 (precast of underground water tanks installation=7,502 saudi riyals per day), 5 (installation of water pumps=7,217 saudi riyals per day), 7 (installation of water meter=9,541 saudi riyals per day), 8 (installation of roof rains=5,851 saudi riyals per day) and 11 (sewer connections=4,877 saudi riyals per day).

Table 3: Crashing Cost for each activity (Case study one)

Task Name	Duration	Start	Finish	Precedence	Cost	Crashing Cost Per day
External Piping - Water & Sewer	58 days	6/19/2019	9/4/2019	2	867,216.94	8,624
Excavation for UG Water Tank	59 days	3/30/2019	6/18/2019		91,146.38	7,028
PCC for UG Water Tank	117 days	9/5/2019	2/14/2020	2,1	32,750.16	7,502
Installation of UGWT	100 days	6/19/2019	11/1/2019	2	2,525,250.00	2,816
Water Pump	59 days	2/17/2020	5/7/2020	3,4	191,100.00	7,217
Installation of OHWT	100 days	5/8/2020	9/24/2020	5	167,258.00	3,997
Water Meter	60 days	8/18/2020	11/9/2020	5,8	152,880.00	9,541
Roof Drain	72 days	5/8/2020	8/17/2020	5	210,824.88	5,851
Water Connections	56 days	9/5/2019	11/21/2019	1,2	78,287.95	9,572
Constt of Sewer Chambers	61 days	5/8/2020	7/31/2020	5	821,642.99	8,471
Sewer Connections	57 days	11/10/2020	1/27/2021	7	100,000.00	4,877

- D. Identify the budgeted crashing cost; the budgeted amount is equivalent to 300,000 Saudi Riyals.
- E. Identify the project minimum crashing duration; 40 days.
- F. Identify the activity crashing limits; The maximum crashing duration of Activities 1(External piping=9 days),2(Excavations= 7 days),3 (precast of underground water tanks installation=6 days),5 (installation of water pumps=8 days),7 (installation of water meter=6 days),8 (installation of roof rains=4 days) and 11 (sewer connections=7 days).
- G. Formulate an LP equation for the total crashing cost in an aim to minimize it;
 $y = 8,624x_1 + 7,028x_2 + 7,502x_3 + 7,217x_5 + 9,541x_7 + 5,851x_8 + 4,877x_{11}$
 St.
- H. Set the budget, crashing duration and the time limit constraints.
 Budget constraint:
 $8,624x_1 + 7,028x_2 + 7,502x_3 + 7,217x_5 + 9,541x_7 + 5,851x_8 + 4,877x_{11} \leq 300,000$
 Minimum Crashing Duration:
 $x_1 + x_2 + x_3 + x_5 + x_7 + x_8 + x_{11} \geq 40$
 Activity crashing limits
 $0 \leq x_1 \leq 9$
 $0 \leq x_2 \leq 7$
 $0 \leq x_3 \leq 6$
 $0 \leq x_5 \leq 8$
 $0 \leq x_7 \leq 6$
 $0 \leq x_8 \leq 4$
 $0 \leq x_{11} \leq 7$
- I. Solve using Microsoft excel: Microsoft excel solver has been utilized to optimize the problem, the optimal values are $x_1=8$ days (External piping), $x_2=7$ days (Excavations), $x_3=6$ days (Precast of underground water tanks), $x_5=8$ days (installation of water pumps), $x_8=4$ days (roof drains), $x_{11}=7$ days (sewer connections). This has a total value of 278,479 Saudi Riyals. This could lead to a crashing duration of 40 days.

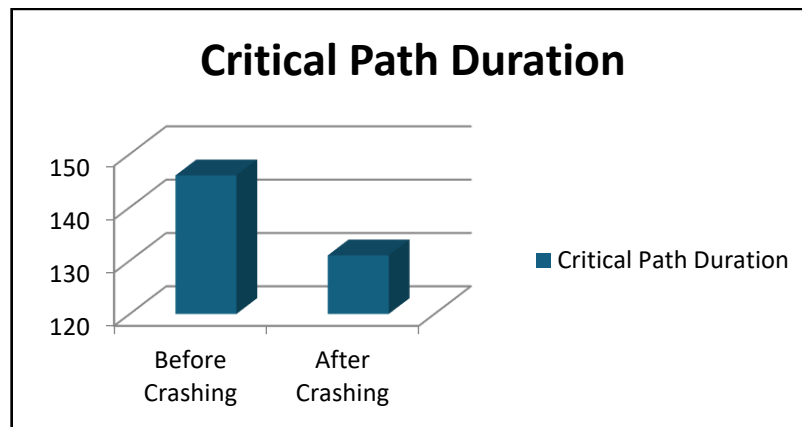


Figure 2: Critical Path Duration Reduction from 146 to 131 days

5. Conclusion

This has presented the project methodology. The formulation of a typical project crashing problem into a linear equation, discussing the variables and the constraints in an attempt to optimize the crashing costs. The constraints have considered crashing budget, minimum crashing duration, maximum activity crashing duration and the integer variables. In the first case study, crashing resulted in a 40-day reduction in project duration at a cost of 278,479 Saudi Riyals. Crashing impacted the critical path (the sequence of dependent activities that determines project duration) by reducing the overall project completion time. In one case study, crashing reduced the completion time by 10.27%.

References

- Abbasimehr, H., & Alizadeh, S. (2013). A Novel Genetic Algorithm-based Method for Building Accurate and Comprehensible Churn Prediction Models. *International Journal of Research in Industrial Engineering*, 2(4), 1.
- Agarwal, A., Colak, S., & Erenguc, S. (2011). A Neurogenetic Approach for the Resource-Constrained Project Scheduling Problem. *Computers & Operations Research*, 38(1), 44-50.
- Alsuliman, J., Bowles, G., Chen, Z., & Smith, S.D (Ed.). (2012). Current Practice of Variation Order Management in the Saudi Construction Industry. In *Proceedings of the 29th Annual Association of Researchers in Construction Management (ARCOM) Conference*: 3-5 September 2012 (pp. 1003-12), Reading, UK., Edinburgh, UK.
- Assaf, S., & Al-Hejji, S. (2006). Causes of Delay in Large Construction Projects. *International Journal of Project Management*, 24, 349-357. <https://doi.org/10.1016/j.ijproman.2005.11.010>
- Azaron, A., Perkgoz, C., & Sakawa, M. (2005). A Genetic Algorithm Approach for the Time-cost Trade-off in PERT Networks. *Applied Mathematics and Computation*, 168(2), 1317-1339.
- Biörck, J., Blanco, J. L., Mischke, J., Ribeirinho, M. J., Rockhill, D., Sjödin, E., & Strube, G. (2020). How Construction Can Emerge Stronger after Coronavirus. *McKinsey & Company*. Retrieved July 12, 2020.
- Bubshait, A., & Al-Juwairah, A. (2002). Factors Contributing to Construction Costs in Saudi Arabia. *Cost Engineering*, 44(5), 30-34.
- Chen, W. N., Zhang, J., Chung, H. S. H., Huang, R. Z., & Liu, O. (2010). Optimizing Discounted Cash Flows in Project Scheduling—An ant Colony Optimization Approach. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, 40(1), 64-77.

- Deloitte. (2020). Future of Work: Ways of Working in Uncertain Times. Retrieved July 2020, from https://www2.deloitte.com/us/en/pages/about-deloitte/articles/ways-of-working-to-sustain-and-thrive-in-uncertain-times.html?id=us:2ps:3gl:consem21:eng:cons:060920:nonem:na:i2i0iCxo:1191982799:440661617432:b:Future_of_Work:Ways_of_Working_BMM
- Deloitte & Touche. (2013). The Corporation Council for the Arab States of the Gulf (GCC) Construction Section Overview. London, United Kingdom

BUSINESS AND MANAGEMENT

**"HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY"**

Leveraging Risk Management to Enhance ESG Performance

Ahmad Saiful Azlin Puteh Salin^{1*}, Roslan Abd Wahab,¹ Amizahanum Adam¹ & Wan Razazila Wan Abdullah¹

¹Faculty of Accountancy, Universiti Teknologi MARA, Perak Branch Tapah Campus, Malaysia

Abstract

The purpose of this research is to provide a conceptual framework for risk management based on environmental, social, and governance (ESG) perspectives. The goals of this ESG risk management are to identify and address ESG that can affect business financial performance and reputation. This will ensure that the company has sustainable operations, meets stakeholders' expectations, secures lower financing costs, complies with rules and regulations, and positively contributes to the environment and society. Businesses that have a systematic process and procedure for ESG risk management have a greater tendency to be more conscientious, less risky, and, hence, more likely to be successful.

Keywords: Risk Management, ESG, Sustainability, Environment, Social, Governance

1. Introduction

ESG risk management has become a vital framework for evaluating and dealing with the non-financial elements of corporate operations. ESG variables comprise a wide array of issues that extend beyond conventional financial measures, with an emphasis on a company's environmental effects, social responsibility, and corporate governance standards. Recently, there has been a notable change in the business environment, as investors, customers, regulators, and other stakeholders are increasingly demanding more openness and responsibility from corporations in various domains.

ESG risk management is the process of identifying, assessing, and mitigating possible risks and opportunities related to ESG matters. Organisations must evaluate their carbon footprint, resource consumption, pollution levels, and ability to withstand climate change from an environmental standpoint. Besides, organisations also need to be on social implications that involve a range of important factors, including labour practices, diversity and inclusion, community participation, and product safety. In addition, good organisations also need to examine their best governance practices, such as the assessment of a company's leadership efficacy, ethical norms, compliance protocols, and board configuration.

The incorporation of ESG risk management into company plans is motivated not just by ethical concerns but also by the possible influence on financial performance. Companies that successfully mitigate their ESG risks may generate enduring value by bolstering their brand, recruiting conscientious investors (Hubel & Scholz, 2020), and reducing the likelihood of expensive regulatory penalties or operational interruptions. On the other hand, if ESG risks are not dealt with, it may result in harm to reputation, legal responsibilities, limited availability of funds, and decreased confidence from stakeholders. Consequently, organisations aiming for sustainable development and resilience in a globally integrated and socially aware economy now see ESG risk management as a crucial strategic priority.

Although much research has been undertaken on risk management and business management (example: Amirudin et al., 2017), there is a scarcity of studies that expressly address risk management within the framework of ESG and sustainability.

Thus, the aim of this research is to construct and discuss a conceptual framework for risk management based on ESG perspectives. This research is important because ESG risk management is a comprehensive strategy that recognises the complex interaction between environmental, social, and governance variables in influencing a company's total risk profile. It goes beyond just following rules and is in line with the wider objectives of sustainability and ethical business practices.

This research has its own significant contribution, as in the ever-changing business environment, it is crucial for companies to incorporate ESG factors into their risk management strategies. This is no longer a secondary issue but rather a fundamental aspect of a company's capacity to successfully navigate risks, develop resilience, and prosper in a dynamic world. This research provides recommendations for establishing the essential part of risk management that should be integrated by companies, risk managers, and practitioners that use ESG practices. In addition, it enhances the existing body of literature and theoretical foundation on the ESG risk management strategy, which is essential for the long-term viability of the organisation.

2. The Benefits of ESG Risk Management

ESG risk management provides several advantages to firms that extend beyond just risk mitigation. It has the potential to significantly influence several areas of a company, including its financial performance, reputation, and relationships with stakeholders. Empirical data and theoretical frameworks in sustainable finance and risk management support the claim that organisations skilled at managing ESG issues tend to demonstrate improved financial performance over long periods of time. The enhancements in financial indicators may be attributed to a combination of variables resulting from the incorporation of ESG principles into organisational strategy and operations.

Operational efficiency benefits result from efforts to maximise resource utilisation and minimise waste formation, leading to reduced costs related to resource purchase, consumption, and disposal. Furthermore, companies that take proactive measures to address environmental and social risks are more likely to demonstrate an increased ability to withstand operational disruptions, regulatory changes, and stakeholder pressures.

This helps to reduce the potential financial losses that may arise from supply chain disruptions, legal liabilities, or damage to their reputation. Moreover, when businesses align their operations with sustainable market trends and customer preferences, they may take advantage of new possibilities, increase their market share, and create multiple sources of income. This ultimately helps them achieve long-term financial stability and competitiveness. Effectively managing ESG risks not only prevents operational problems but also promotes a culture of innovation, efficiency, and value creation. This eventually leads to consistent financial performance and shareholder value.

The claim that showcasing a dedication to ethical business practices and sustainability can improve a company's reputation is highly valid in today's business environment, where stakeholders place growing importance on ethical behaviour, environmental protection, and social accountability. A strong reputation, built by being open and actively involving stakeholders, may be a significant intangible asset. It helps to create trust, credibility, and loyalty among customers, investors, and the wider community. Moreover, the congruence between business ideals and ESG principles not only appeals to conscientious customers but also entices responsible investors who include ESG factors in their investment choices.

The change in investor preferences highlights the increasing acknowledgment of the significance of ESG elements in evaluating a company's long-term capacity to endure and adapt. Therefore, organisations that have strong ESG risk management practices are more likely to have easier access to capital markets and get funding on favourable terms (Folque et al., 2021). This is because investors see them as having a lower risk level and higher potential for creating value. Furthermore, organisations may effectively manage potential reputational risks linked to environmental catastrophes, labour problems, or ethical failings by actively addressing ESG risks. This proactive approach helps protect their brand value and maintain the confidence of stakeholders. Overall, incorporating ESG factors into business plans not only improves the company's image but also acts as a driving force for creating sustainable value and fostering long-term engagement with stakeholders.

The assertion that prioritising ESG activities may result in concrete advantages in employee engagement and retention is based on a sophisticated comprehension of current workforce dynamics and changing generational preferences. Younger generations, especially millennials and Generation Z, are placing a growing emphasis on finding work that is meaningful and aligns with their values and beliefs. Companies that actively promote ESG principles are well-positioned to benefit from this change in demographics. By incorporating sustainability principles into the core of a company's culture, beliefs, and operations, organisations may promote a feeling of purpose and significance among workers, leading to a stronger bond with their job and an increased sense of satisfaction. Consequently, this leads to increased levels of employee engagement, productivity, and loyalty, as people experience a stronger connection between their own beliefs and the purpose of the organisation.

Furthermore, organisations that exhibit a sincere dedication to ESG are more likely to recruit and keep highly skilled individuals, as potential workers are becoming more interested in employers that prioritise environmental conservation, social accountability, and ethical behaviour. The congruence between the values of an organisation and those of prospective recruits creates a mutually advantageous association in which workers are empowered to make valuable contributions to causes that matter to them, while employers get the benefits of a staff that is highly motivated and dedicated. Moreover, ESG activities serve as an indication of a company's potential to thrive in the long run and withstand challenges, therefore improving its employer brand and reputation as a preferred employer in highly competitive talent markets.

Incorporating ESG risk management into organisational strategy brings about a range of advantages, as supported by empirical research and theoretical frameworks. Companies may achieve competitive advantage and access new markets by actively tackling ESG issues. This involves using sustainability problems as opportunities to create new product lines, technologies, and business models, which in turn drives innovation. In addition, including ESG factors into strategic planning processes promotes a focus on long-term goals, strengthening the ability of the organisation to withstand external disruptions, adapt to legislative changes, and respond to stakeholder demands. By adopting a forward-thinking approach, companies may proactively identify upcoming trends, potential dangers, and advantageous possibilities.

This valuable insight allows for informed strategic decision-making and positions them for long-term success in ever-changing business landscapes. Moreover, when organisations prioritise sustainability and ethical business practices, they improve their reputation, recruit highly skilled individuals, and get favourable access to financial markets.

This strengthens their competitive position and ensures their long-term sustainability. Effectively managing ESG risks not only prevents operational problems but also promotes a culture of innovation, efficiency, and value creation. This eventually leads to consistent financial performance, stakeholder trust, and social well-being.

Integrating ESG risk management methods into organisational frameworks is also a strategic approach to ensuring compliance with regulations in the face of changing legislative landscapes and industry standards. Through a methodical evaluation and resolution of ESG risks, firms may pre-emptively identify and alleviate any non-compliance concerns associated with environmental preservation, labour policies, and corporate administration. By adopting this proactive strategy, companies may reduce the likelihood of incurring regulatory fines, penalties, and legal obligations.

Additionally, this approach promotes a culture of corporate responsibility and ethical behaviour. Furthermore, organisations may demonstrate their commitment to compliance and sustainability to stakeholders by keeping up-to-date with new rules and industry best practices and adjusting their policies and processes appropriately. Essentially, including ESG risk management into regulatory compliance endeavours not only reduces legal and reputational risks but also strengthens organisational resilience and cultivates confidence among investors, consumers, and other stakeholders.

3. Risk Management Components and Its Relationship with ESG

This study proposed four important components for risk management for ESG namely risk identification, risk assessment, risk mitigation and risk monitoring.

Risk Identification

Risk identification is the step-by-step process to determine the potential risks to ESG activities. For environmental risk, it could include identifying potential risks related to climate change, resource scarcity, pollution, and other environmental impacts that could affect the company's operations, supply chain, and reputation. For social risk, the company can identify risks such as labor practices, human rights violations, community relations, and diversity and inclusion issues that could impact the company's social license to operate and stakeholder relationships. For governance risk, companies can identify governance and management risks like corruption, conflicts of interest, weak board oversight, and lack of transparency that could undermine the company's credibility and legal compliance.

Risk Assessment

After completing the ESG risk identification process, the company can start analysing the potential hazards and its negative impact to the organization. This process aims to determine which measures should be put in place in order to eliminate or control those ESG risks, as well as specify which of them should be prioritized according to the level of likeliness and impact they have on the ESG business. For environmental risk, companies can assess the financial and reputational impacts of environmental risks, such as regulatory fines, increased costs due to resource scarcity, and potential damage to brand reputation from unsustainable practices. For social risk, companies can evaluate the potential effects of social risks on employee morale, consumer trust, community relations, and legal liabilities, which can directly impact the company's financial performance. For governance risk, companies can assess the implications of governance risks on investor confidence, access to capital, and long-term strategic decision-making, which ultimately affect the company's value.

Risk Mitigation

Risk mitigation is the process of planning for disasters and creating the way to minimize the impacts. It involves a systematic way of reducing the exposure and lessening the likelihood of incidents. For environmental risk, the company needs to develop strategies to mitigate environmental risks, such as adopting sustainable practices, reducing carbon emissions, implementing waste reduction initiatives, and pursuing renewable energy sources. For social risk, company can implement measures to mitigate social risks, including fair labor practices, diversity and inclusion programs, community engagement initiatives, and ethical supply chain management. For governance risk, companies can strengthen governance practices by enhancing board independence, transparency, and accountability, and implementing anti-corruption policies and whistleblower protection mechanisms.

Risk Monitoring and Reporting

Establishing monitoring mechanisms to track the progress of risk mitigation strategies and ESG initiatives is the last recommended component of ESG risk management proposed by this study. In this step, companies need to regularly report and communicate ESG performance and risk management efforts to stakeholders, showcasing transparency, accountability, and commitment to sustainability. This can include by engaging with stakeholders to understand their concerns, expectations, and feedback related to ESG risks and initiatives. Collaborate with stakeholders to develop effective risk management strategies that address their concerns and align with their values.

4. in Managing Risks of ESG

Companies confront several obstacles in managing ESG risks owing to the complex nature of these issues and the changing demands of stakeholders. A significant obstacle that firms have when dealing with ESG risks is the intricate and interwoven nature of ESG factors. ESG hazards are intrinsically interrelated and often span across several dimensions. Environmental hazards might potentially lead to societal and governance consequences. To effectively handle these interdependencies, it is necessary to adopt a comprehensive strategy that takes into account the wider environment.

As a result, it is challenging to get the accessible data that meets the standards for information quality. Acquiring dependable and uniform data for evaluating and reporting on ESG risks might present difficulties. ESG data often originates from several sources and lacks uniformity, which hinders the ability to compare and analyse it across different sectors and enterprises (De Giuli et al., 2024).

With the rise of ESG as a crucial principle in the business world, firms are under growing scrutiny from investors, customers, workers, and regulators to tackle ESG risks. Managing the expectations of external parties while still prioritising internal goals may be challenging, especially when dealing with a varied group of stakeholders that have different expectations and objectives.

Effectively communicating and being transparent are necessary to balance the interests of stakeholders while achieving the company's strategic objectives. This is also included in the management of regulatory ambiguity. The regulatory framework for ESG issues is undergoing significant changes and developments. Companies have the issue of complying with diverse standards, reporting obligations, and disclosure expectations in several countries.

Implementing ESG might be initially pricey and expensive. Certain techniques for mitigating ESG risks may include initial expenses or need the redistribution of resources. Small organisations often have difficulties in striking a balance between the expenses associated with adopting sustainable practices and the potential advantages they may bring in the long run. This also applies to a major corporation that has a supplier with a complicated supply chain. Managing ESG risks in supply chains is difficult owing to the complex and vast networks involved. Enforcing consistent adherence to ESG standards among vendors might pose challenges.

Greenwashing is a significant problem that involves the misleading practice of presenting a company's goods, services, or policies as environmentally friendly or socially responsible, even while they may not really satisfy these requirements. This phenomenon poses diverse dangers across several dimensions. First and foremost, from an ethical perspective, greenwashing weakens the integrity of ESG initiatives, undermining confidence and credibility among stakeholders, such as investors, customers, and regulators. The loss of trust may result in reputational harm and perhaps legal consequences, since stakeholders are increasingly seeking openness and responsibility in relation to environmental and social performance.

Furthermore, greenwashing presents financial hazards, since investors may base their judgements on distorted information, resulting in the misallocation of funds and vulnerability to future financial setbacks. From a regulatory standpoint, greenwashing may lead to regulatory scrutiny and enforcement measures, as authorities strive to fight misleading practices and guarantee adherence to disclosure obligations.

5. Conclusions

The purpose of this study is to propose the framework of risk management that is related with ESG activities and hence, ESG performance of the company. In addition, this paper discusses the benefits and obstacles in adopting ESG risk management that will prevent business organizations from using ESG to create value and sustain long-term performance which will benefit all the related stakeholders.

ESG risk management has become a crucial framework in today's corporate environment and critically used to assess the sustainability and ethical implications of an investment or corporate activity. With the growing worries about climate change, social injustice, and corporate responsibility, investors, stakeholders, and regulatory agencies are becoming more focused on how organisations tackle these challenges. ESG risk management is the process of recognising, evaluating, and reducing the possible risks linked to environmental, social, and governance elements that may affect a company's financial performance, reputation, and long-term sustainability.

The environmental dimension of ESG risk management concerns the influence that a firm has on the natural environment. This entails assessing the company's utilisation of resources, levels of pollution, carbon emissions, and endeavours towards implementing sustainable practices. Neglecting environmental concerns may result in penalties from regulatory authorities, harm to reputation, interruptions in the supply chain, and higher operating expenses. Social considerations refer to how workers are treated, the level of diversity and inclusion, the firm's involvement in the community, and the overall influence the company has on society. Businesses that disregard social factors may encounter employee discontent, consumer boycotts, legal actions, and difficulties in recruiting and maintaining highly skilled employees.

Governance encompasses the framework and procedures by which a firm is managed and supervised. The concept encompasses elements such as the structure of the board, remuneration of executives, openness, and methods to prevent corruption. Inadequate governance may lead to ethical violations, conflicts of interest, shareholder activism, and even legal consequences. To effectively manage ESG risks, it is crucial to have a thorough grasp of the interconnections between these elements and how they interact with a company's operations, strategy, and relationships with stakeholders. Organisations may strengthen their ability to withstand challenges, gain the confidence of stakeholders, take advantage of new possibilities, and position themselves for sustained success in a changing global environment by incorporating ESG factors into their risk management strategy.

References

- Hübel, B., & Scholz, H. (2020). Integrating sustainability risks in asset management: the role of ESG exposures and ESG ratings. *Journal of Asset Management*, 21(1), 52-69.
- De Giuli, M. E., Grechi, D., & Tanda, A. (2024). What do we know about ESG and risk? A systematic and bibliometric review. *Corporate Social Responsibility and Environmental Management*, 31(2), 1096-1108.
- Folqué, M., Escrig-Olmedo, E., & Corzo Santamaría, T. (2021). Sustainable development and financial system: Integrating ESG risks through sustainable investment strategies in a climate change context. *Sustainable Development*, 29(5), 876-890.
- Amirudin, N.R., Nawawi, A., & Salin, A.S.A.P. (2017). Risk management practices in tourism industry – A case study of resort management. *Management and Accounting Review*, 16(1), 55-74

The Knowledge and Practices Environmental Among Students of Kuching Polytechnic Sarawak

Faridah Che In^{1*}, Suraya Yope @Yahya² & Noorul' Ashikin Md Salih³

^{1,2,3} Jabatan Perdagangan, Politeknik Kuching Sarawak, Malaysia

Abstract

Environmental knowledge plays a crucial role for humans and their surroundings. Environmental awareness is a very important element in determining the well-being and quality of human life. This is because a good environment can guarantee the well-being and comfort of communities as they enjoy the fresh air and practice a culture of healthy living. At the same time, people need to be aware and more sensitive to environmental awareness and issues and to be able to deal with pollution that can affect air quality. The objectives of the study have been to identify the level of students' knowledge of recycling issues and to recognize the practices of students on environmental issues. Those involved in this study are students from various fields of study. This study was conducted with 384 respondents of various races and ages. A descriptive approach was used to analyse the data. Research information is collected when questionnaires are filled out by respondents. Some of them are also discussed. In conclusion, this study found that the knowledge level of Polytechnic Kuching Sarawak students is still at a good level.

Keywords: knowledge, practices environmental, students

1. Introduction

Since achieving independence, Malaysia has enjoyed exciting socioeconomic development, and this success has been recognized by the international community. This achievement is the result of the government's commitment and efforts to implement development projects, including the construction of new cities.

However, this has caused climate change to cause a very high increase in greenhouse gases over a period of 800,000 years (IPCC, 2021). Malaysia also recorded an increasingly alarming level of pollution. Landfills are a major source of greenhouse gases such as carbon dioxide and methane. The growing number of consumers has increased the amount of garbage, especially domestic garbage, sent to landfills (Rahaman & Rahim, 2021).

Education is seen as the best method for producing a generation that is highly knowledgeable and environmentally conscious. The objective of environmental education is to create a more environmentally conscious and sensitive society, as well as to provide information, skills, values, and a willingness to work individually and collectively to solve environmental problems (Rahim & Othman, 2019).

It is also critical to establish a more environmentally conscious society in light of the growing and deteriorating environmental issues (Mravcová, 2024). By spreading knowledge, people will become more conscious and concerned, which will lead to their acting in a more environmentally friendly manner. Thus, the purpose of this preliminary study was to discuss the level of knowledge and practice among students regarding the environment.

2. Literature Review

Knowledge on Environment

Knowledge is defined as the capacity to acquire, retain and use information; a mixture of understanding, experience, wisdom and skill (Rahaman & Rahim, 2021). The mastery of this knowledge requires two main principles that overlap each other, namely the concept of an object is thought of as a whole where this requires the ability to think, while the second is a concept that requires the power of the senses (sari et al. 2020). Debrah, Vidal & Dinis (2021) conduct a study to see the level of knowledge about the environment among secondary and tertiary schools. The available research suggests that students at both secondary and tertiary levels generally exhibit positive environmental attitudes and a high level of awareness of environmental issues (Marpa, 2020).

Environment Practice

As the world grapples with the pressing issue of environmental sustainability, it is crucial to examine the role of youth in shaping and adopting eco-friendly practices. As the world grapples with the pressing issue of environmental sustainability, it is crucial to examine the role of youth in shaping and adopting eco-friendly practices. A growing body of literature highlights the importance of building knowledge and leadership skills of youth in order to promote their engagement in environmental issues and empower them to affect positive change in their local and global communities (Mahat et al., 2021). Research suggests that while individuals tend to behave in ways that are socially desirable, their moderate environmental awareness must be transformed into a strong interest that immediately translates into best practices for sustainability (Piscitelli & D'Uggento, 2022). To get all young people to become more involved, the most effective way must be found quickly, even if it is not easy to make a direct link between values and action.

2. Methodology

This study is quantitative and uses a survey as its non-experimental design. Respondents' questionnaires are sent as the primary means of gathering data. SPSS Version 23 was used to examine the study results. A standard research study sample size of 384 respondents with a 95% confidence level and a 5% margin of error was employed. This study utilised the simple non-probability sampling technique. A survey instrument was created using measurement items and questions meant to collect demographic information from respondents. The study employed a questionnaire using a five-point Likert scale: strongly disagree = 1, disagree = 2, agree = 3, agree strongly = 4, agree very strongly = 5. The questionnaire's internal consistency was examined by Cronbach's coefficient alpha method with SPSS (Table 1).

Table 1: Internal Coherence Consistency Coefficients

Field	Numbers of items	Cronbach Alpha
Knowledge environmental	10	0.781
practice environmental	10	0.876

3. Results and Discussion

The demographic profile of the respondents is presented in Table 1. A large majority of respondents fall within the 18-21 age group, accounting for 91%, which is not surprising considering the student population's age distribution. When it comes to gender, female students (60.94%, 234 respondents) outnumber male students (39.06%, 150 respondents) at Polytechnic Kuching, Sarawak. This indicates a higher representation of female students in the polytechnic compared to male students. In terms of religion, Islam is the dominant faith among the respondents (40.44%, 186 respondents), followed by Christianity (42.97%, 165 respondents), Buddhism (6.51%, 25 respondents), and Hinduism (2.08%, 8 respondents).

Table 2: Demographic Profile of Respondents

Demographic	Categories	Frequency
Gender	Male	150
	Female	234
Age	18 - 19 years	180
	20 - 21 years	150
	More than 21 years	54
Religion	Islam	186
	Christian	165
	Buddha	25
	Hindu	8

In Table 3, it is demonstrated that students have a high level of knowledge about the environment as a whole. "I know about the concept of recycling" (Item 1) received the highest ranking with a mean of 4.31. This indicates that students possess knowledge about the environment, especially the harmful impact of human utilisation of plants and animals. Items 2, 3, 4, 5, 6, 7, and 8 also show a high level of knowledge. Although most items exhibit a moderate level of knowledge, items 9 and 10 are ranked as moderate with the lowest mean of 3.1.

Table 3: Means and Standard Deviations of Knowledge in Environmental Domain Items Arranged in Descending Order According to Their Means

No.	Item	M	SD	Level
1	I know about the concept of recycling.	4.31	1.22	Very high
2	Naturally, existence of plants and animals is for human utilization	3.99	1.3	High
3	5R refers to " Refuse, Reduce, Recycle, Repurpose & Reuse".	3.74	1.45	High
4	Materials made of glass can be recycled	3.69	1.28	High
5	Plants can also be recycled	3.53	1.45	High
6	Ecosystems are vulnerable, and they can be easily deteriorated	3.42	1.4	High
7	The nature is strong, and it can cope with consequences of human development activities	3.42	1.38	High
8	Plants and animals have as much right as humans to exist	3.41	1.37	High
9	The earth is like a spaceship with finite room and resources.	3.2	1.47	Moderate
10	If things continue on their present course, we will soon experience a major ecological catastrophe.	3.1	1.33	Moderate

Table 4: Means and Standard Deviations of Practice in Environmental Domain Items Arranged in Descending Order According to Their Means

No.	Item	M	SD	Level
1	I make sure that the appliance is energy efficient before I buy it.	3.88	1.33	High
2	I prefer living away from the noise	3.72	1.41	High
3	I use water wisely for daily purposes.	3.6	1.31	High
4	I buy organic fruits and vegetables	3.5	1.28	High
5	I prefer using air conditioners than opening the windows.	3.49	1.47	High
6	I make sure to have some green plants inside my house.	3.38	1.48	High
7	I open the windows of the house occasionally.	3.34	1.37	High
8	I try to use sunlight instead of artificial lights.	3.32	1.43	High
9	I use paper bags more than plastic bags.	3.25	1.46	moderate
10	I dispose of old batteries and electronics safely.	3.19	1.51	moderate

Table No. 4 describes the level of practice in the environment among students at Polytechnic Kuching Sarawak. Mostly the level of practice is high. Item No. 1, namely, "I make sure that the appliance is energy efficient before I buy it, is high according to items No. 2, 3, 4, 6, 7, and 8. It is surprising that the student prefers to buy organic fruits and vegetables. However, this is not impossible because in Borneo, organic fruits and vegetables are easily available from local residents. The only item not stated between 9 and 10 is moderate. In addition, item No. 10, which reads "I dispose of old batteries and electronics safely," is ranked the last with a mean of 1.51.

In recent years, the growing awareness of environmental issues has led to a surge in green campaigns aimed at educating the public and promoting eco-friendly practices. The results presented in Tables 3 and 4 indicate that the level of knowledge and practice of environmental issues among the students enrolled is "high." This may be due to campus environmental factors also influencing knowledge. It also lines with Ansu-Mensah, (2021) and Singh et al., (2023). Research suggests that such initiatives can effectively enhance consumers' knowledge and understanding of environmental concerns. In addition to that, there are also several other activities held on campus that also contribute to this high mean, such as the green campaign and Smart Green.

Recent studies have highlighted that the level of practice among students in various disciplines remains notably high. For instance, a study in Ghana found that a significant majority (65.2%) of junior high school students practised good oral hygiene habits, such as brushing their teeth multiple times a day and using fluoridated toothpaste (Acheampong et al., 2023). Similarly, research conducted among pharmacy students in Zambia indicated high adherence to infection prevention and control measures, with most students demonstrating good practice scores in these areas (Mudenda et al., 2023). Students demonstrate a commendable commitment to maintaining health and hygiene standards based on these findings. This indicates that improvements in educational systems can lead to enhancements in teaching methods, evaluation practices, environmental behaviors, and the development of graduates' health and environmental capabilities.

4. Implications and Direction for Future Research

This study focused on aspects of knowledge and practice in the environment among college students in Polytechnic Kuching, Sarawak. This paper concludes with knowledge and practice at a high level in the environment. The paper concludes with the following suggestion from the researcher. Further research could explore the development and implementation of modern environmental awareness programs for students by establishing a separate department dedicated to environmental conservation. The researcher suggests that environmental studies should be integrated into college curricula and taught to all students regardless of gender. This could be achieved by incorporating more hands-on, practical programs into their studies.

References

- Acheampong, M., Osafo, J., & Armah, F. A. (2023). Oral health knowledge, practice and associated factors among Junior High School students of Koforidua, Ghana: a cross-sectional study. *BMC Oral Health*. Retrieved from BMC Oral Health.
- Ansu-Mensah, P. (2021). Green product awareness effect on green purchase intentions of university students': an emerging market's perspective. *Future Business Journal*, 7(1). <https://doi.org/10.1186/s43093-021-00094-5>
- Debrah, J. K., Vidal, D. G., & Dinis, M. A. P. (2021). Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review. *Recycling*, 6(1), 6.
- Intergovernmental Panel on Climate Change, IPCC, (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. In V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (Eds.). Cambridge University Press. In Press.
- Kang, H. (2021). Sample size determination and power analysis using the G* Power software. *Journal of educational evaluation for health professions*, 18

- Mahat, H., Hashim, M., Saleh, Y., Nayan, N., Norkhaidi, S. B., & Mohamad, N. F. (2021, March). Environmental sustainability engagement practices among youths in Muallim District, Perak, Malaysia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 683, No. 1, p. 012126). IOP Publishing
- Marpa, E. P. (2020). Navigating Environmental Education Practices to Promote Environmental Awareness and Education. *Online Submission*, 2(1), 45-57
- Mravcová, A. (2024). Environmental Sustainability under the Impact of Current Crises. *Studia Ecologiae et Bioethicae*, 22(2).
- Mudenda, S., Botha, J., Mukosha, M., Daka, V., Chileshe, M., & Mwila, C. (2023). Knowledge, attitude, and practices toward infection prevention and control among undergraduate pharmacy students in Zambia: findings and implications. *Antimicrobial Stewardship & Healthcare Epidemiology*. Retrieved from Cambridge Core.
- Piscitelli, A. and D'Uggento, A.M. Do young people really engage in sustainable behaviors in their lifestyles? *Soc Indic Res* 163, 1467–1485 (2022)
- Rahaman, Z. A., & Rahim, A. A. (2021) Pengetahuan Dan Amalan Kitar Semula Dalam Kalangan Pelajar Universiti Pendidikan Sultan Idris. *Environment*, 6(25), 207-218.
- Rahim, N. Z. A., Sum, S. M., & Othman, N. (2019). Environmental Education in Malaysia: Past, Present and Future. *European Proceedings of Social and Behavioural Sciences*.
- Sari, R. K., Sutiadiningsih, A., Zaini, H., Meisarah, F., & Hubur, A. A. (2020). Factors affecting cognitive intelligence theory. *Journal of Critical Reviews*, 7(17), 402-410.
- Sondhi, S., Chawla, U., & Iqbal, H. (2023). Relationship between social cause, environment conservation and environmental attitude, towards promoting green purchasing behavior. *Serbian Journal of Management*, 18(1), 27-43.

Unveiling Greenwashing: Risks in Sustainability and ESG Reporting

Nurul Nazlia Jamil^{1*} & Ersu Tri Wahyuni²

¹Faculty of Economics and Muamalat, Universiti Sains Islam Malaysia, Malaysia

²Fakultas Ekonomi dan Bisnis Universitas Padjadjaran, Bandung, Indonesia

Abstract

In recent years, the corporate world has witnessed a surge in sustainability reporting, reflecting a growing awareness of environmental and social responsibility. However, amidst this trend lies a significant risk of greenwashing. Greenwashing refers to the deceptive practice of conveying a false impression or providing misleading information about a company's environmental efforts. This paper explores the phenomenon of greenwashing and its ramifications for sustainable reporting. Companies often resort to superficial gestures or cosmetic changes to portray themselves as environmentally conscious, while their core operations remain unchanged. The paper also examines the implications of greenwashing for stakeholders and the environment. Misleading sustainability reporting can erode trust among consumers, investors, and communities, leading to reputational damage and financial losses. The study employs an inductive approach that analyzes literature to develop coherent narratives and theoretical insights regarding the phenomenon of greenwashing and its implications for sustainability reporting. The study makes attempts to highlight the challenges of detecting and combating greenwashing. With the lack of standardised metrics and regulatory oversight, distinguishing between authentic sustainability practices and deceptive claims becomes increasingly difficult. This opacity poses risks not only to stakeholders but also to the credibility of sustainability reporting as a whole. The paper concludes that the need for increasing integration of ESG metrics into business practices, the innovative approaches in ESG practices, and the shift towards risk management can minimize greenwashing activities. In conclusion, this paper underscores the importance of addressing greenwashing to foster genuine progress towards sustainability. By embracing these changes and viewing ESG as an integral part of their strategy, companies can not only fulfill their ethical obligations but also unlock new opportunities for growth and resilience.

Keyword: Greenwashing, Sustainability Reporting, Environmental, Social and Governance

1. Introduction

In an era where environmental, social, and governance (ESG) considerations are increasingly becoming integral to business strategies, the concepts of greenwashing and sustainability reporting have emerged as focal points in corporate discourse. ESG factors encompass a broad spectrum of criteria that measure a company's performance and impact on the environment, society, and governance practices. As companies strive to align with sustainability goals and cater to the growing demands of socially responsible investors and consumers, the significance of accurate and transparent sustainability reporting cannot be overstated.

However, amidst the surge in sustainability reporting, concerns regarding greenwashing have intensified. According to Free et al. (2024), greenwashing a term coined to describe the deceptive practice of overstating or misrepresenting a company's environmental efforts, poses a significant risk to the integrity of ESG initiatives. Companies may resort to superficial measures or token gestures to portray themselves as environmentally conscious, while their actual practices remain unsustainable or even detrimental to the planet. This phenomenon not only erodes trust among stakeholders but also undermines genuine sustainability efforts, diverting attention and resources away from meaningful initiatives.

Against this backdrop, sustainability reporting plays a crucial role in providing stakeholders with insights into a company's ESG performance and commitments. Transparency and accountability are paramount to ensuring the credibility of such reports. However, the lack of standardized metrics and regulatory oversight poses challenges in discerning between authentic sustainability practices and greenwashing. This is consistent with the study by Yu et al. (2020), which shows investors, consumers, and other stakeholders often face difficulty making informed decisions and holding companies accountable for their ESG claims.

This introduction sets the stage for a deeper exploration of ESG considerations, greenwashing, and sustainability reporting. By examining the motivations behind greenwashing, the implications for stakeholders and the environment, and the challenges in detecting and combating deceptive practices, we aim to shed light on the complexities of navigating the evolving landscape of corporate sustainability. Moreover, we underscore the importance of transparency, accountability, and robust verification mechanisms in fostering genuine progress towards a more sustainable future.

2. Literature Review

In recent years, the intertwined concepts of greenwashing, environmental, social, and governance (ESG) criteria, and sustainability reporting have garnered significant attention in both academic and corporate circles. This literature review aims to provide a comprehensive overview of the existing research, theories, and insights regarding these interconnected themes.

Greenwashing, as a deceptive practice aimed at creating a false impression of environmental responsibility, has been extensively studied in the literature. Scholars have explored various facets of greenwashing, including its motivations, manifestations, and consequences. For instance, Schaefer et al. (2019), identified a range of motives driving greenwashing behaviour, such as gaining competitive advantage, mitigating regulatory risks, and enhancing corporate image. Similarly, Delmas and Burbano (2011) conducted empirical research to demonstrate how firms engage in greenwashing to exploit consumer preferences for environmentally friendly products, thereby influencing purchasing decisions.

The rise of ESG criteria as a framework for assessing corporate sustainability performance has reshaped the landscape of business practices and reporting standards. Researchers have investigated the integration of ESG factors into investment strategies, corporate decision-making processes, and stakeholder engagement initiatives. Eccles et al. (2011) proposed the concept of "integrated reporting," which emphasizes the holistic portrayal of a company's financial and non-financial performance, including ESG metrics. This approach aligns with the growing recognition that sustainable value creation requires a comprehensive understanding of both financial and extra-financial factors.

Sustainability reporting serves as a vital mechanism for communicating a company's ESG commitments, initiatives, and outcomes to stakeholders. Scholars have examined the evolution of sustainability reporting frameworks, the effectiveness of disclosure practices, and the challenges associated with ensuring transparency and credibility. Adams (2008) highlighted the importance of standardized reporting guidelines and assurance processes in enhancing the reliability of sustainability disclosures. Moreover, Schaltegger (2018) emphasized the role of narrative reporting in complementing quantitative metrics by providing context and insights into a company's sustainability journey.

The intersection of greenwashing, ESG, and sustainability reporting has become a focal point of inquiry, reflecting the need to address ethical, regulatory, and practical considerations. Researchers have explored the implications of greenwashing for sustainability reporting credibility, investor decision-making processes, and regulatory enforcement efforts. For instance, Marquis and Toffel (2011) investigated the impact of media scrutiny on firms accused of greenwashing, finding that negative publicity can lead to reputational damage and financial penalties.

In conclusion, the literature on greenwashing, ESG, and sustainability reporting underscores the complexity and importance of navigating corporate sustainability challenges. Moving forward, interdisciplinary research efforts are needed to develop robust methodologies, frameworks, and policies that promote transparency, accountability, and genuine progress towards a more sustainable and responsible business environment.

Greenwashing

Greenwashing takes many forms, ranging from vague or misleading advertising claims to token gestures and superficial sustainability initiatives. Researchers have documented various greenwashing strategies employed by companies across different industries and contexts. For example, Parguel et al. (2011) categorized greenwashing tactics into different types, such as vague or irrelevant claims, false or misleading information, and hidden trade-offs. Moreover, Lyon and Montgomery (2015) examined the prevalence of greenwashing in the energy sector, highlighting the use of deceptive advertising and lobbying tactics to promote fossil fuel interests under the guise of environmental stewardship.

Greenwashing can have profound consequences for companies, consumers, investors, and society at large. Scholars have investigated the impact of greenwashing on consumer trust, brand reputation, and purchasing behaviour. For instance, Lin-Hi and Müller (2013) explored the relationship between corporate environmental performance and consumer trust, finding that greenwashing undermines trust and credibility in companies' environmental claims. Moreover, Marquis and Toffel (2011) examined the reputational risks associated with greenwashing, highlighting how negative publicity and media scrutiny can damage corporate reputation and shareholder value.

Efforts to combat greenwashing have focused on enhancing transparency, accountability, and regulatory oversight. Researchers have proposed various solutions and best practices for promoting genuine sustainability efforts and deterring deceptive practices. For example, Lyon and Maxwell (2011) advocated for greater transparency and disclosure requirements, coupled with independent verification and certification mechanisms. Similarly, Chen and Chu (2024) emphasized the importance of regulatory enforcement and legal remedies in holding companies accountable for greenwashing behaviour.

In conclusion, greenwashing represents a complex and multifaceted phenomenon with far-reaching implications for businesses, consumers, and society. By understanding the motivations, manifestations, and consequences of greenwashing, policymakers, practitioners, and researchers can develop effective strategies and interventions to promote transparency, integrity, and sustainability in corporate practices.

The Reporting Framework

Governance has been around for a while, most companies report on their share structure, ownership and most investors actually do want to know if managers are being paid too much and if the Board is qualified. Although G doesn't necessarily have a dollar figure attached to it, it is important, and investors know that. Around the time of the 2005 UNEP report, when the term was first coined, environment was also considered very important. The S or social issues only took on more relevance later, especially with the 2008 financial crisis and the renewed debate about ESG and fiduciary duty. There is plenty of evidence that the ESG factors impact the financial well-being of a business and that without due consideration of the E and S businesses not only increase their risk, they also miss opportunities.

As the ESG "industry" has expanded, the term has become erroneously intertwined with sustainability. However, it is essential to emphasise that sustainability is not a subset of ESG but rather the encompassing concept to which all ESG efforts contribute. Sustainability embodies the principles and values of living in harmony with the planet while achieving peace and equality through our activities and institutions. In contrast, ESG efforts, simply put, are how organisations measure, monitor and manage their performance to be more sustainable.

If an organisation is merely focussing on philanthropy and volunteering programmes, that is CSR or Corporate Social Responsibility efforts (and not ESG or Sustainability). Yes, CSR was effective in driving the responsibility agenda but it became too broad, and philosophical for businesses. Whereas ESG has gained traction as it gave quantitative measures to which business leaders and investors could relate more directly to their business, and therefore could more readily adopt the related frameworks. This is a serious issue for stakeholders for several reasons. Despite its admirable objectives, ESG initiatives have predominantly cultivated a culture focused on meeting regulatory requirements rather than fostering the transformative innovation necessary to address environmental challenges. Instead of inspiring genuine commitment to sustainability, the ESG framework, with its emphasis on regulatory compliance, accessible funding, and attractive incentives, has unintentionally encouraged superficial practices. This has led to the proliferation of greenwashing tactics, where companies prioritize appearances over substantive environmental action, thus undermining the original intent of ESG initiatives.

True champions of environmental and societal sustainability see themselves as caretakers of the planet and its inhabitants, actively leading the way in developing creative solutions to current challenges in ways that are profitable. Instead of being motivated by external rewards or regulatory demands, authentic steward leaders are internally compelled by a sincere dedication to leave behind a beneficial legacy. The world of ESG has taken off and is catching on in Asia. Everyone is talking about how important adopting ESG initiatives is and how investors are taking notice of risk mitigation through ESG performance. The term has become one of those acronyms that many people recognize, yet not everyone understands. Without getting too pedantic, definitions are important to ensure alignment, prevent misallocation of valuable resources and guard against accidental greenwashing.

Understanding where it came from, its purpose and objectives, gives us insights as to how the term ESG has been used, misused and perhaps abused. It's not in anyone's interest, let alone a company's self-interest, to reduce ESG to mere marketing or differentiation strategies or view it solely as a risk management exercise. Whilst important to look back and establish clarity on definitions, I now find myself looking to the future. As we move forward, I begin to wonder where in ESG does humanity and well-being fit? How might we evolve this tool from doing less bad i.e., mitigation, to positive or regenerative investments i.e., the real impact of ESG capital?

As the importance of Environmental, Social, and Governance factors in investment decision-making continues to grow, there is a need for a uniform and global reporting framework for ESG. This framework would provide consistent guidelines and standards for companies to report their ESG performance, allowing investors to easily compare and evaluate different companies. Furthermore, a uniform and global reporting framework would enhance transparency and credibility of ESG information, addressing concerns about greenwashing and providing investors with reliable data.

The current frameworks available across many countries are:

1. **Global Reporting Initiative:** This is one of the most widely used frameworks for ESG reporting. It provides guidance and indicators for reporting on a wide range of sustainability issues.
2. **Sustainability Accounting Standards Board:** This framework focuses on industry-specific metrics and disclosures, providing investors with more relevant and comparable ESG information.
3. **Task Force on Climate-related Financial Disclosures:** This framework, established by the Financial Stability Board, focuses specifically on climate-related risks and opportunities.
4. **Carbon Disclosure Project:** This is a widely recognized framework that helps companies disclose their carbon emissions and climate change strategies.
5. **Integrated Reporting Framework:** This framework encourages companies to provide a holistic view of their performance, including financial, environmental, social, and governance aspects.
6. **CDP Water Security:** This framework focuses on water-related risks and management strategies. Water security frameworks are particularly relevant for industries that heavily rely on water resources, such as agriculture, manufacturing, and energy production. These are specialized frameworks for water management.

In order to effectively assess and compare ESG performance across companies and industries, there is a need for a uniform and global reporting framework. The lack of a uniform and global reporting framework for ESG makes it difficult for investors to compare the sustainability performance of different companies. Additionally, without a uniform and global reporting framework, companies may have varying interpretations of what constitutes ESG reporting and may be able to manipulate or withhold relevant information.

ESG Reporting

ESG reporting has evolved from a niche practice to a mainstream corporate activity, driven by a growing recognition of the interconnectedness between business operations and broader societal and environmental issues. Researchers have traced the historical development of ESG reporting frameworks, from early corporate social responsibility (CSR) initiatives to the emergence of standardized reporting guidelines and frameworks.

For instance, Hoang (2018) identified the evolution of ESG reporting from voluntary, non-standardized disclosures to more structured and comprehensive reporting practices, influenced by factors such as regulatory pressures, stakeholder demands, and market expectations. Reporting plays a vital role by not only communicating positive stories but also by acknowledging and addressing key material issues that could impact the business continuity in the short and long term. This dual focus ensures a well-rounded and transparent representation of the business's ESG performance and challenges.

ESG should not be treated as a mere tick-box exercise. Instead, it should be viewed as a strategic imperative seamlessly integrated across business operations, ensuring comprehensive and effective addressing of all ESG issues in the short and long term. Furthermore, having a uniform and global reporting framework for ESG, it would establish consistent guidelines and metrics for ESG reporting, ensuring that companies report relevant and comparable information. This would make it easier for investors to analyze and compare ESG performance across different companies and industries.

Moreover, a uniform framework would provide a comprehensive and interconnected view of a company's overall performance, allowing stakeholders to gain a deeper understanding of how ESG factors are integrated into the core business strategy. This holistic view would enable investors to make informed decisions that align with their ethical and sustainable investment objectives, contributing to the overall advancement of sustainable practices across industries. Additionally, a global reporting framework could facilitate collaboration and knowledge sharing among companies, investors, and other stakeholders. This exchange of information and best practices could lead to the development of innovative solutions and initiatives to address global sustainability challenges, fostering a more cohesive and proactive approach towards achieving environmental and social goals on a global scale.

Ultimately, it will contribute to the advancement of a more sustainable and responsible global economy by promoting greater awareness of environmental impact issues within corporate structures. Given the growing significance of Environmental, Social, and Governance factors in investment decision-making, the need for a uniform and global reporting framework becomes even more apparent. The existing frameworks, while valuable, lack the consistency and standardization necessary for effective comparison and evaluation. Furthermore, without a uniform and global reporting framework, there is a risk of misleading or incomplete information being reported.

A uniform and global reporting framework for ESG would not only standardize reporting and improve transparency but also promote a deeper understanding of how ESG factors are integrated into a company's core business strategy. This comprehensive view would empower stakeholders to make informed decisions aligning with their ethical and sustainable investment objectives, thereby contributing to the broader advancement of sustainable practices across industries.

This is consistent with Mahmud et al. (2017) mentioned that the implementation of a global reporting framework could facilitate collaboration and knowledge sharing among companies, investors, and other stakeholders. This exchange of information and best practices could lead to the development of innovative solutions and initiatives to address global sustainability challenges, ultimately fostering a more cohesive and proactive approach towards achieving environmental and social goals on a global scale.

In conclusion, the implementation of a uniform and global reporting framework for ESG is crucial. It will harmonize ESG disclosures, enhance transparency, foster accountability, and drive continuous improvement in sustainable business practices. By providing clear and consistent guidelines, this framework will enable investors to make informed decisions and comparisons across companies and industries.

3. A Model for ESG Reporting

In the realm of corporate governance and business strategy, the integration of ESG criteria stands out as a transformative global trend, redefining traditional paradigms of success and sustainability. This shift is particularly pronounced in the Asia-Pacific region, which has emerged as a forerunner in embedding ESG metrics into corporate frameworks and executive incentives. Recent studies and reports paint a clear picture of this evolution. In 2023, an impressive 77% of employers in the Asia-Pacific region incorporated ESG measures into their executive incentive plans, marking a significant leap from 63% in the previous year (Isik et al., 2024). This uptick is not just a statistic but a testament to the growing recognition of ESG's critical role in fostering long-term, sustainable corporate growth.

However, the landscape of ESG integration is as diverse as it is dynamic. Countries such as Singapore, Australia, and Japan are leading the charge, with adoption rates soaring high – 93% in Singapore, 86% in Australia, and 72% in Japan (Isik et al., 2024). These figures mirror, if not surpass, the trends observed in more traditionally ESG-focused regions like Europe and North America. This leadership emphasises a broader regional commitment to sustainable and responsible business practices, driven by both internal corporate governance values and external investor pressures.

However, according to Mohd Daud et al. (2024), in other parts of Asia-Pacific, such as China, Hong Kong, India, and Malaysia, the adoption of ESG metrics exhibits a more gradual trajectory. In these markets, inconsistencies in disclosure practices and varying regulatory frameworks contribute to a more staggered integration of ESG principles. Yet, the direction is clear: an increasing number of leading companies in these countries are aligning their business practices with ESG priorities, indicating a region-wide shift towards more sustainable business models.

According to Baratta et al. (2023), the industry-specific variations in ESG adoption further illustrate the complexity of this trend. Sectors like consumer staples, energy, financials, and utilities are more proactive in embracing ESG metrics, reflecting their direct impact on environmental and social aspects. Meanwhile, the rise in ESG metric adoption in sectors such as real estate and communications services highlights a growing awareness across diverse business landscapes. As the study observes these global trends, it becomes evident that ESG integration is not a passing fad but a fundamental shift in how businesses operate and define success. The Asia-Pacific region's leadership in this domain sets a compelling example for the rest of the world, showcasing the potential of ESG to drive not just ethical and sustainable practices, but also robust and resilient business growth.

4. Challenges in ESG Reporting and Ratings

While the integration of ESG principles marks a progressive stride in corporate responsibility, it is not without its complexities and challenges. Central to these challenges is the issue of ESG reporting and ratings areas that have been subject to increasing scrutiny for their opacity and inconsistency. The ESG rating system, a critical tool for investors to assess a company's sustainability and ethical impact, has faced criticism for its lack of transparency and standardization (Wang et al. 2023). Major rating agencies like MSCI, S&P Global, and Morningstar's Sustainalytics each use different methodologies, leading to significant variances in scores. For instance, studies show only about a 60% correlation in ESG ratings among providers, compared to up to 99% in credit ratings. This disparity can leave investors navigating a maze of conflicting information, challenging the reliability of these ratings as tools for informed decision-making.

Beyond the ratings themselves, the process of ESG reporting is filled with difficulties. The data, often scraped from diverse sources of varying quality, is fed into models to produce composite scores. However, the combination of disparate metrics can render these scores arbitrary, raising questions about their real-world relevance and accuracy. A study conducted by Galletta et al. (2023) shows European banks present a case in point, struggling with the intricacies of new ESG requirements, particularly the Green Asset Ratio (GAR). Introduced by the European Banking Authority (EBA), the GAR is a measure intended to reflect the extent to which a bank's asset portfolio aligns with sustainable activities. However, early assessments indicate that the banking industry is substantially behind the curve, with estimates suggesting a figure lower than 7%. This shortfall highlights the challenges institutions face in aligning their operations with evolving ESG standards.

Moreover, the EBA's requirement has spurred debates among banks and investors about the efficacy and impact of such metrics. European banks are advocating for a more nuanced approach, suggesting that investors should consider a broader range of ESG metrics rather than focusing solely on GAR. This viewpoint emphasises a broader issue in the ESG domain: the need for metrics that are not only comprehensive and transparent but also adaptable to the complexities of different industries and markets. The challenges in ESG reporting and ratings lie in achieving a balance between comprehensive assessment and practical applicability. As we push forward in this ESG-driven era, these challenges highlight the need for continued refinement and harmonisation of reporting standards and methodologies, ensuring that ESG remains a robust and reliable compass for sustainable and ethical business practices.

5. Innovations in ESG Practices

As ESG practices increasingly become a cornerstone in modern business strategy, innovative approaches to ESG reporting are emerging, reshaping the landscape of corporate responsibility and transparency. A notable example of this innovation is the adoption of the Simplified ESG Disclosure Guide (SEDG) by ESGpedia in Malaysia (Chung et al.2024). This initiative marks a significant step in simplifying the ESG reporting process for small and medium-sized enterprises (SMEs), a sector that often grapples with the complexities of comprehensive ESG reporting. The SEDG, launched by Capital Markets Malaysia, is a pioneering effort providing SMEs with a streamlined and standardised set of guidelines tailored for ESG disclosures. This move not only facilitates easier compliance for SMEs but also ensures their competitive edge in the global market, where ESG adherence is increasingly becoming a benchmark.

Further advancing the ESG reporting landscape are digital tools and platforms, exemplified by STACS's ESGpedia. ESGpedia, a platform developed by Hashstacs Pte Ltd (STACS), is revolutionising the ESG space by digitalising the reporting process. This platform integrates tools such as a digital assessment and a carbon calculator aligned with GHG Protocol and ISO14064 methodologies, providing SMEs with automated calculations and deeper insights into their greenhouse gas emissions. The digitalisation of these tools democratises access to ESG reporting, allowing a broader range of companies to participate in sustainable practices effectively. Furthermore, ESGpedia's influence is not limited to Malaysia. As a prominent ESG data and technology firm in Asia, STACS's platform plays a crucial role in numerous endeavors, such as the ESCAP Sustainable Business Network's Asia-Pacific Green Deal digital platform and the Monetary Authority of Singapore's Greenprint ESG Registry. According to Ho (2023) with over 5 million data points on sustainability, ESGpedia acts as a central hub for corporations, SMEs, and the financial sector, aiding not only in meeting ESG regulations but also in advancing their wider ESG objectives.

These innovations in ESG practices are a demonstration to the evolving nature of corporate sustainability efforts. By leveraging technology and simplifying reporting processes, these tools and platforms are ensuring that ESG compliance is no longer a daunting task but an accessible and integral aspect of business operations. As we continue to witness these advancements, it is clear that the path to sustainable and responsible business practices is becoming more navigable and inclusive, paving the way for a greener and more ethical corporate world.

The Shift Towards Risk Management

In the ever-evolving landscape of corporate governance, a significant trend is emerging: the framing of ESG and Diversity, Equity, and Inclusion (DEI) strategies within the broader, more traditional concept of Risk Management. This has been mentioned in the study by Hubel and Scholz (2020), this paradigm shift reflects a strategic realignment, as businesses seek to navigate the complex interplay of social responsibility and operational risk.

At the heart of this trend is the recognition that ESG and DEI issues are not just ethical imperatives but also crucial risk factors that can impact a company's long-term viability. Factors such as climate change, social justice, and workforce diversity are increasingly viewed through the lens of risk assessment and mitigation (Kandpal et al.2024). This perspective allows companies to address these concerns proactively, framing them as integral parts of their risk management strategies rather than standalone initiatives.

Concurrently, we are witnessing the emergence of terms like Corporate Citizenship, Wellness, and Belonging as less controversial and more universally palatable alternatives to ESG and DEI. Corporate Citizenship, for instance, encompasses a broad range of socially responsible activities and emphasises a company's commitment to ethical behaviour and community involvement. This term is gaining traction as it encapsulates the essence of social responsibility without the political overtones that sometimes accompany ESG discussions.

Wellness and Belonging are similarly becoming focal points, especially in the context of employee engagement and workplace culture. These terms signify a shift from a narrow focus on diversity metrics to a broader emphasis on creating inclusive environments where all employees feel valued and supported. This approach not only enhances employee satisfaction and productivity but also mitigates the risks associated with workplace discontent and turnover.

Examples of this shift are evident in various industry sectors. Financial institutions, traditionally at the forefront of risk management, are integrating ESG considerations into their investment and lending decisions, recognising the financial risks associated with environmental and social issues (Hubel and Scholz, 2020). Similarly, technology companies are increasingly focusing on wellness and belonging initiatives, acknowledging the risks to innovation and growth posed by non-inclusive cultures.

This realignment towards risk management, with a focus on Corporate Citizenship, Wellness, and Belonging, represents a pragmatic approach to navigating the complex and often politically charged landscape of ESG and DEI. By incorporating these elements into their broader risk management frameworks, companies can ensure that their strategies are not only socially responsible but also aligned with their core business objectives and risk profiles.

5. Conclusion

The rise of ESG initiatives following the Paris Agreement demonstrated a commitment by businesses and investors to contributing to a more sustainable future. However, the commercial interests infiltrating the ESG landscape have undermined the movement's transformative potential. The current trend toward market-driven solutions has led to an ESG consultancy model that often prioritizes client satisfaction over genuine environmental progress. This has resulted in weakened standards, greenwashing, and a loss of public trust.

A significant shift is needed to achieve the true potential of ESG or a framework that replaces it. To make meaningful environmental and social progress, we must break down the illusions and prioritize independent, transparent verification of sustainability claims. Companies must be held legally accountable for misleading practices, and consultancies should assist businesses in achieving established targets, not shaping targets to appease clients. The urgency of the climate crisis and widespread environmental degradation demands immediate action. If left unchecked, the current ESG model will further erode public support for environmental solutions. We must move beyond the flawed foundations and build a new system focused on integrity, scientific rigour, and verifiable outcomes.

As we look towards the horizon of ESG practices, it is evident that the field is poised for continued evolution and innovation. The future of ESG is likely to be shaped by an increasingly sophisticated regulatory landscape and a growing emphasis on investor expectations for transparency and accountability. Regulatory bodies worldwide are expected to play a pivotal role in shaping the future of ESG practices. We anticipate a trend towards more standardised and stringent ESG reporting requirements, which will likely include comprehensive disclosure mandates and more defined metrics for sustainability and social impact. This regulatory push will drive companies to not only comply but to also integrate ESG principles more deeply into their core business strategies.

Investor expectations are also set to evolve. As shareholders and stakeholders become more ESG-savvy, their demands for ethical practices, environmental stewardship, and social responsibility will increase. This shift will likely lead to a more dynamic and interactive dialogue between companies and their investors, with a greater focus on long-term value creation and impact. Technological advancements will also play a crucial role in the future of ESG. Digital tools and platforms will become more prevalent, offering enhanced capabilities for data collection, analysis, and reporting. This digitalisation will make ESG reporting more accessible and efficient, enabling a wider range of companies to engage in sustainable practices.

In conclusion, our exploration of the evolving landscape of ESG has highlighted several key points: the increasing integration of ESG metrics into business practices, the challenges of ESG reporting and ratings, innovative approaches in ESG practices, the shift towards risk management, and the leadership of the APAC region in ESG integration. These facets feature the dynamic and multifaceted nature of ESG, reflecting its growing importance in the global business and investment landscape. Staying informed and adaptable is crucial in this rapidly evolving field. As regulatory frameworks evolve, investor expectations change, and new technologies emerge, businesses must remain agile and proactive in their approach to ESG. As we navigate this complex and ever-changing terrain, the importance of ESG in shaping a sustainable, ethical, and profitable future has never been clearer.

References

Adams, B. (2008). *Green development: Environment and sustainability in a developing world.* Routledge.

- Baratta, A., Cimino, A., Longo, F., Solina, V., & Verteramo, S. (2023). The impact of ESG practices in industry with a focus on carbon emissions: Insights and future perspectives. *Sustainability*, 15(8), 6685.
- Chen, P., & Chu, Z. (2024). Mere facade? Is greenwashing behaviour lower in low-carbon corporates? *Business Strategy and the Environment*.
- Chung, R., Bayne, L., & Birt, J. (2024). Stakeholder responses to mandating environmental, social and governance reporting in Hong Kong. *China Journal of Accounting Research*, 100353.
- Delmas, M. A., & Burbano, V. C. (2011). The drivers of greenwashing. *California management review*, 54(1), 64-87.
- Eccles, R. G., Serafeim, G., & Krzus, M. P. (2011). Market interest in nonfinancial information. *Journal of Applied Corporate Finance*, 23(4), 113-127.
- Free, C., Jones, S., & Tremblay, M. S. (2024). Greenwashing and sustainability assurance: A review and call for future research. *Journal of Accounting Literature*.
- Galletta, S., Goodell, J. W., Mazzù, S., & Paltrinieri, A. (2023). Bank reputation and operational risk: The impact of ESG. *Finance Research Letters*, 51, 103494.
- Ho, J. (2023). 11 Banking, Blockchain, and ESG. The Role of Distributed Ledger Technology in Banking: *From Theory to Practice*, 235.
- Hoang, T. (2018). The role of the integrated reporting in raising awareness of environmental, social and corporate governance (ESG) performance. In *Stakeholders, governance and responsibility* (pp. 47-69). Emerald Publishing Limited.
- Hübel, B., & Scholz, H. (2020). Integrating sustainability risks in asset management: the role of ESG exposures and ESG ratings. *Journal of Asset Management*, 21(1), 52-69.
- Işık, C., Ongan, S., Islam, H., Jabeen, G., & Pinzon, S. (2024). Is economic growth in East Asia pacific and South Asia ESG factors based and aligned growth? *Sustainable Development*.
- Kandpal, V., Jaswal, A., Santibanez Gonzalez, E. D., & Agarwal, N. (2024). Corporate Social Responsibility (CSR) and ESG Reporting: Redefining Business in the Twenty-First Century. In *Sustainable Energy Transition: Circular Economy and Sustainable Financing for Environmental, Social and Governance (ESG) Practices* (pp. 239-272). Cham: Springer Nature Switzerland.
- Lyon, T. P., & Montgomery, A. W. (2015). The means and end of greenwash. *Organization & Environment*, 28(2), 223-249.
- Mohd Daud, S. N., Ghazali, N. S., & Mohammad Ismail, N. H. (2024). ESG, innovation, and economic growth: empirical evidence. *Studies in Economics and Finance*.
- Parguel, B., Benoît-Moreau, F., & Larceneux, F. (2011). How sustainability ratings might deter 'greenwashing': A closer look at ethical corporate communication. *Journal of business ethics*, 102, 15-28.
- Lin-Hi, N., & Müller, K. (2013). The CSR bottom line: Preventing corporate social irresponsibility. *Journal of Business Research*, 66(10), 1928-1936.
- Mahmud, S., Biswas, T., & Islam, N. (2017). Sustainability reporting practices and implications of banking sector of Bangladesh according to global reporting initiative (GRI) reporting framework: An empirical evaluation. *International Journal of Business and Management Invention*, 6(3), 01-14.
- Marquis, C., & Toffel, M. W. (2011). *The globalization of corporate environmental disclosure: accountability or greenwashing?* Boston: Harvard Business School.
- Schaltegger, S. (2018). Linking environmental management accounting: A reflection on (missing) links to sustainability and planetary boundaries. *Social and Environmental Accountability Journal*, 38(1), 19-29.
- Schaefer, S. D., Terlutter, R., & Diehl, S. (2019). Is my company really doing good? Factors influencing employees' evaluation of the authenticity of their company's corporate social responsibility engagement. *Journal of business research*, 101, 128-143.

- Wang, J., Ma, M., Dong, T., & Zhang, Z. (2023). Do ESG ratings promote corporate green innovation? A quasi-natural experiment based on SynTao Green Finance's ESG ratings. *International Review of Financial Analysis*, 87, 102623.
- Yu, E. P. Y., Van Luu, B., & Chen, C. H. (2020). Greenwashing in environmental, social and governance disclosures. *Research in International Business and Finance*, 52, 101192

Is the Business Incubation Program a Catalyst in Implementing Digital Entrepreneurship Education? Developing a Multiple Case Study in Malaysian Polytechnics

Nur Syahirah Rosli^{1*}, Suhaida Abdul Kadir², Rahimah Jamaluddin³ & Enio Kang Mohd Sufian Kang⁴

^{1,2,3,4} Faculty of Educational Studies, Department of Science and Technical Education, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

*Corresponding author

Abstract

The landscape of business models is shifting towards digital platforms, elevating the role of "digital entrepreneurship." Due to this, business incubators are seen as the catalyst for advancing the integration of digital entrepreneurship in education. Despite the establishment of digital technology policies for TVET institutions in a global and local context, Malaysian polytechnics encountered difficulties in setting up digital-based incubators due to limited business digitalization and unclear practical incubation facets for digital entrepreneurship education within the institutions. To address this, a multiple-case study should be developed to gain insights into the implementation of digital entrepreneurship education in Malaysian polytechnics by integrating the Student Encouragement Entrepreneurship Incubation Model, Institutional Isomorphism Theory, and New Venture Creation Theory as the theoretical lenses. Data will be collected via semi-structured interviews with student entrepreneurs, entrepreneurship mentors, and incubator managers, selected through heterogeneous sampling. Method triangulation will involve direct observations and document analysis to enhance trustworthiness. Within-case and cross-case analyses will identify similarities and differences among the cases. The findings will explore entrepreneurial motivation, incubator management strategies, and pedagogical approaches for implementing digital entrepreneurship education in Malaysia's business incubation program. These critical elements are essential for ensuring the relevance and effectiveness of business incubation programs in enhancing product innovation and commercialization among student entrepreneurs. The study findings aim to inform policymakers, particularly within the Malaysian Ministry of Higher Education and the Polytechnic and Community College Education Department, to develop strategies fostering a robust ecosystem for digital entrepreneurship education within TVET institutions, particularly polytechnics.

Keywords: Digital Entrepreneurship, Entrepreneurship Education, Incubator, TVET, Qualitative

1. Introduction

The Fourth Industrial Revolution (4IR) encompasses emerging digital technologies like the Internet of Things, cloud computing, and artificial intelligence, integrating them across various sectors (World Economic Forum, 2020). The COVID-19 pandemic has accelerated the adoption of digital technologies and created significant opportunities for transforming business models towards digital realms, thus fostering "digital entrepreneurship," which entails the digital transformation of creating new or existing businesses, products, or services (World Bank Group, 2016; Kraus et al., 2019; Legese Feyisa, 2020; Okwori et al., 2021). The implementation of digital technologies has positively impacted entrepreneurs, leading to significant policy shifts to promote business digitalization (Kalolo, 2019).

As a result, the influence of 4IR is driving demand for new initiatives in digital entrepreneurship education within Technical and Vocational Education and Training (TVET) (Halabisky, 2019). UNESCO's emphasis on TVET for producing trained student entrepreneurs is viewed as essential for meeting business digitalization needs (ILO-UNESCO, 2020). As the global demand for entrepreneurial digital competencies grows, experts highlight the importance of business incubators in accelerating digital technology adoption among student entrepreneurs in education (Grimaldi and Grandi, 2005; Jansen et al., 2015; Yamockul et al., 2019). In this case, a business incubation program is referred to as structured entrepreneurship training, offering flexible working spaces and shared infrastructure or services to enhance entrepreneurs' potential and refine their business skills (Hackett and Dilts, 2004; Mian et al., 2016; UBI Global, 2019).

Further exploration into digital entrepreneurship education reveals that 4IR's impact necessitates new proactive pedagogical approaches for TVET, focusing on developing student entrepreneurs capable of thriving in a digitally-driven world (OECD, 2019). Consequently, UNESCO (2018) has called for the TVET education system to swiftly adapt to technological changes through business incubation programs, ensuring that digital entrepreneurship education aligns with the skills needed for an era of human-machine collaboration. According to the Malaysian Ministry of Higher Education (2022), polytechnics had the lowest rate of student entrepreneur graduates among Malaysian higher education institutions, at just 9.5 percent in 2021.

The Industry4WRD National Policy on Industry 4.0 by the Malaysian Ministry of International Trade and Industry (2018) identified challenges faced by TVET training providers, including talent supply skill levels, digital infrastructure, funding support, and innovation capacity, to create the right digital entrepreneurship ecosystem for 4IR. In response, the TVET 4.0 Framework 2018-2025 was created to guide polytechnics in business digitalization through business incubation programs (Malaysian Ministry of Education, 2018). This policy assigns a key role to Malaysian polytechnics in implementing digital entrepreneurship education within these programs. Therefore, Malaysian polytechnics should leverage business incubation programs to integrate digital entrepreneurship education, strengthening connections between student entrepreneurs, industry players, and governments to enhance product commercialization within their institutions.

2. Digital Entrepreneurship Education Implementation in Malaysian Polytechnics' Business Incubation Program

Aligned with Malaysia's 4IR educational policy (Ministry of Education Malaysia, 2018), the Entrepreneurship Development for Polytechnic and Community College (CEDev) plays a pivotal role in facilitating the implementation of digital entrepreneurship education within business incubation programs. CEDev introduced the Standard Operating Handbook for Entrepreneurship Incubator of Malaysian Polytechnic and Community College (Polytechnic and Community College Education Department, 2021), offering a structured model of a strategic business incubation program tailored to Malaysian polytechnics. Despite significant government efforts to promote digital entrepreneurship in higher education, understanding the motivations driving graduate-level student entrepreneurs remains limited (Ooi and Ahmad, 2012). Abbas and Ahmad Sabri (2022) and Mamat et al. (2023) identified several motivating factors of individuals to involve in entrepreneurship, including improving life quality, flexible working hours, personal development, recognition, and moral support. Nonetheless, Ho and Turner (2019) stressed the necessity for educators to shift their mindsets to prepare student entrepreneurs for digital entrepreneurship by emphasising innovation and adaptability.

Jamil et al. (2016) examined the landscape of digital entrepreneurship education within business incubation programs, mirroring Malaysia's focus on technology-driven initiatives. However, Khalid et al. (2014) described the evolution of pedagogical approaches for business digitalization towards the second phase of business incubation programs, which includes technical concept development, entrepreneur grooming, business establishment, commercialization strategies, and market expansion. Mohd Ghazali (2010) emphasised the importance of prioritising entrepreneur development and enterprise creation at this advanced stage, offering services like talent development, infrastructure support, consultancy, and technology transfer. However, Ruslan (2018) noted that many studies in Malaysia are descriptive, focusing on specific incubation programs without broad generalisation. Thus, Sufian (2006) proposed utilising Malaysian higher education institutions to foster new entrepreneurs by leveraging institutional expertise and maximising research and development (R&D). All in all, Jamil et al. (2016) indicated that the success of Malaysia's business incubation programs can be attributed to integrated services, ongoing government backing, and increased collaboration among academia, government, and industry, forming a triple-helix dynamic.

Nevertheless, the current business incubation program model provided by CEDev (Polytechnic and Community College Education Department, 2021) lacks a necessary focus on pedagogical approaches and incubator management strategies designed to foster digital entrepreneurship within the business incubation framework, concentrating primarily on general program implementation at Malaysian polytechnics. There is also a significant research gap concerning the educational context of Malaysian business incubation programs (Yunos, 2002; Sufian, 2006; Khalid et al., 2012; Nasir et al., 2017; Ruslan, 2018), despite extensive research on university-based business incubator programs in developed countries (Bergek and Norrman, 2008; Jansen et al., 2015; Pauwels et al., 2016; Dalmarco et al., 2018; Korejo, 2023).

This gap highlights the need to clarify entrepreneurial motivations and incubator strategies in developing countries like Malaysia. This will improve resource utilization, mentorship, and access to business capital in TVET institutions such as polytechnics. Understanding these aspects, especially for sustainable business incubation in digital entrepreneurship education, will help policymakers create guidelines for fostering innovation and student entrepreneurial growth.

3. A Proposed Theoretical Framework

This qualitative research is guided by the Student Entrepreneurship Encouragement Model (Jansen et al., 2015), Institutional Isomorphism Theory (DiMaggio and Powell, 1983), and New Venture Creation Theory (Gartner, 1985) as its theoretical framework. The Institutional Isomorphism Theory explains how external pressures, like government initiatives, influence stakeholders' motivations within Malaysian polytechnics. Gartner's New Venture Creation Theory highlights the multifaceted nature of entrepreneurship by considering individual, environmental, organisational, and process-related factors that impact new ventures.

By incorporating Garner's theory, the study aims to understand the interconnected dimensions affecting the implementation of digital entrepreneurship education in polytechnics' business incubation program. The Student Entrepreneurship Encouragement Model helps in understanding the incubation stages and entrepreneurial strategies to promote entrepreneurship education among student entrepreneurs. Yin (2018) observed that analytical generalisation from a theoretical framework can lead to modifying, rejecting, or advancing the existing framework, or developing new concepts upon completing the study.

Therefore, the theoretical framework offers a foundation for understanding the complex dynamics in this multiple case study to answer the following research questions:

- a) What are the entrepreneurial motivations of student entrepreneurs, entrepreneurship mentors, and incubator managers to involve in digital entrepreneurship within business incubation program at Malaysian polytechnics?
- b) How do incubator management strategies facilitate the implementation of digital entrepreneurship within Malaysian polytechnics' business incubation program?
- c) How do the pedagogical approaches of digital entrepreneurship education is being implemented within Malaysian polytechnics' business incubation program?

4. Method

The multiple case study approach suits the research questions as it examines real-life situations within the bounded system of Malaysian polytechnics' business incubation programs. When conducting case study research, it is essential for researchers to thoughtfully decide on the specific elements to include in the study, such as events, programs, activities, individuals, and processes. As a result, the unit of analysis of this multiple case study is the business incubation program itself, allowing for a detailed examination of its intricacies. This approach, aligned with Merriam and Tisdell (2016) and Yin (2018), provides a comprehensive understanding without seeking statistical generalisation, using a small sample size of no more than four or five cases. Polytechnics' business incubation program should be purposefully chosen based on criteria such as involving student entrepreneurs from various departments, offering services or facilities for incubator apprentices, and using digital tools to enhance business digitalization. Consistent Creswell and Poth (2018), this study will use semi-structured interviews as the primary data collection method, with direct observation and document analysis for method triangulation to increase trustworthiness of this research.

The study will select research participants, including student entrepreneurs, entrepreneurship mentors, and incubator managers, using heterogeneous and snowball sampling strategies. Heterogeneous sampling will capture diverse viewpoints within the business incubation program. Following semi-structured interviews with incubator managers, snowball sampling is employed to engage entrepreneurship mentors and student entrepreneurs through referrals, ensuring cooperation and suitability for the study. This method ensures data collection aligns with inclusion criteria, with primary participants suggesting others. Atlas.ti software will be utilised to enable the researchers to organise research data such as interview transcripts, direct observation field notes, and related document artefacts. Data saturation will be determined by the repetition of codes and categories during the transcription process. Data analysis will begin with within-case analysis by constructing detailed descriptions of each polytechnic's business incubation program. A cross-case analysis will follow, comparing and contrasting the cases to identify similarities, differences, and patterns to address the research questions.

5. Results and Discussion

Theoretically, combining the individual and environmental dimensions of New Venture Creation Theory (Gartner, 1985) with Institutional Isomorphism Theory (DiMaggio and Powell, 1983) to address the first research question will provide researchers with a deeper understanding of how entrepreneurial motivations toward business digitalization align with these theories within TVET institutions like polytechnics. Recognizing influential factors such as government policies and educational standards, like the TVET 4.0 Framework 2018 to 2025 (Malaysian Ministry of Education, 2018), highlighted in the environmental dimension of New Venture Theory, will impact entrepreneurial motivations either directly or indirectly. This exemplifies mimetic isomorphism, which occurs when organisations replicate successful activities observed in their field.

Through this multiple case study, researchers can expand the theories by identifying the intrinsic and extrinsic motivations of student entrepreneurs, entrepreneurship mentors, and incubator managers involved in business incubation programs within TVET institutions. By exploring these entrepreneurial motivations, Malaysian polytechnics can increase the legitimacy of business incubation programs since these motivations are dynamic constructs that can change over time as individuals progress through different stages of their digital entrepreneurship education journey.

To address the second research question, it is essential to broaden the theoretical framework through the integration of the New Venture Creation Theory's organisational dimension by Gartner (1985) and the Student Encouragement Entrepreneurship Incubation (SEEI) Model by Jansen et al. (2015). These theories provide a foundational structure for understanding incubator management strategies to implement digital entrepreneurship education within Malaysian polytechnics' business incubation programs. Gartner's theory emphasises the dynamic interplay between organisational encouragement for entrepreneurs, the venture, and the environment, highlighting factors such as knowledge acquisition and strategy formulation.

Conversely, the SEEI Model by Jansen et al. (2015) offers a structured framework for understanding the stages of stimulation, education, and incubation in successful business incubation programs by illustrating the necessary business assistance components. Through this study, researchers will underscore the crucial role of government agencies, alumni, and organisations in providing business incentives, necessary resources, expertise, and networking opportunities to encourage the business digitalization aspects of each business incubator within TVET institutions.

In regard to the third research question on pedagogical approaches for implementing digital entrepreneurship education in Malaysian polytechnics' business incubation programs, the researchers will be able to explore the practicality of the SEEI Model developed by Jansen et al. (2015), which includes stimulation, education, and incubation stages in the context of developing countries. This alignment indicates that both the New Venture Creation Theory and the SEEI Model recognize the importance of structured processes in fostering entrepreneurial endeavours, whether within educational institutions or the broader entrepreneurial landscape. In this study's context, the pedagogical approaches for each phase described in the SEEI Model will help researchers provide a tailored guideline for implementing digital entrepreneurship education in polytechnics or similar institutions within their business incubation programs.

The first phase of SEEI model, which is "Educate", focuses on raising initial awareness among students by fostering an environment that encourages entrepreneurial pursuits through various educational initiatives in each Malaysian polytechnic. The "Stimulate" phase provides educational support to refine business ideas into comprehensive business plans, ensuring alignment with the polytechnic's niche and industry focus.

Jansen et al. (2015) also explain the "Incubate" phase, detailing the infrastructure and support provided by incubator management to foster the growth of student entrepreneurs' businesses. Through this multiple case study, researchers will expand the SEEI model within the context of TVET institutions' pedagogical approaches, particularly in Malaysian polytechnics. This will explore how each institution can align their product innovation for commercialization within business incubation programs.

Overall, this study integrates the New Venture Creation Theory with Institutional Isomorphism Theory to provide a nuanced understanding of entrepreneurial motivations, incubator management strategies, and pedagogical approaches within Malaysian TVET institutions, particularly polytechnics' business incubation program. Additionally, the alignment of organisational strategies with the SEEI Model developed by Jansen et al. (2015) underscores the significance of structured incubation processes in fostering digital entrepreneurship. Figure 1 shows the entrepreneurial components adapted from the theories and models selected for this study, which are crucial to consider to contribute to the body of knowledge in this study's context.

By examining intrinsic and extrinsic factors that drive student entrepreneurs, mentors, and incubator managers, the research highlights how governmental policies and educational standards outlined for TVET institutions will be able to influence entrepreneurial aspirations toward business digitalization. The pedagogical approaches outlined will offer practical guidelines for implementing digital entrepreneurship education, thereby enhancing the quality and impact of business incubation programs in Malaysian polytechnics. Ultimately, this research contributes valuable insights into the dynamic interplay of individual, organisational, process and environmental factors in shaping digital-based entrepreneurial outcomes in the context of TVET institutions, particularly in polytechnics.

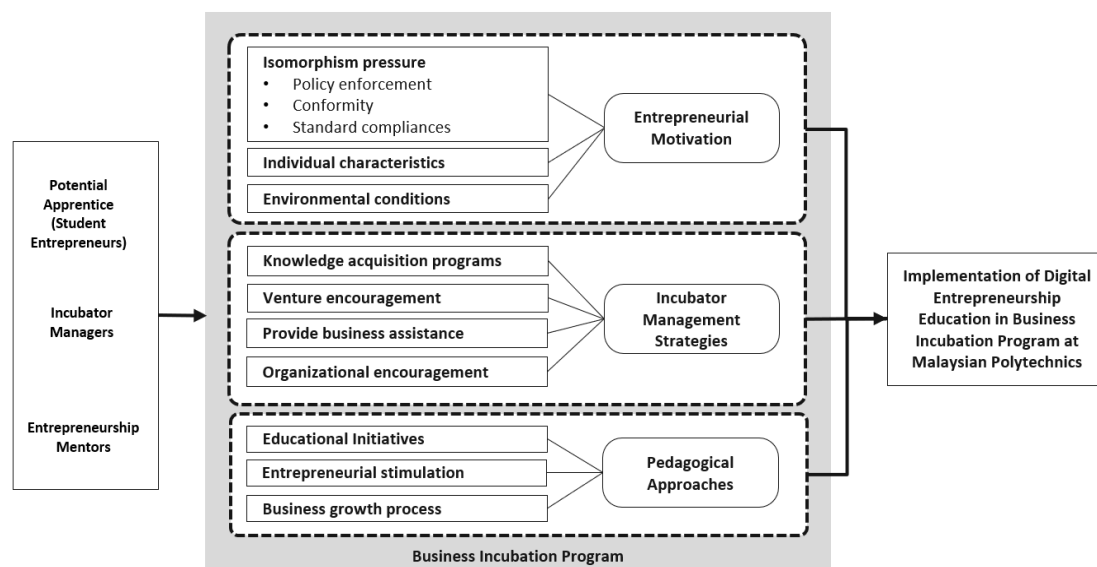


Figure 1: Entrepreneurial Components Adapted from Theories and Model Selected for This Study in Implementing Digital Entrepreneurship Education in Business Incubation Program

Source: (DiMaggio and Powell, 1983; Gartner, 1985; Jansen et al., 2015)

6. Implications, Conclusion and Future Recommendations

This multiple case study provides a fertile ground for theoretical exploration in order to assist researchers in gaining a deeper understanding of how the implementation of digital entrepreneurship education align with the selected theories and model in the context of Malaysian polytechnics' business incubation program. By integrating the New Venture Creation Theory and Institutional Isomorphism Theory, researchers can deepen existing theories by examining how entrepreneurial motivations evolve over time throughout different stages of digital entrepreneurship education. This study will demonstrate how TVET institutions adopt tailored incubator practices to meet governmental expectations and educational policies, thereby extending the theoretical framework's application to educational context. Policymakers can utilise these insights to design supportive measures and develop curricula that address the real-world needs of digital entrepreneurship, ensuring that entrepreneurial implementation in TVET institutions is relevant and effective.

While the findings will be rooted in the unique educational, economic, and cultural environment of Malaysian polytechnics with a specialised focus on TVET institutions, they will help to contextualise the study's outcomes and suggest directions for future research. Firstly, developing metrics and evaluation frameworks to assess the effectiveness of business incubation programs in TVET institutions is crucial to ensure continuous improvement based on feedback and outcomes. Additionally, it is important to conduct detailed analyses of various stakeholders involved in business incubation programs, including government agencies, private sector partners, and alumni networks, to identify their roles and contributions in enhancing support structures for aspiring digital entrepreneurs. Moreover, comparative studies between different regions or countries can help identify contextual factors influencing the effectiveness of digital entrepreneurship education, providing valuable insights for tailoring educational programs to specific contexts and improving their quality.

Acknowledgment

We sincerely thank Universiti Putra Malaysia, Malaysian polytechnics, the Malaysian Ministry of Higher Education, and the Department of Polytechnic and Community College Education (JPPKK) for approving this study. Special thanks to Majlis Amanah Rakyat for their financial support through the Graduate Excellence Programme (GrEP), which greatly contributed to the completion of this conference paper.

References

- Abbas, L. N., & Ahmad Sabri, N. S. (2022). Attitudes and Motivations Graduates in Digital Entrepreneurship. *Online Journal for TVET Practitioners*, 7(2), 76–85.
- Bergek, A., & Norrman, C. (2008). Incubator best practice: A framework. *Technovation*, 28(1-2), 20-28.
- Dalmarco, G., Hulsink, W., & Blois, G. V. (2018). Creating entrepreneurial universities in an emerging economy: Evidence from Brazil. *Technological forecasting and social change*, 135, 99-111.
- DiMaggio, P. J., & Powell, W. W. (1983). The Iron Cage Revisited: Institutional Isomorphism in Organizational Fields. *American Sociological Review*, 48(2), 147–160.
- Gartner, W. B. (1985). The Describing Framework for Conceptual Creation Venture Phenomenon of New Venture Creation. *Academy of Management Review*, 10(4), 696–706.
- Grimaldi, R., & Grandi, A. (2005). Business incubators and new venture creation: an assessment of incubating models. *Technovation*, 25(2), 111-121.
- Hackett, S. M., & Dilts, D. M. (2004). A Real Options-Driven Theory of Business Incubation. *Journal of Technology Transfer*, 41–54.
- Halabisky, D. (2019). Policy Brief on Incubators and Accelerators that Support Inclusive Entrepreneurship. *OECD SME and Entrepreneurship Papers*, No. 13, 1–20.
- Harper-Anderson, E., & Lewis, D. A. (2018). What Makes Business Incubation Work? Measuring the Influence of Incubator Quality and Regional Capacity on Incubator Outcomes. *Economic Development Quarterly*, 32(1), 60–77.
- Hassan, N. A. (2020). University Business Incubators as A Tool for Accelerating Entrepreneurship: Theoretical Perspective. *Review of Economics and Political Science*, Emerald Publishing Limited.
- Ho, Y. F., & Turner, J. J. (2019). Entrepreneurial Learning' -The Role of University Led Business Incubators and Mentors in Equipping Graduates with The Necessary Skills Set for Industry 4.0. *International Journal of Education*, 4(30), 283–298.
- ILO-UNESCO. (2020). *The Digitization of TVET and Skills Systems*. <https://www.ilo.org/publications/digitization-tvet-and-skills-systems>

- Jamil, F., Ismail, K., Siddique, M., Khan, M. M., Kazi, A. G., & Qureshi, M. I. (2016). Business incubators in Asian developing countries. *International Review of Management and Marketing*, 6(4), 291-295.
- Jansen, S., Van De Zande, T., Brinkkemper, S., Stam, E., & Varma, V. (2015). How education, stimulation, and incubation encourage student entrepreneurship: Observations from MIT, IIT, and Utrecht University. *The International Journal of Management Education*, 13(2), 170-181.
- Kalolo, J. F. (2019). Digital revolution and its impact on education systems in developing countries. *Education and Information Technologies*, 24(1), 345-358. <https://doi.org/10.1007/s10639-018-9778-3>
- Khalid, F. A., Gilbert, D., & Huq, A. (2012). Third-generation business incubation practices in Malaysian ICT incubators—a bridge too far? *American Journal of Management*, 12(2/3), 88-107.
- Khalid, F. A., Gilbert, D., & Huq, A. (2014b). The way forward for business incubation in ICT incubators in Malaysia. *International Journal of Business and Society*, 15(3), 395-412.
- Kraus, S., Palmer, C., Kailer, N., Kallinger, F. L., & Spitzer, J. (2019). Digital entrepreneurship: A research agenda on new business models for the twenty-first century. *International Journal of Entrepreneurial Behaviour and Research*, 25(2), 353-375.
- Lamine, W., Anderson, A., Jack, S. L., & Fayolle, A. (2021). Entrepreneurial space and the freedom for entrepreneurship: Institutional settings, policy, and action in the space industry. *Strategic Entrepreneurship Journal*, 15(2), 309-340.
- Legese Feyisa, H. (2020). The World Economy at COVID-19: Contemporary Review. *International Journal of Economics, Finance and Management Sciences*, 8(2), 63.
- Lim, W. Y., Amat-Senin, A., & Low, H. H. (2020). Perspectives of Officers on Obstacles Affecting Malaysian University Symbiosis Program in Business-Academia Commercialization. *International Journal of Advanced Research in Economics and Finance*, 2(1), 12-21.
- Malaysian Ministry of Education. (2018). *TVET 4.0 Framework 2018 - 2025*. Department of Polytechnic and Community College Education Ministry of Education Malaysia. <https://mypolycc.edu.my/flipbook/TVET%204.0%20Framework%202018%20-%202025/>
- Malaysian Ministry of Higher Education, M. (2022). *Laporan Kajian Pengesanan Graduan 2021: Kebolehpasaran Graduan Pasca Pandemik COVID-19*. <https://www.mohe.gov.my/muat-turun/penerbitan-jurnal-dan-laporan/lkpg/2022-4/1409-laporan-kajian-pengesanan-graduan-2022-pdf/file>
- Malaysian Ministry of International Trade and Industry, M. (2018). *Industry 4WRD National Policy on Industry 4.0*. <https://www.malaysia.gov.my/portal/content/31224>
- Mamat, S. N., Shamsudin, A., Mohd Pauzi, N. F., Bustamam, K. S., Adanan, S. A., Abdullah Sani, A., & Saidin, A. (2023). Undergraduate Students' Outlook on their Digital Entrepreneurship Readiness, Attitude and Motivation. *International Journal of Academic Research in Business and Social Sciences*, 13(10).
- McAdam, M., Miller, K., & McAdam, R. (2016). Situated regional university incubation: A multi-level stakeholder perspective. *Technovation*, 50-51, 69-78.
- Mian, S., Lamine, W., & Fayolle, A. (2016). Technology Business Incubation: An overview of the state of knowledge. *Technovation*, 50-51, 1-12.
- Mohd Ghazali, M. Y. (2010). Building an innovation-based economy: The Malaysian technology incubator experience. *Journal of Change Management*, 3(2), 177-188.
- OECD, T. E. C. (2019). *The Missing Entrepreneurs*. http://www.oecd-ilibrary.org/industry-and-services/the-missing-entrepreneurs_9789264188167-en

- Ooi, Y. K., & Ahmad, S. (2012). A study among university students in business start-ups in Malaysia: Motivations and obstacles to become entrepreneurs. *International Journal of Business and Social Science (IJBS)*, 3(19), 181-192.
- Pauwels, C., Clarysse, B., Wright, M., & Van Hove, J. (2016). Understanding a new generation incubation model: The accelerator. *Technovation*, 50–51(October), 13–24.
- Polytechnic and Community College Education Department, J. (2021). *Panduan Operasi Standard Inkubator Keusahawanan Politeknik dan Kolej Komuniti*. <https://www.mypolycc.edu.my/index.php/muat-turun/garis-panduan-c/bahagian-ambilan-dan-pembangunan-pelajar/send/10-bapp/696-panduan-operasi-standard-inkubator-keusahawanan-politeknik-dan-kolej-komuniti>
- Ruslan, M. F. (2018). A review and research direction: business incubators in Malaysia. *The Journal of Social Sciences Research*, 106-111.
- Sufian, J. (2006). Incubators As Catalysts in Developing High Technology Businesses: Malaysia's Experience. *ATDF Journal Volume*, 3(1), 25–29.
- UBI Global. (2019). *UBI Global World Rankings of Business Incubators and Accelerators 2019-2020*, 1-24. <https://doi.org/10.13140/RG.2.2.16066.53441>
- UNESCO. (2018). A Global Framework of Reference on Digital Literacy for Indicator 4.4.2. <https://uis.unesco.org/sites/default/files/documents/ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf>
- World Bank Group. (2016). *Enabling Digital Entrepreneurs*. <https://pubdocs.worldbank.org/en/354261452529895321/WDR16-BP-Enabling-digital-entrepreneurs-DWELSUM.pdf>
- World Economic Forum. (2020). *The Future of Jobs Report 2020*. http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf
- Yamockul, S., Pichyangkura, R., & Chandrachai, A. (2019). University business incubators best practice: Factors affecting Thailand UBI performance. *Academy of Entrepreneurship Journal*, 25(1), 1-14.
- Yin, R. K. (2018). Case study research and applications: Design and methods. In *Journal of Hospitality & Tourism Research*. SAGE Publications.
- Yunos, M. G. M. (2002). Building an innovation-based economy: The Malaysian technology business incubator experience. *Journal of Change Management*

EDUCATION, TEACHING, AND LEARNING

**"HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY"**

Immersive Learning Experience *Akhlak Islamiyyah* via Augmented Reality (AKHAR): ADDIE Model Approach

Mastura Mohamad¹, Norsalwati Mohd Razalli^{1*}, Asri Sabri¹, Zainal Ariffin Ahmad² & Ari Budiharto³

^{1*} Sultan Idris Shah Polytechnic, Sungai Lang 45100, Sungai Air Tawar, Selangor, Malaysia

²Academy of Sciences Malaysia, Menara Matrade, Tingkat 20, Sayap Barat, Jalan Sultan Haji Ahmad Shah, 50480 Kuala Lumpur, Malaysia

³Besar Pengembangan Penjaminan Mutu Pendidikan Vokasi (BPPMPV) Pertanian, Jalan Raya Jangari KM. 14 Desa Sukajadi, Kecamatan Karantengah, Kabuten Cianjur 43281 Po. Box 138, Indonesia

*norsalwati@psis.edu.my

Abstract

The use of Extended Reality (XR) technologies, such as Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), in education has garnered significant attention in recent years. Educators have highlighted the benefits of XR for learners and the effectiveness of AR and VR technologies in the classroom. However, technological practices are not tailored explicitly for designing and implementing induction activities across diverse learning environments. Additionally, the rapid evolution of educational technologies and pedagogical approaches necessitates continuous evaluation and adaptation of induction strategies to ensure optimal student learning outcomes. This paper focuses on developing the *Akhlak Islamiyyah* Augmented Reality (AKHAR) application using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model as an induction strategy for teaching *Akhlak Islamiyyah* (Islamic ethics) courses in polytechnics. The research methodology employs the ADDIE model as a framework for analyzing, developing, designing, implementing, and evaluating the AKHAR application. Unity software was utilized to create AKHAR, and the study involved five technology experts from the university and polytechnic and community college lecturers. The assessment of AKHAR covers three main aspects: design, technical, and multimedia. Using frequency analysis and Statistical Packages for the Social Sciences (SPSS) version 26, the evaluation revealed that AKHAR's design meets the needs of students' and teachers' learning mediums. The application proved an effective induction practice, capturing students' interest and motivation through engaging and interactive experiences. Furthermore, the use of immersive technologies in AKHAR enhances learning performance and facilitates the acquisition of fundamental knowledge and the application of know-how in Islamic ethics.

Keywords: ADDIE Model, *Akhlak Islamiyyah*, Immersive Learning, Augmented Reality

1. Introduction

Integrating technology has become crucial in enhancing learning experiences in today's rapidly evolving educational landscape. One area that has garnered attention is the development of immersive learning experiences, particularly in teaching Islamic ethics (Amirah et al., 2022). *Akhlak Islamiyyah* (Islamic Ethics) is a fundamental aspect of Muslim belief and practice, guiding individuals in their conduct and interactions with others (Aly & Anshory, 2024; Zulia et al., 2024). What happens is that Technical and Vocational Education and Training (TVET) educators miss focusing on learning objectives for students during induction. An interactive learning environment created on the subject can enhance the student's understanding and engagement; thus, an introduction is needed to attract the students to *Akhlak Islamiyyah's* studies.

Akhlak Islamiyyah's curriculum is indeed crucial for moral development. However, there seems to be a gap where students are able to undergo a truly immersive learning experience suited specifically for this subject. Some of the traditional teaching methods might not effectively engage students to learn and practice real hands-on interactive learning experiences (Oviawe et al., 2021). In addressing this issue, our research seeks to introduce a new approach towards the realization of immersive *Akhlak Islamiyyah* education using the Analysis, Design, Development Evaluation, and Implementation (ADDIE) model and, in doing so, positively influence student behaviors by enhancing their perception and application of ethical principles. In other words, it encompasses understanding learner needs and preferences, visualization of interactive content, integration into technical solutions for delivery, programming the educational process itself, and assessing its value (Abdul Rahman et al., 2020; Khazali et al., 2023).

The objective of this study is to design an efficient learning process with the ADDIE model strategy (Anuar et al., 2021). It is in line with the purpose of teaching and learning, which emphasizes being able to fulfill learners' needs for Islamic ethics lessons (Baharudin et al., 2020). The literature review will encompass current studies and practices involving immersive learning through instructional design models (e.g., ADDIE) in teaching *Akhlak Islamiyyah*. It will review studies using technology to improve ethics education (including the use of Augmented Reality (AR) and simulation).

Further details of these will be provided in the review, including obstacles and opportunities for teaching *Akhlak Islamiyyah*, the importance of technology in virtue acquisition, and how to create immersive learning experiences. This review will help you to get a good base of the status as well. The ADDIE model in this project produces an *Akhlak Islamiyyah* Augmented Reality (AKHAR) application as an e-learning program that meets the diversity of learning styles and preferences (Giannakos, 2022). It will be a holistic way in which immersive learning using the AKHAR application is informative and transformative for its users. In this research paper, we demonstrated how the ADDIE model was utilized to generate an augmented immersion for learning into the AKHAR application.

2. Methodology

The product evaluation checklist form was applied as an instrument to evaluate the development of this module. The questionnaire was administered to five lecturers of technologists and experts from the university, polytechnic, and community college. The validation and reliability of the AKHAR were reviewed by experts based on technical aspects of the design through incorporated multimedia elements accompanying Johar and Abdullah (2019). Note that statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 26 with descriptive statistics, and the results are presented in frequency tables. The AKHAR application was developed using the ADDIE model, which involved five phases: Analysis, Design, Development, Implementation, and Evaluation. The AKHAR application was created using Unity software and requires access to the Android operating system. The interpretation of the achievement level is evaluated as presented in Table 1.

Table 1: The Indicator level of Achievement

Total Marks	Grade	Interpretation
80 – 100	A	Very good
65 – 79	B	Good
50 – 64	C	Fair
40 – 49	D	Below Average
0 – 39	E	Failed

Source: (Sharili Nair Vargavan & Faridah Yunus, 2021)

Phase 1: Analysis

During the analysis phase of the project, two methods were used to identify the problem: reviewing past studies and conducting a cognitive test. The questionnaires were distributed to 33 diploma students at conventional Polytechnics. Thus, the study targeted second-semester students majoring in Diploma in Islamic Finance at three selected Polytechnics: Sultan Idris Shah Polytechnic (PSIS), Nilai Polytechnic (PNS), and Seberang Prai Polytechnic (PSP). The study aims to identify the challenges students face in the teaching and learning process of *Akhlak Islamiyyah*. The review of past studies revealed a lack of application of the Islamic Ethics e-Module using AR in Education, particularly TVET in Malaysia. This application is notably absent in the field of technical and vocational education, especially in the subject of Islamic Ethics. Table 2 indicates that 57.6% of students show above-average understanding, 30.3% need improvement, and 12.1% are high achievers. Hence, it is vital for educators to attract students' interest in learning Islamic ethics to produce a successful ummah in this world and the hereafter.

Table 2: Cognitive Test

Score Marks	Frequency	Percentage (%)
80 – 100	4	12.1
65 – 79	19	57.6
50 – 64	8	24.2
40 – 49	2	6.1
0 – 39	0	0
Total	33	100

Phase 2: Development

This phase focuses on developing the graphic design for the topics in *Akhlak Islamiyyah*. Four content topics are created in the AKHAR application: (1) an introduction to *Akhlak Islamiyyah* (Islamic ethics), (2) the nature of *mahmudah* (righteous deeds), (3) the nature of *mazmumah* (bad despicable), and (4) *muamalat* (mutual dealings) issues and ethics problems. This topic is based on the Department of Polytechnic and Community College (DPCCE) syllabus. The phase also considers developers' and students' hardware and software requirements. Unity software is used to develop the e-module, with the AKHAR application utilizing the Android operating system to scan the Makar produced by the Vuforia engine. Figure 1 illustrates the AKHAR application Guide User Interface (GUI), featuring integrated AR elements such as 2D and 3D models, text, and graphics. The AKHAR app is currently available only to Android users, and the application provides students with a new experience, allowing them to explore enjoyable learning by combining the virtual and real worlds (Figure 1).

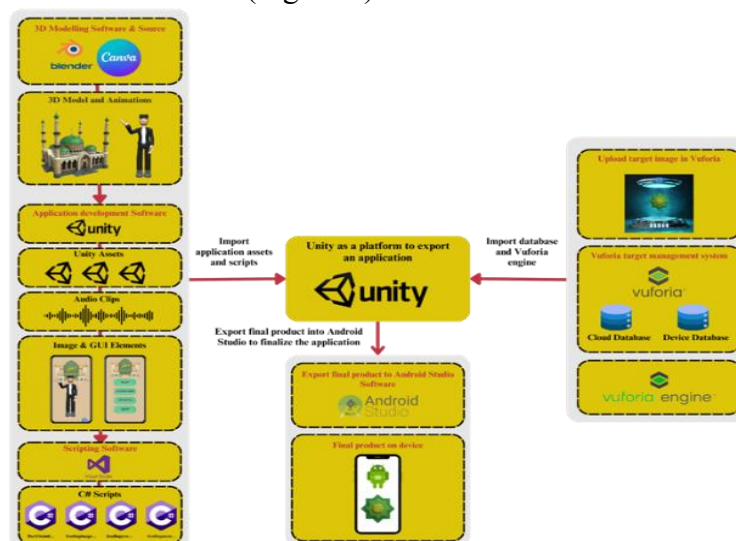


Figure 1: The Process of Developing AKHAR Applications (Khazali et al., 2023)

Phase 3: Design

The design phase involves various activities, including creating application interfaces, developing content, and incorporating multimedia elements such as text, graphics, and dimensional animations (2D and 3D), as portrayed in Figure 3, adapted from (Khazali et al., 2023). The application will be constructed based on a previously created storyboard, followed by creating a prototype that mirrors the planned interface from the design phase. The project development process integrates multiple platforms and stages into one component, as depicted in Figure 2. It begins with downloading elements and objects from Canva and Pixabay, such as background images, audio, and GUI components.

Note that 3D models are created using Blender software, with 3D objects modeled based on 2D image references and enhanced with animations to appear realistic and engaging. Consequently, these 3D objects are imported into Unity for application development. In Unity, the 2D and 3D objects are organized according to the storyboard, and C# scripts are added to enable functionality and interlink scenes. The image target is placed on the image known as Makar in the optional scene, linking to the Vuforia engine to ensure the AR function operates effectively. When the user scans the image target, the correctly positioned 3D object will appear. The final step involves exporting the app to Android Studio, where the Android version and preferences are configured for display on Android devices.



Welcoming Remarks

Main Menu

Main Topics

Phase 4: Implementation

Upon completing the development of the AKHAR application, the subsequent phase entailed implementing its usability. According to (Hafis et al., 2019), usability refers to the ease of use of user interfaces, allowing customers to perform tasks transparently, agilely, and efficiently. During this phase, a survey was distributed to five experts specializing in information technology and multimedia, specifically focusing on AR, to test the application in design and technical and multimedia aspects. Note that the experts were from universities, polytechnics, and community colleges. The implementation phase aimed to gather feedback and evaluate the suitability of the AKHAR application for student learning based on the study's objectives.

Phase 5: Evaluation

During this stage, we assessed the effectiveness of applications developed for students and lecturer's post-implementation. Specifically, we focused on the AKHAR application, which caters to students enrolled in the Diploma in Islamic Banking and Finance program for Islamic students in Semester 2. To measure the impact of the application, we administered pre- and post-tests to evaluate the student's induction progress. To ensure swift student feedback, we designed an online questionnaire using simple language and a Likert scale (ranging from one for strongly disagreeing to five for strongly agreeing). The questionnaire was structured based on the ARCS model created by John Keller. It comprised five sections: demography, attention (A), relevance (R), confidence (C), and satisfaction (S), all tailored to align with the specific relevance and usability of the AKHAR application.

4. Results and Findings

Table 3 evaluates the validity and reliability of three aspects (design, technical, and multimedia, adapted from Johar and Abdullah, 2019) using Cronbach's Alpha, mean scores, and standard deviations. The reliability coefficients for all aspects (design: 0.82, technical: 0.83, multimedia: 0.95) exceed the acceptable threshold of 0.7, indicating good to excellent reliability. Mean scores are high (design: 4.60, technical: 4.54, multimedia: 4.38), reflecting positive feedback from technology experts, although the multimedia aspect shows slightly more variability (standard deviation: 0.78) compared to design (0.40) and technical (0.39). Consequently, all aspects are accepted as reliable and valid for the study.

Table 3: Validity and Reliability

Aspects	Mean	Standard Deviation	Cronbach's Alpha (α)	Expert Decisions
Design	4.60	.40	.82	Accepted
Technical	4.54	.39	.83	Accepted
Multimedia	4.38	.78	.95	Accepted

5. Conclusion

In conclusion, the findings suggest that the AKHAR application is well-suited for use by both students and lecturers. The design, including the user-friendly navigation system and accessible display, makes the AKHAR app highly favorable for students. The experts we consulted have highlighted that the AKHAR application system is easily accessible for download, features smooth transitions between displays, and presents clear diagrams from a technical standpoint. The multimedia aspect, including 2D, 3D, and text models, is engaging and suitable for general use. Furthermore, the interactive element of the AKHAR application is deemed highly accessible for students to absorb and understand. This interaction is facilitated through active engagement, such as answering quizzes provided during induction, rather than passively receiving information. It is hoped that other institutions, the Islamic finance industry, and government agencies can widely use the AKHAR application.

Acknowledgment

We would like to express our gratitude to the participants in this study. Additionally, special thanks to our families, colleagues, and the Commerce Department at Politeknik Sultan Idris Shah, Politeknik Nilai, and Politeknik Sungai Petani for their support, which significantly contributed to the success of this study.

Author Contributions

Mastura Mohamad: Involved as subject matter expert for content creator of *Akhlak Islamiyyah* course; Norsalwati Mohd Razalli: Involved in conceptualization, methodology development, software implementation, as well as writing, reviewing, and editing of the project; Asri Sabri: Involved in software development and data collection; Dr. Zainal Ariffin Ahmad: Undertook tasks related to validation, editing and supervision; Ari Budiharto: Contributed to validation and editing processes.

References

- Abdul Rahman, K., Khalid, N., & Othman, H. (2020). Analisis Rekabentuk Aplikasi Augmented Reality” bagi pembelajaran Komponen Sistem Unit Komputer. *6th International Conference on Information Technology & Society, 2017*, 1–9. <https://www.researchgate.net/publication/352107263%0AAAnalisis>
- Aly, S. M., & Anshory, M. I. (2024). Internalisasi Nilai-nilai Agama Islam dalam Membentuk Perilaku Sosial Keagamaan Anak Santri. *TSAQOFAH*, 4(1). <https://doi.org/10.58578/tsaqofah.v4i1.2572>

- Amirah Syafiqah, & Khadijah. (2022). Penggunaan “Augmented Reality” di dalam Pengajaran Sirah. *International Journal of Advanced Research in Islamic Studies and Education*, 2(2), 56–67.
- Anuar, S., Nizar, N., & Ismail, M. A. (2021). The Impact of Using Augmented Reality as Teaching Material on Students' Motivation. *Asian Journal of Vocational Education and Humanities*, 2(1), 1–8. <https://doi.org/10.53797/ajvah.v2i1.1.2021>
- Baharudin, H., Yusof, A. H., Abdullah, F., & Mohd, S. (2020). Aplikasi Mudah Alih Bahasa Arab Tahun 1 Berbantuan Teknologi Realiti Luasan (AR). *Proceeding of ICITS*, 1–8.
- Giannakos, M. (2022). Experimental Studies in Learning Technology and Child-Computer Interaction. In *SpringerBriefs in Educational Communications and Technology*. <https://link.springer.com/book/10.1007/978-3-031-14350-2>
- Hafis, M., Tolle, H., Supianto, A. A., Suryanda Atmojo, L., Rochmainy, S. N., & Chandra Christian, I. (2019). Game design elements and educational game design for rate of reaction topic in high school chemistry subject. *Proceedings - 2019 5th International Conference on Science and Technology, ICST 2019*. <https://doi.org/10.1109/ICST47872.2019.9166318>
- Johar, S. H., & Abdullah, N. S. (2019). OJ-TP Pembangunan e-Modul Augmented Reality bagi Subjek Semiconductor Devices untuk Guru TVET. *Online Journal for Tvet Practitioners*, 4(2), 99–104. <https://doi.org/10.30880/ojtp.2019.04.02.012>
- Khazali, N. A., Ismail, I., Sakamat, N., Zain, N. H. M., Noh, N. A. M., & Ishak, N. H. (2023). Smart pictorial dictionary via mobile augmented reality. *Bulletin of Electrical Engineering and Informatics*, 12(2), 1019–1028. <https://doi.org/10.11591/eei.v12i2.4009>
- Oviawe, J. I., Azman, M. N. A., Kiong, T. T., & Retnowati, E. (2021). Effect of assessment for learning method on students' academic achievement in carpentry and joinery in technical colleges. *International Scientific Electronic Journal*, 52(4), 121–131. <https://doi.org/10.32744/pse.2021.4.8>
- Sharmili Nair Vargavan, & Faridah Yunus. (2021). Penggunaan Augmented Reality (AR) untuk meningkatkan kemahiran membaca perkataan bahasa Inggeris kanak-kanak prasekolah. *International Journal of Education and Pedagogy*, 3(1), 172. <http://myjms.mohe.gov.my/index.php/ijeap/article/view/12831>
- Zulia, W. M., Nurmalia, & Fatmawati. (2024). RIYADHAH (Jurnal Pendidikan Islam) Pengaruh Pendidikan Agama Islam Terhadap Moral Dan Etika Siswa. *Jurnal Riyadhah*, 2(1).

YouTube for Research Courses: Implications on Learner Satisfaction & Subject Performance

Nurul Hidayana Mohd Noor^{1*}

¹Faculty of Administrative Science & Policy Studies, Universiti Teknologi MARA (UiTM), Malaysia

Abstract

YouTube is a video-sharing site that allows users to watch and share video clips. Past studies have found that online videos such as YouTube have been widely used in learning in the classroom and are also commonly used in courses in addition to podcasts, wikis, and blogs. YouTube is also used to encourage self-learning and is an educational instrument that improves learning innovatively and creatively. However, many educators would prefer to use technology in their teaching strategy. Educators can no longer remain in a comfort zone with traditional teaching methods but instead equip themselves with the latest knowledge and skills. This research explores the influence of system, interaction, and content factors on students' satisfaction with YouTube and their subject performance. Using systematic sampling, the data were collected using a survey approach from the final-year undergraduate students at Universiti Teknologi MARA (UiTM), Negeri Sembilan. The structural equation modeling technique examined the research model based on the final data of 212 undergraduate students. The results indicate that system, interaction, and content factors statistically affect students' satisfaction. On the other hand, system and content factors significantly influence subject performance. The results of this study show that YouTube videos can stimulate creativity, student interest, satisfaction, and motivation. As a consequence, universities must plan and formulate targeted training and development programs for educators to ensure they remain relevant in fast-changing educational settings.

Keywords: YouTube, Learning Satisfaction, Subject Performance, Technology, Quantitative

1. Introduction

The use of information and communication technology (ICT) in education in the 21st century is a phenomenon that has been around for a while. The development of ICT greatly influences today's culture and provides a new shift in pedagogical techniques (Al-Rahmi et al., 2020). Conventional learning that takes the form of chalk and talk and depends entirely on the teacher and whiteboard is less suitable to be practiced in today's net generation (Carrión-Martínez et al., 2020). Video streaming media, such as YouTube, is famous and influential as a medium of teaching and learning. The YouTube application is a video-sharing site uploaded by users and allows users to watch and share video clips.

The study by Tadbier and Shoufan (2021) showed that online videos such as YouTube have been used in classroom learning in addition to podcasts, wikis, and blogs. YouTube provides educational materials, is practical, and can be used by all groups. It can be accessed anywhere and at any time, provides various information, and, most importantly, can be accessed for free. YouTube will make students focus more on the material presented through exciting and interactive videos. Amos (2021) found the advantages of YouTube videos in self-learning activities. The educators should be able to master the skills of using ICT to facilitate the teaching and learning process.

Therefore, to help educators apply technology, activities such as courses and workshops related to technology must be actively conducted to improve skills and knowledge. However, it is not uncommon for educators to use learning videos on YouTube as material to teach their students (Sharma & Srivastava, 2020). Previous studies have shown several problems with using YouTube videos as learning media. First, there is a lack of supporting media devices available. The availability of facilities is the main difficulty experienced by educators (Okoye et al., 2023). The limited range of Wi-Fi hampers educators. If the router is far from the device, educators experience difficulties streaming YouTube videos. Thus, the main objective of this study is to identify the influence of the system, interaction, and content factors of YouTube and its effect on undergraduate students' satisfaction and research subject performance.

2. Literature Review

2.1 Information Systems Success Model

Over the years, many theories of technology acceptance with different predictor factors were built to measure user agreement to indicate the success or failure of an information system. Many researchers have developed and used the information system success model developed by DeLone and McLean (1992). DeLone and McLean (1992) produced the model based on the theory of User Information Satisfaction (UIS) introduced by Bailey and Pearson (1983) with slight modifications. By synthesizing various studies on system success, DeLone and McLean (1992) organized various dimensions of success proposed by researchers into 6 (six) variables, namely: system quality, information quality, user, user satisfaction, individual impact, and organizational impact.

Successful implementation of an information system can be seen from the qualitative characteristics of the quality system, the quality of the output in the form of information produced, the consumption of the output seen by the user, user response to that information seen from user satisfaction, the influence on organizational performance, or organizational impact. In its development, the success model information systems DeLone and McLean (1992) developed into seven factors. They added a service quality variable (service quality), replacing the impact variable individual and organizational impacts into benefits net (net benefits), as well as adding variables interest in using (intention to use) as an alternative from user variables (use) so that factors information system success according to Delone and Mclean (2003).

2.2 YouTube as an Effective Learning Medium

In line with the advancement of technology in education, educational programs are directed toward the mastery of technology-based knowledge and skills. Using YouTube media makes students feel enthusiastic, happy, and focused on learning (Zhou et al., 2020). YouTube creates an exciting learning process that is easy and not limited by time and space, making it easier for students to learn. Based on YouTube, it provides services for uploading, downloading, and sharing videos. YouTube provides a variety of technical things, such as how to use applications on a computer and various practical ways to do things that are initially complicated and impractical. YouTube always provides the latest news and information, which can be seen because it is audiovisual and more accurate (Kohler & Dietrich, 2021).

YouTube does not only provide one type of content but covers a variety of content in the form of event information, education, technical matters, and much more. Incorporating YouTube into research education is a simple and user-friendly way to improve collaboration and students' understanding. According to Alobaid (2020), YouTube will stimulate active learning and provide additional knowledge beyond the expected ability. YouTube can explain theory by involving students in innovative learning methods.

Instructors can use this technology for sharing information and creating a learning community. Amos (2021) states that YouTube is an alternative, timely learning resource for educators and students. Integrating specific videos from YouTube can develop students' appreciative abilities and provide a learning experience limited to the subject matter and the technology used (Tadbier & Shoufan, 2021). Figure 1 portrays the conceptual model of the study.

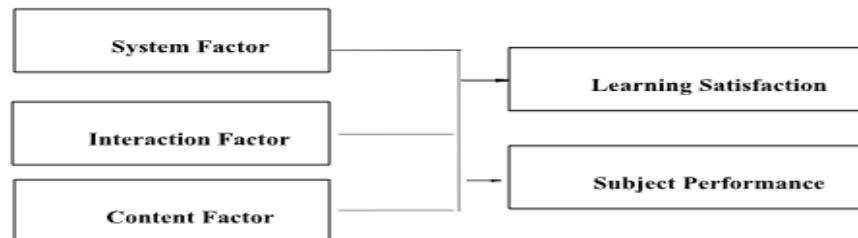


Figure 1: Conceptual Model

3. Methodology

This study uses a survey method to collect data. The instruments are adapted from a study by Harper et al. (2023). The researcher has gathered the subject performance instrument through a course grade. Respondents were undergraduate students from the Faculty of Administrative Science and Policy Studies, UiTM, who took research subject (ADS651). Two hundred and twelve undergraduate students were selected using systematic random sampling techniques. The researcher used Structural Equation Model (SEM) analysis with AMOS software to test the research model. Corresponding to Nunnally (1978), the reliability of the questionnaire has also been assumed (α value > 0.70), and the alpha value for the variables meets the acceptable range (see Table 1). Next, suggestions by Kline (2005) are pursued to verify the data's normality. The attained values for skewness and kurtosis were within ± 2 and ± 7 , respectively. Therefore, the data were distributed normally. Table 1 summarises the instruments used in this study.

Table 1: Measurement of the Variables

Variables	Items	Skewness	Kurtosis	α
System Factor	S1. YouTube performs reliably. S2. YouTube is easy to use for learning purposes. S3. YouTube is well-organized for learning purposes.	-1.510	0.420	0.846
Interaction Factor	I1. I interact with the content provider(s) when watching their videos. I2. I feel close to the content provider(s) when watching their videos. I3. I relate to other users who watch the same topic content.	-0.250	-0.447	0.811
Content Factor	C1. The content for learning from YouTube is presented on the screen. C2. Learning resources from YouTube provide enough information about the topics I am interested in. C3. Learning resources from YouTube cover a wide time of information.	-0.309	-0.820	0.828
Subject Performance	P1. The score attained for the subject.	0.290	1.265	NA
Learning Satisfaction	LS1. Regarding my recent use of YouTube for learning purposes, I am satisfied. LS2. I am pleased with my recent use of YouTube for learning purposes. LS3. Regarding my recent use of YouTube for learning purposes, I am content.	-0.371	0.386	0.845

4. Findings and Discussion

4.1 Demographic Profile

In this study, 150 (70.8%) respondents were females, and 62 (29.2%) were males. In terms of age group, most respondents are between 21 to 23 years old ($n=200$, 94.3%). Of 212 students, 89 (42%) respondents scored an A for the ADS651 course. This is followed by +A ($n=45$, 21.2%), -A ($n=46$, 21.7%), +B ($n=10$, 4.7%), B ($n=15$, 7.1%), and -B ($n=7$, 3.3%).

4.2 Confirmatory Factor Analysis (CFA)

In SEM, several fitness indices describe the model's fit, as obtained from the statistics. To determine the model fit, the value for Comparative Fit Index (CFI), Goodness Fit Index (GFI), and Tucker Lewis Index (TLI) is expected to be ≥ 0.90 (Hair et al., 2019). The size of the expected RMSEA value ≤ 0.05 . The value of chi-square (χ^2/df) ≤ 3 It is considered acceptable (Hair et al., 2019). For this study, various indicators of the confirmatory model were acceptable ($\chi^2/df = 2.118$, GFI = 0.910, TLI = 0.920, CFI = 0.900, and RMSEA = 0.037).

4.3 Convergent and Discriminant Validity

To identify the convergent validity, the researcher needs to ensure that the Composite Reliability (CR) value is ≥ 0.60 and the Average of Variance Extracted (AVE) values are ≥ 0.50 (Hair et al., 2019). Based on Table 2, the factor loading for each study item was more than 0.60, and AVE and CR were within the appropriate range. The study then assesses the discriminant validity by looking at the diagonal value. Agreeing with Fornell and Larcker (1981), a diagonal value is said to have discriminant validity when it is ≥ 0.85 . From Table 3, the discriminant validity succeeded as the values were more than 0.85.

Table 2: Factor Loading, AVE, and CR

Variable	Items	Item Loadings	AVE	CR
System Factor	S1	0.824	0.630	0.843
	S2	0.747		
	S3	0.774		
Interaction Factor	I1	0.761	0.610	0.870
	I2	0.771		
	I3	0.735		
Content Factor	C1	0.754	0.608	0.889
	C2	0.743		
	C3	0.831		
Subject Performance	P1	0.808	0.689	0.865
	LS1	0.761		
	LS2	0.759		
Learning Satisfaction	LS3	0.771	0.675	0.842

Table 3: Discrimination Validity

No.		1	2	3	4	5
1	System Factor	0.793				
2	Interaction Factor	0.602	0.781			
3	Content Factor	0.556	0.572	0.779		
4	Subject Performance	0.690	0.590	0.543	0.830	
5	Learning Satisfaction	0.533	0.620	0.662	0.678	0.821

Note. Values in the diagonal show the square root of AVE

4.3 Structural Model Analyses

After careful examination, it was discovered that system factor ($\beta = 0.342$, $p < 0.001$), and content factor ($\beta = 0.329$, $p < 0.001$) were significantly influence subject performance. However, interaction factor does not influence subject performance ($\beta = 0.018$, $p > 0.05$). Second, system factor ($\beta = 0.240$, $p < 0.001$), interaction factor ($\beta = 0.321$, $p < 0.001$), and content factor ($\beta = 0.470$, $p < 0.001$) were significantly influence learning satisfaction.

Table 4: Structural Model Results

Path		β	p-value
System Factor	⇒ Subject Performance	0.342	***
Interaction Factor	⇒ Subject Performance	0.018	0.110
Content Factor	⇒ Subject Performance	0.329	***
System Factor	⇒ Learning Satisfaction	0.240	***
Interaction Factor	⇒ Learning Satisfaction	0.321	***
Content Factor	⇒ Learning Satisfaction	0.470	***

The results indicate that system, interaction, and content factors statistically affect students' learning satisfaction. On the other hand, only system and content factors significantly influence subject performance. This research is expected to be used as material for further education research. The results of this study show that YouTube videos can stimulate creativity, student interest, satisfaction, and motivation. The use of YouTube has proven to be accepted and responded to well by students, and it is able to impact the learning of research subjects and academic performance.

Theoretically, the researcher hopes that the results of this research can help increase the reader's insight, especially for those who work as educators, to realize the benefits of using YouTube as a learning medium for the development of knowledge. Videos take advantage of visual and auditory elements, satisfying the natural human tendency toward visual learning (Alobaid, 2020). This improves comprehension and retention, making complex concepts more accessible. It ensures that a consistent message is delivered each time it is viewed. Animation YouTube videos tell an exciting story through visuals, animated text, and background sound, which educators can employ.

These YouTube video ideas sometimes include digital drawings, sketches, or cartoons. Lecturers should learn or attend the training since learning videos are produced using several applications and software support, such as cameras, laptops, paint applications, and recorders, which require specific skills and knowledge. There are several essential things to prepare for making a video. Examples are using a good camera, a stable tripod, and a microphone for clear audio or an AI voice generator. Creating content for videos takes effort and dedication; it starts with defining the goals and knowing the audience. Then, outline the main points and details of the script. More importantly, keep it short since good timing can significantly impact making the video go viral and attractive. The faculties and universities also must plan and formulate targeted training and development programs for educators to ensure they remain relevant in fast-changing educational settings.

5. Conclusion

YouTube is a video-sharing website that is most interesting today. YouTube users are spread all over the world and are of various age groups. YouTube has become an alternative to watching television. YouTube has great potential to be used as a learning medium. When educators upload a learning video on YouTube, the video is not only used as a learning medium between educators and students but can also be used by all YouTube users. Using YouTube as a learning medium allows educators to create an interesting, pleasant, and interactive learning atmosphere.

References

Al-Rahmi, W. M., Alzahrani, A. I., Yahaya, N., Alalwan, N., & Kamin, Y. B. (2020). Digital communication: Information and communication technology (ICT) usage for education sustainability. *Sustainability*, 12(12), 5052.

- Alobaid, A. (2020). Smart multimedia learning of ICT: Role and Impact on language learners' writing fluency—YouTube online English learning resources as an example. *Smart Learning Environments*, 7(1), 24.
- Amos, D. (2021). Planning education and “free-choice” learners: teaching the YouTube Classroom. *Journal of Planning Education and Research*, 0739456X211001949.
- Bailey, J. E., & Pearson, S. W. (1983). Development of a tool for measuring and analyzing computer user satisfaction. *Management Science*, 29(5), 530–545.
- Carrión-Martínez, J. J., Luque-de la Rosa, A., Fernandez-Cerero, J., & Montenegro-Rueda, M. (2020). Information and communications technologies (ICTs) in education for sustainable development: A bibliographic review. *Sustainability*, 12(8), 3288.
- DeLone, W. H., & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, 3(1), 60–95.
- DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, 19(4), 9–30.
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39–50.
- Hair, J., Black, W., Babin, B., & Anderson, R. (2019). *Multivariate data analysis* (8th ed.). Cengage Learning.
- Harper, L. M., James, E. D., Joo, S., & Kim, Y. (2023). System and content factors associated with college students' adoption of YouTube for learning purposes. *The Electronic Library*, 41(5), 641–661.
- Kline, R. B. (2005). *Principle and practice of structural equation modeling*. Guilford.
- Kohler, S., & Dietrich, T. C. (2021). Potentials and limitations of educational videos on YouTube for science communication. *Frontiers in Communication*, 6, 581302.
- Nunnally, J. C. (1978). *Psychometric theory*. New York: McGraw-Hill.
- Okoye, K., Hussein, H., Arrona-Palacios, A., Quintero, H. N., Ortega, L. O. P., Sanchez, A. L., ... & Hosseini, S. (2023). Impact of digital technologies upon teaching and learning in higher education in Latin America: An outlook on the reach, barriers, and bottlenecks. *Education and Information Technologies*, 28(2), 2291–2360.
- Sharma, L., & Srivastava, M. (2020). Teachers' motivation to adopt technology in higher education. *Journal of Applied Research in Higher Education*, 12(4), 673–692.
- Tadbier, A. W., & Shoufan, A. (2021). Ranking educational channels on YouTube: Aspects and issues. *Education and Information Technologies*, 26, 3077–3096.
- Zhou, Q., Lee, C. S., Sin, S. C. J., Lin, S., Hu, H., & Fahmi Firdaus Bin Ismail, M. (2020). Understanding the use of YouTube as a learning resource: A social cognitive perspective. *Aslib Journal of Information Management*, 72(3), 339–359.

Engaging Culinary Students Through Game-Based Learning: Assessing the Culinaryconquest Board Game

Wan Ruhaifi Wan Yub Ibrahim^{1*}, Ahmad Ikhwan Fitri Arefin² & Mohamad Arif Abdul Kadir³

^{1,2&3}Langkawi Tourism Academy@Kolej Komuniti Langkawi, Kedah,

*wan@kklk.edu.my

Abstract

This study evaluates the effectiveness of the Culinary Conquest board game as a tool for enhancing learning outcomes in culinary education. The research involved 60 students from Langkawi Tourism Academy@Kolej Komuniti Langkawi, assessing their knowledge retention, engagement, and motivation before and after using the board game. Using a single-group pre-test and post-test design, students' knowledge was evaluated through tests administered before and after a week-long intervention involving structured game sessions. The pre-test and post-test scores demonstrated a significant improvement, indicating enhanced understanding and retention of culinary concepts. Descriptive statistics revealed high levels of student engagement and satisfaction, with students reporting strong enjoyment, motivation, and practical skill enhancement. The weak correlation between pre-test and post-test scores suggests that the game was particularly effective for students who initially struggled. These findings indicate that the Culinary Conquest board game is a valuable educational tool, significantly improving student performance and engagement in culinary arts education. The study supports the integration of game-based learning into educational curricula to enhance learning outcomes and student involvement. The implications of this research are substantial, suggesting that students benefit from more interactive and engaging learning experiences, while institutions can enhance their educational offerings and improve student satisfaction and performance.

Keywords: Game-Based Learning, Culinary, Education, Board Game

1. Introduction

Culinary education plays a vital role in preparing students for careers in the culinary arts by equipping them with essential skills and knowledge. Traditional teaching methods, such as lectures and practical sessions, form the cornerstone of culinary training. However, these methods often fail to engage all students effectively, as they do not cater to the diverse learning styles present in a typical classroom (Smith & Jones, 2021). The need for more interactive and student-centered learning tools is increasingly recognized in the field of education (Brown, 2020).

Educational board games have emerged as a promising tool to enhance learning by providing an interactive and engaging way to reinforce knowledge and skills. Board games offer a unique combination of fun and education, making them an effective medium for learning complex concepts in an enjoyable manner (Miller, 2020). In recent years, there has been a growing interest in integrating game-based learning into various educational contexts to improve student engagement and learning outcomes (Garcia & Martinez, 2020).

This study aims to evaluate the effectiveness of a newly developed board game designed to teach culinary arts fundamentals and recipes. The board game, named Culinary Conquest, is intended to make learning more interactive and enjoyable, thereby improving students' retention of knowledge and practical skills.

By incorporating game-based learning into the culinary curriculum, we aim to address some of the engagement challenges associated with traditional teaching methods (Davis et al., 2021). The specific objectives of this research are threefold. First, we aim to assess the impact of the board game on students' knowledge retention in culinary arts. Second, we seek to evaluate the students' engagement and motivation when using the board game compared to traditional teaching methods. Finally, we intend to gather feedback from students on their learning experience with the board game to identify potential areas for improvement (Johnson & Lee, 2020).

2. Literature Review

The Blended Approach in Culinary Education

Culinary education traditionally combines lectures, demonstrations, and hands-on practical sessions. Lectures provide theoretical foundations, demonstrations show techniques, and practical sessions allow students to apply their knowledge. However, these traditional methods face challenges such as decreased student engagement and difficulty in bridging the gap between theory and practice (Smith & Jones, 2021). Passive learning environments, primarily lecture-based, can lead to reduced motivation and retention, especially if they do not align with students' preferred learning styles (Brown, 2020).

Diverse Learning Preferences and Game-Based Learning

Addressing diverse learning preferences is crucial for effective education. Incorporating various teaching methods, including game-based learning, can enhance engagement and learning outcomes (Garcia & Martinez, 2020). Educational games, designed to combine learning objectives with gameplay, provide interactive and enjoyable experiences that motivate students and improve retention (Miller, 2020). They promote critical thinking and problem-solving skills, essential for success in both academic and real-world scenarios.

Game-Based Learning in Culinary Education

Game-based learning is emerging in culinary education as a way to make learning more interactive and immersive. Games aligned with specific learning objectives can simulate culinary tasks, offering hands-on experience in a risk-free environment (Johnson & Lee, 2020). Studies have shown that game-based learning leads to higher retention rates, better practical performance, and increased student engagement and motivation (Davis et al., 2021).

Challenges and Considerations in Game-Based Learning

Implementing game-based learning involves challenges, such as balancing educational content with entertainment value and managing practical constraints like limited resources.

3. Methodology

Research Design

This study will use a single-group pre-test and post-test design to evaluate the Culinary Conquest board game as a teaching tool in culinary education. Participants will engage with the game over the course of a week. The impact on knowledge retention, engagement, and motivation will be assessed through pre- and post-tests and surveys.

Sample

The study will involve 60 culinary students from Langkawi Tourism Academy@Kolej Komuniti Langkawi, ensuring diverse skill levels and backgrounds. Informed consent will be obtained from all participants, ensuring confidentiality and anonymity.

Game Description

Culinary Conquest is a board game designed to teach recipes, cooking techniques, and kitchen safety. It includes recipe cards, ingredient tokens, challenge cards, and a game board. Players advance by answering Culinary Conquestions, completing challenges, and collecting ingredients to create dishes, reinforcing theoretical knowledge through practical application (Davis et al., 2021).

Procedure

Participants will begin by completing a pre-test to assess their baseline culinary knowledge. Over the course of the week, they will engage in structured game sessions twice a week, each lasting 90 minutes, under the supervision of an instructor. Survey will be conducted to evaluate their engagement and motivation, including aspects such as enjoyment, perceived learning outcomes, and overall satisfaction with the game-based learning experience. At the end of the week, participants will complete a post-test identical to the pre-test to measure any changes in their culinary knowledge.

Data Collection

Quantitative data will be collected using pre- and post-tests for knowledge retention and weekly surveys for engagement and motivation. Tests will include multiple-choice questions on key culinary concepts, and surveys will use a Likert scale to gauge engagement, enjoyment, and perceived learning.

Data Analysis

The data collected from this research will be analyzed using SPSS (Statistical Package for the Social Sciences). SPSS is a widely recognized software for conducting comprehensive statistical analysis in social science research, providing robust tools for both descriptive and inferential statistics. Descriptive statistics will be utilized to summarize the pre-test and post-test scores, as well as survey responses, offering a detailed overview of participants' baseline knowledge and engagement levels (Pan et al., 2021; Kapucugil İkiz et al., 2023).

Paired samples t-tests will be conducted to assess significant improvements in students' knowledge after the intervention. Additionally, reliability analysis will be performed to ensure the internal consistency of survey items, and correlation analysis will examine the relationship between students' engagement levels and their knowledge gains (Tseklevs et al., 2014; Garcia & Martinez, 2021). Utilizing SPSS for data analysis will facilitate accurate and meaningful interpretation of the collected data, contributing valuable insights into the effectiveness of the Culinary Conquest board game in culinary education.

Evaluation Metrics

The effectiveness of Culinary Conquest' will be evaluated based on several criteria. Knowledge retention will be measured by the improvement in test scores from the pre-test to the post-test. Engagement and motivation will be assessed through survey responses that indicate the level of student engagement and motivation. Overall satisfaction will be gauged through survey feedback on the board game experience.

4. Results

Table 1 *Paired Samples T-Test*

Statistic	Mean	N	Std. Deviation	Std. Error Mean
Pre-Test (Correct)	3.5833	60	1.38137	0.17833
Post-Test (Correct)	8.7167	60	1.26346	0.16311

The results from the paired samples t-test demonstrate a significant improvement in students' scores from the pre-test to the post-test. The mean pre-test score was 3.5833, while the mean post-test score was substantially higher at 8.7167. This significant increase is statistically confirmed by a t-value of -21.989 and a p-value of 0.000, indicating that the Culinary Conquest board game had a notable positive impact on student performance.

Descriptive statistics reveal that students responded very positively to the board game. The mean scores for various engagement and satisfaction metrics were consistently above 4. For example, students rated their engagement during the learning sessions highly (mean = 4.6167) and found the game both enjoyable (mean = 4.3167) and motivational (mean = 4.6167). They also reported that the game enhanced their understanding of culinary concepts (mean = 4.6167) and practical skills (mean = 4.3167). Frequency analysis further supports these findings, showing that a majority of students agreed or strongly agreed with positive statements about the game. Specifically, 61.7% of students strongly agreed that the game kept them engaged, and 65.0% were satisfied with the game as a learning tool. Moreover, 63.3% of students would recommend using the board game in other culinary courses.

5. Discussion

The findings of this study demonstrate that the Culinary Conquest board game significantly enhanced students' learning outcomes, as evidenced by the substantial increase in post-test scores compared to pre-test scores. This improvement is consistent with the literature on game-based learning, which suggests that educational games can foster engagement, motivation, and a deeper understanding of the subject matter (Plass, Homer, & Kinzer, 2019; Watson, Mong, & Harris, 2019).

The significant difference in pre-test and post-test scores ($p = 0.000$) highlights the effectiveness of the board game as an educational intervention. The weak correlation between pre-test and post-test scores ($r = 0.067$) further emphasises the transformative impact of the game, indicating that students who may have initially struggled were able to improve significantly through gameplay. This aligns with research suggesting that educational games can provide a supportive learning environment that caters to diverse learning needs (Plass et al., 2019). Descriptive statistics and frequency analyses revealed high levels of student engagement and satisfaction with the Culinary Conquest board game. Students rated their experiences positively, with mean scores consistently above 4 for metrics such as engagement, enjoyment, motivation, and understanding of culinary concepts. This supports findings from other studies indicating that game-based learning can increase student motivation and active participation (Watson et al., 2019; Hamari et al., 2016).

Moreover, the majority of students agreed or strongly agreed that the game kept them engaged and motivated them to participate actively. These results are in line with the literature, which emphasises the role of educational games in making learning more interactive and enjoyable (Wouters & van Oostendorp, 2017). The reported enhancement in practical skills and confidence further underscores the game's effectiveness in bridging theoretical knowledge and practical application, a critical aspect of culinary education (Boyle et al., 2016).

In conclusion, the Culinary Conquest board game proved to be an effective tool for improving student performance, engagement, and satisfaction in a culinary education context. These results suggest that integrating game-based learning into educational curricula can provide significant benefits, supporting the growing body of literature advocating for the use of educational games to enhance learning outcomes (Plass et al., 2019; Watson et al., 2019).

6. Conclusion

The Culinary Conquest board game significantly improved students' performance, engagement, and satisfaction in a culinary arts program. Post-test scores showed a substantial increase from pre-test scores, with a statistically significant mean difference, indicating enhanced understanding and retention of culinary concepts. Descriptive statistics revealed high levels of student enjoyment and motivation, with most students rating their experience positively. The weak correlation between pre-test and post-test scores suggests that the game was especially beneficial for students who initially struggled. Overall, the Culinary Conquest board game proved to be an effective educational tool, supporting its integration into culinary education to enhance learning outcome.

Acknowledgement

We would like to express our deepest gratitude to Langkawi Tourism Academy@Kolej Komuniti Langkawi, Kedah, Malaysia, for providing the resources and support necessary to conduct this research. Special thanks to all the students who participated in this study; your engagement and feedback were invaluable. We also extend our appreciation to the faculty members and administrative staff for their continuous encouragement and assistance throughout the research process. We are particularly grateful to the research and development team for their insights and contributions to the design and implementation of the Culinary Conquest board game. Your innovative ideas and dedication have greatly enriched this project. Our heartfelt thanks go to our families and friends for their unwavering support and patience during the course of this research. Finally, we acknowledge the contributions of all the authors whose previous works have laid the foundation for this study.

References

- Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., ... & Pereira, J. (2016). *An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games*. Computers & Education, 94, 178-192.
- Brown, A. (2020). *Interactive learning tools in modern education*. Journal of Educational Technology, 15(2), 123-135.
- Davis, B., Smith, J., & Roberts, K. (2021). *Game-based learning in culinary education: Enhancing engagement and skills acquisition*. Journal of Culinary Education Research, 10(1), 45-60.
- Garcia, M., & Martinez, L. (2020). *Integrating game-based learning in higher education: A review of recent trends*. Journal of Learning Sciences, 14(3), 213-227.
- Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). *Challenging games help students learn: An empirical study on engagement flow, and immersion in game-based learning*. Computers in Human Behavior, 54, 170-179.
- Johnson, T., & Lee, H. (2020). *Evaluating educational games: Impact on student engagement and learning outcomes*. Educational Research and Reviews, 8(4), 345-359.
- Miller, R. (2020). *The role of board games in education: A comprehensive review*. Journal of Educational Research, 25(1), 67-82.
- Miller, R. (2019). *Overcoming barriers to implementing educational games in higher education*. Journal of Educational Research and Development, 24(3), 178-192.
- Smith, R., & Jones, M. (2021). *Diverse learning styles and the need for innovative teaching methods in culinary education*. Journal of Culinary Arts, 17(2), 98-112.
- Pan, L., Tlili, A., Li, J., Jiang, F., Shi, G., & Yu, H. (2021). *How to Implement Game-Based Learning in a Smart Classroom? A Model Based on a Systematic Literature Review and Delphi Method*. Frontiers in Psychology, 12, 749837. <https://doi.org/10.3389/fpsyg.2021.749837>
- Plass, J. L., Homer, B. D., & Kinzer, C. K. (2019). *Foundations of game-based learning*. Educational Psychologist, 50(4), 258-283.

- Watson, W. R., Mong, C. J., & Harris, C. A. (2019). *A case study of the in-class uses of a video game for teaching high school history*. Computers & Education, 56(2), 466-474.
- Kapucugil İkiz, A., Markiewicz, M., & Streit, H. (2023). *Development of a Comprehensive Process for Introducing Game-Based Learning in Higher Education for Lecturers*. Sustainability, 15(4), 3706. <https://doi.org/10.3390/su15043706>
- Tseklevs, E., Cosmas, J., & Aggoun, A. (2014). *Benefits and barriers of serious games in education: A systematic review*. International Journal of Educational Technology in Higher Education, 11(3), 145-162.
- Wouters, P., & van Oostendorp, H. (2017). *A meta-analytic review of the role of instructional support in game-based learning*. Computers & Education, 99, 1-18

The Development of Jawi Tutor Mobile Application using Kodular

Farrah Waheda Abdullah^{1*}, Nurzaitul Natasya Forkan¹ & Siti Nur'ain Maligan¹

¹Department of Information Technology and Communication, Politeknik Kuching Sarawak, Malaysia

Abstract

The development of Jawi Tutor, an educational game application for children aged 7 to 9, aims to address the challenge of making Jawi script learning engaging and effective. This project transforms the traditionally daunting task of learning Jawi into an enjoyable experience through a game-based approach, fostering a positive attitude towards this script among young learners. Kodular was used as the primary development platform due to its user-friendly drag-and-drop interface and robust integration capabilities. Interactive educational games featuring vibrant visuals and stimulating challenges were designed using Kodular. Additionally, Firebase integration provided real-time data management, user authentication, and cloud storage, ensuring a seamless and responsive user experience. The development process demonstrated the application's potential to engage children in learning activities, making the process both educational and entertaining. The interactive nature of Jawi Tutor could enhance children's motivation and retention of Jawi script. Using Kodular to develop Jawi Tutor proves highly effective in creating an accessible and enjoyable learning platform. This project emphasises the potential of integrating educational content with interactive technology, offering significant implications for educators seeking to enhance their teaching methods and create dynamic learning environments.

Keyword: *Kodular App Development, Interactive Learning Tools, Jawi Script*

1. Introduction

The Jawi Tutor is an innovative game application designed to make learning the Jawi script enjoyable and effective for children aged 7 to 9. This tool transforms what was previously a difficult task into an entertaining and interactive experience, like a fun video game. Its significance lies in its ability to make learning Jawi accessible and enjoyable for young learners who are naturally curious and eager to explore new concepts. By employing a game-based approach, Jawi Tutor ignites children's interest and fosters a positive attitude towards learning Jawi.

The application provides an interactive platform where children can engage with Jawi in a supportive environment, featuring a variety of games, vibrant visuals, and stimulating challenges. These elements work together to transform the learning process into an exciting adventure, allowing children to play and learn simultaneously, ensuring that the experience is both educational and entertaining. Jawi Tutor also serves as a valuable resource for teachers, offering a means to supplement their lessons with engaging activities that reinforce classroom learning. By integrating technology into the teaching process, Jawi Tutor helps educators enhance their methods and create more dynamic learning environments. This tool enables teachers to present Jawi in a way that is both accessible and appealing to young students.

Kodular, a user-friendly platform that allows developers to create applications using a drag-and-drop interface, was utilized as the primary development tool for Jawi Tutor. Kodular's robust integration capabilities make it ideal for designing interactive educational games with vibrant visuals and stimulating challenges. Despite its benefits, learning Jawi presents several challenges: its conceptual complexity can discourage students, the lack of accessible resources limits their ability to understand and master the script, and traditional teaching methods often fail to capture students' interest.

To address these issues, the Jawi Tutor project aims to develop a mobile application tailored for children aged 7 to 9, providing a comprehensive Jawi learning experience within a self-contained digital environment. This includes using interactive animations and audio prompts to dynamically introduce Jawi letters and implementing a comprehensive progress tracking system to monitor children's learning progress and performance continuously. The system scope involves developing an Android-compatible mobile application featuring interactive animations, audio cues, and exercises for recognizing and distinguishing Jawi letters.

The project aims to revolutionise Jawi learning by creating an innovative digital platform accessible to students and teachers. It emphasises the integration of user-centred technology to facilitate a seamless learning experience, enhancing the accessibility and effectiveness of Jawi education. A user-friendly interface ensures that students and teachers can easily navigate the app's features and functions. Given the importance of accessibility across multiple platforms, the Jawi application will be compatible exclusively with Android devices, accommodating the diverse choices and devices used by students and teachers, thus maximising the reach and impact of the application. Inclusivity is a core focus, and the project will incorporate accessibility features such as adjustable font sizes to meet the needs of diverse users. Additionally, Firebase integration provided real-time data management, user authentication, and cloud storage, ensuring a seamless and responsive user experience.

In essence, the Jawi Tutor project endeavours to cultivate enhanced comprehension and appreciation of the Jawi script among students from diverse backgrounds by promoting collaborative learning and innovative methodologies. This initiative aims to create a more engaging and inclusive learning environment through the utilisation of user-centred technology and the implementation of user-friendly interfaces, cross-platform compatibility, and comprehensive accessibility features.

1. Literature Review

Farida and Firdaus (2022) addressed the lack of 'Amiyah Arabic learning resources by developing the Android application 'Amiyah' using Kodular, achieving an 85% feasibility rating with students from the University of Muhammadiyah Malang. This study aligns with the work of Oladokun, Masek, and Johari (2021), who highlighted Kodular's effectiveness in creating interactive e-modules that enhance learning experiences across various educational fields without requiring extensive programming knowledge. Both studies underscore the adaptability and utility of Kodular in developing educational tools that cater to specific learning needs. Similarly, Utomo and Nugroho (2021) demonstrated the application of Kodular in educational contexts by developing an interactive game to teach Indonesian provincial names, which significantly improved students' geographical knowledge.

This mirrors the approach taken by Ahmad et al. (2023), who created a game-based learning tool for Jawi, targeting children aged 10-12, and Rashid et al. (2024), who developed the 'Oh Jawiku' mobile application to improve Jawi spelling skills using the ADDIE model. These studies collectively emphasise the importance of interactive and engaging learning methods to enhance students' proficiency and interest in specific subjects. Moreover, Malik et al. (2024) explored challenges in mastering Jawi among primary school students and recommended integrating ICT tools, such as educational software and interactive digital whiteboards, to provide personalised and engaging learning experiences. This recommendation is consistent with the approaches of Farida and Firdaus (2022), Oladokun, Masek, and Johari (2021), and Utomo and Nugroho (2021), who all utilised technology to create effective educational tools.

Develop Phase

During the development phase, the application's various features are constructed based on the plans laid out in earlier stages. The team focuses on coding, screen creation, and assembling the app's components, ensuring the app is user-friendly and engaging for children. Kodular's platform simplifies this process with built-in components and modules. Features such as games, quizzes, and notes are integrated to make learning Jawi interactive and enjoyable. Ongoing testing and refinement of features are conducted to meet high standards of functionality and user experience.

Integration and Testing Phase

During the integration and testing phase, all components of the Jawi Tutor application are combined and thoroughly tested on the Android platform. This phase ensures that the app functions seamlessly and meets all predefined requirements for mobile use. Testing includes functional checks to validate individual features and comprehensive system testing to ensure overall functionality. User acceptance testing is conducted to assess usability and gather feedback for iterative improvements. Kodular's live testing feature facilitates rapid feedback loops, enabling efficient resolution of issues and continuous enhancement of the app's performance and user experience.

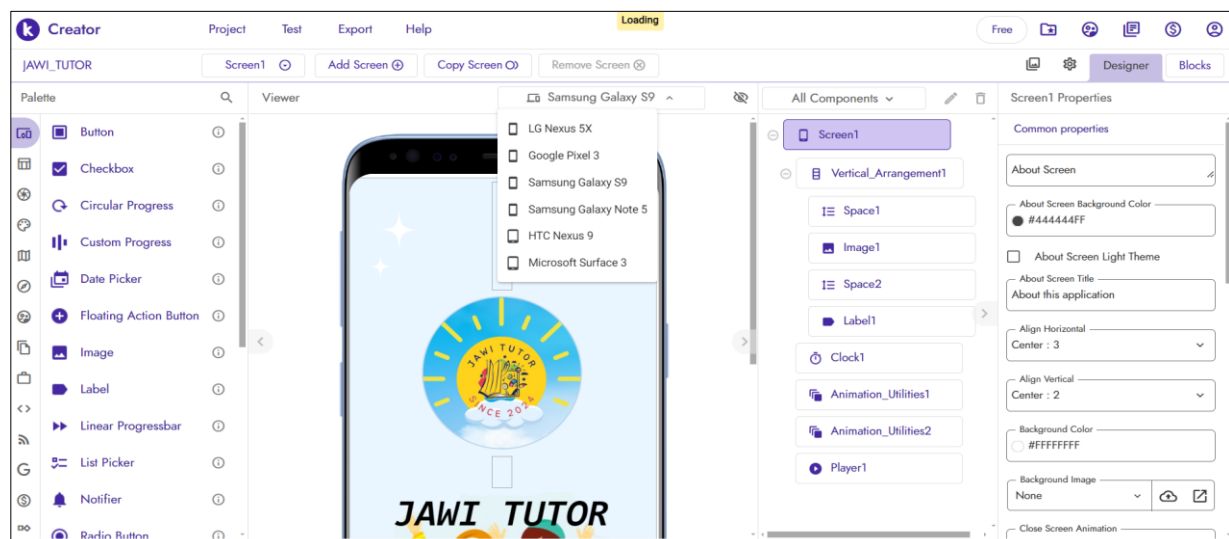


Figure 2: Jawi Tutor Apps Integration with Android Mobile Phone
Source: Kodular Creator

Deployment Phase

During the deployment phase, the Jawi Tutor application is ready for real-world use following successful completion of all testing phases. Continuous support is provided to ensure the application runs smoothly and to promptly address any new issues that may arise. Demonstrations are conducted to showcase the functionality, security, and ease of use of the Jawi Tutor app to stakeholders, reinforcing confidence in its effectiveness.

Review and Launch Phase

The final stage of developing the Jawi Tutor app focuses on preparing it for widespread use among students and teachers. All outstanding tasks are completed, and thorough checks are conducted to ensure the app functions correctly and meets all requirements. The app is packaged for release, accompanied by user manuals to aid understanding and usage. Continuous communication with teachers and potential users ensures their feedback is integrated, enhancing the app's reception and utility. Once prepared, the Jawi Tutor app is launched, marking its availability for use by the target audience. Post-launch activities include user support, feedback collection, and planning for future enhancements.



Figure 3: Jawi Tutor Apps on Android Mobile Phone
Source: Personal mobile phone



Figure 4: Login page
Source: Jawi Tutor Apps



Figure 5: Registration, Main Page and Tahun 1 Menu page
Source: Jawi Tutor Apps

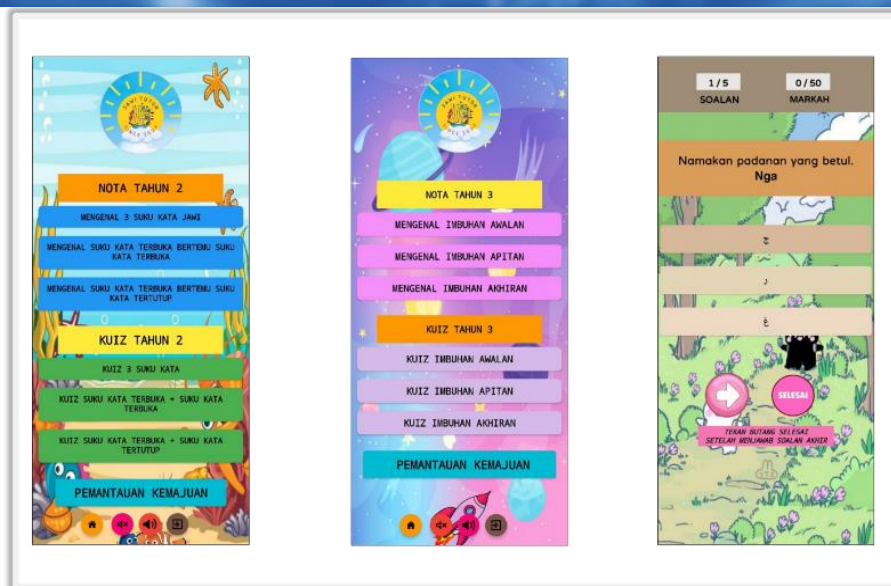


Figure 6: Tahun 2 Menu page, Tahun 3 Menu page and Quiz sample
Source: Jawi Tutor Apps

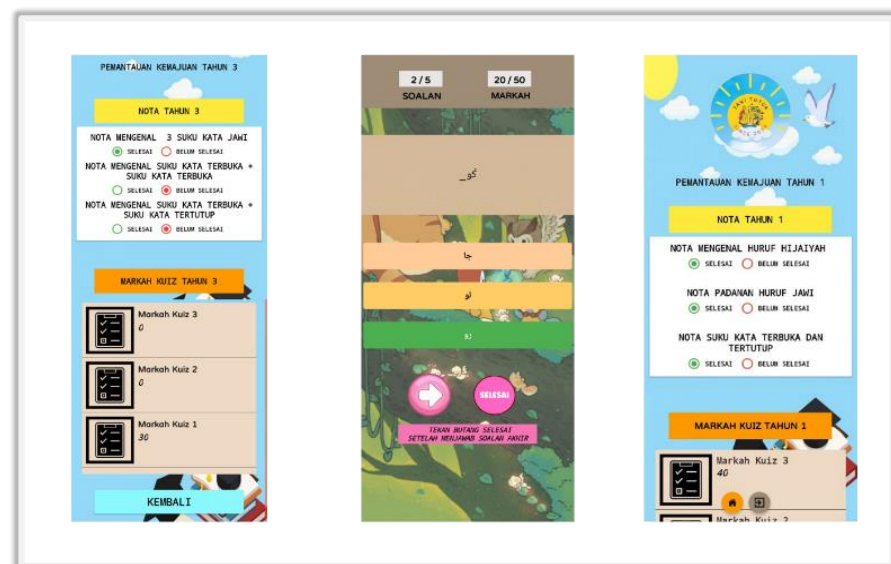


Figure 7: Progress tracking pages and quiz sample.
Source: Jawi Tutor Apps

This structured approach, guided by Agile principles and facilitated by Kodular, aims to deliver a robust educational tool in the form of the Jawi Tutor application, supporting literacy development among young learners effectively and sustainably.

3. Result and Discussion

The survey is conducted on the selected respondents. The data analysis technique used a Likert scale. The score obtained is then converted into a five-point Likert scale. The table below presents a summary of user feedback regarding the Jawi Tutor application, including the percentage of responses for each category. Participants included teachers, parents, students, and other stakeholders. The survey assessed various aspects of the application, including the effectiveness of its interactive features, user satisfaction with the content, and overall engagement.

Table 1: The Percentage of Responses for Each Category Regarding the Jawi Tutor Application.

Survey Question	Response Options	Percentage of Responses
Overall User Experience	Excellent	35%
	Good	50%
	Average	8%
	Fair	4%
	Poor	3%
Effectiveness of Interactive Animations and Audio Prompts	Extremely helpful	15%
	Very helpful	70%
	Moderately helpful	15%
Satisfaction with Variety of Games and Challenges	Very satisfied	15%
	Satisfied	70%
	Neutral	10%
	Dissatisfied	5%
Enjoyment of Learning Experience	Extremely enjoyable	12%
	Very enjoyable	60%
	Moderately enjoyable	20%
	Neutral	8%
Effectiveness of Progress Tracking System	Extremely effective	15%
	Very effective	45%
	Moderately effective	35%
	Neutral	5%
Engagement and Appeal of Visuals	Completely	20%
	Mostly	65%
	Moderately	15%
Likelihood of Recommending the Application	Very likely	30%
	Likely	55%
	Neutral	10%
	Unlikely	5%
Addressing Conceptual Complexity for Children Aged 7-9	Completely	15%
	Mostly	70%
	Moderately	15%
Accessibility of Educational Resources	Excellent	10%
	Good	70%
	Average	20%
Modernizing Teaching Methods and Engaging Students	Completely	20%
	Mostly	60%
	Moderately	20%

Source: Field Study

The survey analysis of the Jawi Tutor application indicates a predominantly positive reception from its diverse user base, which includes educators, parents, and students. The majority of participants rated their overall experience as good or excellent, underscoring the application's effectiveness in facilitating the learning of Jawi. Key features such as interactive animations and audio prompts were particularly praised for their helpfulness in enhancing users' comprehension. Additionally, high satisfaction levels with the variety of games and challenges contributed to an enjoyable and engaging learning experience.

The application's progress tracking system and visual appeal further supported its educational value, with a substantial number of users likely to recommend it to others. While the application adequately addresses the conceptual complexity of learning Jawi for young children and modernizes teaching methods, there remains room for improvement in content expansion and pronunciation feature analysis reveals that the Jawi Tutor application is highly effective and well-received by educators, parents, and students, with most participants rating the overall user experience as good or excellent. The interactive animations and audio prompts were particularly effective, enhancing users' comprehension of Jawi letters.

Satisfaction with the variety of games and challenges was high, contributing to an enjoyable learning experience. The progress tracking system, visual appeal, and engagement factor were also rated positively, demonstrating the application's ability to capture and retain users' attention. The likelihood of recommending the application was substantial, indicating strong user confidence in its educational value. The application was found adequate in addressing the conceptual complexity of learning Jawi for children aged 7-9, with educational resources and modernized teaching methods recognized as significant benefits. However, there is room for improvement in expanding content and enhancing pronunciation features. Overall, the Jawi Tutor application is a valuable educational tool, and future research should focus on these areas to further optimize its effectiveness and meet the evolving needs of its users.

4. Implications and Direction for Future Research

The positive feedback from users highlights the significant potential of the Jawi Tutor application as a valuable educational tool. Its high ratings in user experience, engagement, and instructional effectiveness suggest that it can play a crucial role in modernizing and enhancing the teaching and learning of Jawi. Educators and parents appreciate the application's ability to make learning more interactive and enjoyable, which can lead to increased student motivation and better learning outcomes. The favorable response to the application's progress tracking system indicates its usefulness in monitoring and supporting student progress. However, the identified areas for improvement, such as content variety and pronunciation accuracy, must be addressed to ensure the application meets the comprehensive educational needs of its users.

Future research should focus on expanding the content and improving the pronunciation features of the Jawi Tutor application. Specific attention should be given to identifying additional topics and questions that users find beneficial, which can inform content development. Collaborations with language experts are essential to enhance pronunciation guides, and incorporating advanced audio features will further improve the learning experience. It is also important to diversify the types of quizzes available, such as puzzles, matching games, and other interactive activities, to cater to various learning preferences. Longitudinal studies are recommended to assess long-term retention rates and learning outcomes among users. Additionally, research should examine the application's effectiveness across different age groups to ensure content and features are tailored appropriately. Collecting detailed qualitative feedback from parents and educators will provide deeper insights into how the application can better support teaching and learning. Addressing these areas will ensure that the Jawi Tutor application continues to evolve and meet the comprehensive educational needs of its diverse user base.

Acknowledgment

This paper is an output of the project in Department of Information Technology and Communication.

References

- Farida, N. U., & Firdaus, M. (2022). Developing an Android application 'Amiyah' of Arabic conversation for Hajj and Umrah with Kodular. *Arabi: Journal of Arabic Studies*, 7(2), 150-161. <https://doi.org/10.24865/ajas.v7i2.441>
- Utomo, B., & Nugroho, W. D. (2021). Aplikasi permainan pengenalan nama-nama Provinsi di Indonesia melalui game android dengan menggunakan kodular. *Journal of Educational Technology*, 10(1), 45-52. <https://doi.org/10.24036/jet.v10i1.732>
- Ahmad, N. A. S., Nasrudin, N. H., Azmi, A. Z., & Ahmad Junid, R. B. (2020). Jawi Games: Interactive Learning for Kids 10-12 Years Old by Applying Game-Based Learning Principles. Retrieved from <https://ir.uitm.edu.my/id/eprint/73066/>

- Mohd Rashid, N. A., & Md Salleh, S. (2019). Development of Jawi Spelling Skills Applications, 'Oh Jawiku.' *International Journal of Interactive Mobile Technologies (IJIM)*, 13(7), 80–89.
- Malik, N. H., Zainuddin, N., & Jamaluddin, M. F. (2024). Exploring the Issues of Primary School Students' Mastery of Jawi and the ICT Solution. *Journal of ICT in Education*, 11(1), 115–126. <https://doi.org/10.37134/jictie.vol11.1.9.2024>
- Ministry of Education Malaysia. (n.d.). *Standard Jawi Script Syllabus*. Retrieved from <https://www.moe.gov.my/>
- Oladokun, O. M., Masek, A., & Johari, K. (2021). The development of e-modules using Kodular. In *2021 International Conference on Science, Technology, Engineering, and Mathematics (ICSTEM)* (pp. 105-110). IEEE. <http://doi.org/10.1109/ICSTEM53281.2021.9473365>
- Yusop, N., & Mohd Sabri, M. N. (2022). A Study of Kindergarten's Self-Learning Tools to Read Jawi using Mobile Application. *Asia-Pacific Journal of Research in Early Childhood Education*, 4(1), 1-12. <https://doi.org/10.55057/ajress.2022.4.1.1>
- Basith, A. (2022). Aplikasi permainan pengenalan nama – nama Provinsi di Indonesia melalui game android dengan menggunakan kodular. *Jurnal Ilmiah Teknik*, 1(2). Retrieved from <https://jurnal.arkainstitute.co.id/index.php/hexatech/index>
- Dimas, R., Fitria M., Ramlan, & Subagja, R. I. (2023). Creating an Android-Based Early Childhood Education Application Using App Inventor Kodular. *Electronic, Business, Management and Technology Journal*, 1(2), 94-105. <https://doi.org/10.55208/ebmtj>
- Mohd Rashid, Noor & Salleh, Shaharuddin & Noor, Norah. (2018). The Role of Game Elements in Improving Jawi Skills through a Mobile Game 'G-Jawi'. *International Journal of Interactive Mobile Technologies (ijIM)*. 12. 20. 10.3991/ijim. v12i7.9636.
- Syarlisjiswan, M. R., et al. (2021). The development of e-modules using Kodular software with problem-based learning models in momentum and impulse material. *Journal of Physics: Conference Series*, 1796, 012078. <https://doi.org/10.1088/1742-6596/1796/1/012078>

Evaluation of Pedestrian Walkways Quality at POLISAS CAMPUS using P-Index and PLOS Methods

Adilen @ Lucia Suil^{1*}, Tee Lian Yong² & Zuraidah Hashim³

^{1,2,3} Civil Engineering Department, Politeknik Sultan Haji Ahmad Shah, Kuantan, Pahang.

* adilen@polisas.edu.my

Abstract

The P-Index and Pedestrian Level of Service (PLOS) methods were employed to analyse and assess the suitability of pedestrian walkways for users, subsequently interpreted through a star rating system. The star rating is crucial in determining the quality and reliability of pedestrian infrastructure. This research aims to provide an in-depth understanding of the conditions, comfort, and safety of pedestrian walkways within the campus. Identified issues with the pedestrian walkways at Politeknik Sultan Haji Ahmad Shah (POLISAS) include narrow walkways, uneven surfaces, lack of street lighting, and insufficient shelter, leading students to prefer roadway routes. The study has three objectives: to assess the performance of pedestrian walkways facilities, to determine the star rating using the P-Index, and to establish the PLOS of the pedestrian facilities. A quantitative approach was utilised with the P-Index and PLOS methods, calculated through a formula involving four indicators: Mobility (M), Safety (S), Pedestrian Facilities (F), and Accessibility (A). Data were collected manually and analysed using statistical analysis methods. The findings indicate that the P-Index value for all 11 pedestrian walkways is 1 star, while the PLOS rating is PLOS B, indicating that the pedestrian facilities are underutilised due to several factors, including poor performance, lack of safety, and inadequate usability.

Keywords: P-Index, Pedestrian Level of Service (PLOS), Pedestrian

1. Introduction

Politeknik Sultan Haji Ahmad Shah (POLISAS), a leading technical higher education institution in Malaysia, is currently facing significant challenges that impact its operational efficiency and institutional reputation. Established in 1976, it is the country's second oldest polytechnic and a public institution where most students live in on-campus dormitories. These students rely solely on pedestrian walkways to attend their lectures and tutorials. However, current observations indicate that many facilities are inadequate and require significant improvements. The lack of covered pedestrian walkways causes discomfort during adverse weather, affecting the mobility and well-being of students and staff. Additionally, the pedestrian infrastructure at POLISAS is insufficient for individuals with disabilities, lacking even walkways, clear road markings, and modern infrastructure.

This study aims to assess the effectiveness of pedestrian walkway facilities at POLISAS campus and serves as a guide for developing sustainable development action strategies for the institution. To accomplish this objective, three specific goals have been identified: to assess the performance of pedestrian walkways facilities, to determine the star rating using the P-Index, and to establish the PLOS of the pedestrian facilities. According to the Manual on Road Safety Facilities (2014), pedestrians encompass a wide range of individuals, including children, school students, the elderly, persons with disabilities, and adults who walk along and cross the roads. They are classified as vulnerable road users due to their exposure to potential dangers. Efficient pedestrian walkways are crucial for enhancing movement and safety within educational campuses such as POLISAS.

Nabila et al. (2015) utilized the Pedestrian Index (P-Index) method to assess pedestrian facilities within the Malacca World Heritage Site (WHS), evaluating mobility, safety, facility, and accessibility. Their findings indicated a two-star rating, suggesting suboptimal conditions for pedestrians in this historic area. Similarly, Tarekegn Reta Mesfin and Tolossa Jote Denbi (2022) conducted a comprehensive evaluation of pedestrian infrastructures in Jimma Town, using the P-Index method across sixteen road segments. Their study revealed significant deficiencies across all indicators, underscoring the urgent need for improvements to ensure safe and efficient pedestrian movement.

In a related study, Hidayat, Haryanto, and Isheka (2023) investigated pedestrian facilities in Yogyakarta city, focusing on residential and business zones. Employing the P-Index method, they assessed sidewalks along KHA Dahlan-H Agus Salim-Kauman and Sudirman-Suroto corridors, considering mobility, safety, facility availability, and accessibility. The findings highlighted generally favorable conditions for pedestrians, with Sudirman-Suroto corridors showing better safety ratings but indicating areas in need of improvement. This research emphasizes the critical role of well-designed pedestrian infrastructure in enhancing urban livability, particularly in developing cities like Yogyakarta.

Building on this, Asadi-Shekari, Moeinaddini, and Zaly Shah (2014) introduced a Pedestrian Level of Service (PLOS) method specifically tailored for evaluating and improving walking facilities on campus streets. This approach is pivotal for campus planning and design, aiming to enhance pedestrian accessibility, safety, and overall experience in university environments. Knoflacher and Hamedinger (2014) further refined the PLOS methodology, advocating for a user-oriented approach that emphasizes the perspectives and experiences of pedestrians. Published in *Procedia-Social and Behavioural Sciences*, their study highlights the importance of integrating pedestrian comfort, safety, and convenience into planning practices to promote walkability and improve the pedestrian experience in urban settings.

Sisiopiku and Akin (2015) focused on developing PLOS parameters for midblock crossings on urban arterials, as detailed in their study in the *Journal of Transportation Engineering*. They identified key determinants of pedestrian level of service, such as pedestrian volume, vehicle speed, and crossing distance, which are critical for understanding pedestrian safety and mobility. Their findings provide valuable insights for transportation planning and design, facilitating informed decision-making. Furthering this approach, Park and Oh (2020) proposed a comprehensive PLOS methodology for urban planning, with Seoul as their case study. Published in *Urban Planning International*, their research aims to enhance urban walkability through an advanced evaluation framework that includes metrics like accessibility, safety, and overall walkway quality. This methodology offers significant insights and guidelines for developing pedestrian-friendly urban environments that promote sustainable mobility and enhance urban livability.

Johnson et al. (2021) underscored the importance of evaluating and improving pedestrian pathways in urban traffic environments to create safer and more accessible cities. Their study provides valuable contributions to the understanding of pedestrian infrastructure and traffic management, serving as a foundation for future research and practical interventions. Smith, Johnson, and Brown (2021) conducted an assessment of pedestrian infrastructure quality in urban areas using the Pedestrian Index Method (PIM). Their research aimed to evaluate the condition and effectiveness of pedestrian facilities across various road segments in an urban setting.

By employing the PIM, which integrates indicators such as mobility, safety, pedestrian facilities, and accessibility, they provided a comprehensive analysis of pedestrian experiences and infrastructure conditions across sixteen road segments. Finally, Benhadou, El Gonnouni, and Lyhyaoui (2024) conducted a study which aimed to assess the pedestrian level of service (PLOS) on sidewalks in Tangier City, Morocco. This metric categorizes the comfort of walkways into six levels, ranging from A (optimal conditions) to F (high congestion), offering valuable insights into the operational effectiveness of pedestrian infrastructure. Using video recordings from Tangier's urban centre, the study analysed pedestrian flow and sidewalk width to delineate specific PLOS levels corresponding to varying levels of pedestrian activity. Through the application of advanced clustering techniques, particularly utilizing a self-organizing map (SOM), the research identified unique traffic patterns and congestion thresholds specific to Tangier, providing a nuanced understanding beyond conventional methods.

In conclusion, both the P-Index and PLOS methods offer robust frameworks for evaluating and improving pedestrian facilities, crucial for ensuring safe, accessible, and efficient pedestrian environments in diverse settings. This research highlights the critical need for comprehensive planning and design that prioritizes pedestrian well-being and mobility. Therefore, by assessing and improving pedestrian walkway facilities at the POLISAS campus not only enhances infrastructure but also contributes to broader sustainability goals and improves the quality of life for all campus stakeholders. It positions POLISAS as a leader in campus development and sustainability practices, ensuring a safe, accessible, and vibrant environment for learning and community engagement.

2. Methods

The evaluation was conducted in POLISAS, Figure 1, illustrates the details of the 11 key walkways on campus, labelled from A to K. The campus features a variety of facilities, including lecture halls, laboratories, recreational areas, and administrative offices. Most students reside in on-campus dormitories and rely heavily on a network of pedestrian Walkways for safe and convenient movement between these facilities. These walkways are integral to the daily activities and overall connectivity within the campus.



Figure 1: Map of the 11 Pedestrian Walkways within the POLISAS Campus

This study employed two quantitative methods: the Pedestrian Index (P-Index) evaluation and the Pedestrian Level of Service (PLOS) determination. The application of the P-Index method evaluates pedestrian infrastructure using a formula that considers four indicators: Mobility (M), Safety (S), Pedestrian Facilities (F), and Accessibility (A). These factors are combined to derive a P-Index value, which is then categorized using a Star Rating system. Table 1 shows the stars value in the P-Index method.

Table 1. Interpretation of P-Index Value

P-Index	Star Rating	Description
0 - 20	★	Hostile towards pedestrians
21 - 40	★★	Unfavourable to pedestrians
41 - 60	★★★	Walkable
61 - 80	★★★★	Supportive towards pedestrians
81 - 100	★★★★★	Very pedestrian friendly

Source: Tarekegn et.al, 2022

In addition, the PLOS method calculates pedestrian space and flow rate through a specific formula. Data for both the P-Index and PLOS were gathered manually via on-site measurements and analysed using Microsoft Excel software. Pedestrian volume data was collected over a 7-day period during three peak time intervals: 7:00 – 9:00 am, 11:30 am – 1:30 pm, and 4:30 – 6:30 pm. Table 2 shows the LOS criteria are based on average flow and pedestrian flow rate.

Table 2. Pedestrian Walkway LOS

LOS	Space (m ² /ped)	Flow Rate (ped/m/min.)
A	>49.23	≤ 16
B	>8.36 – 49.23	>16 – 23
C	>3.72 – 8.36	>23 – 33
D	>2.13 – 3.72	>33 – 49
E	>1.02 – 2.13	>49 – 75
F	≤1.02	varies

Source: HCM, 2000

3. Results and Discussion

The evaluation of pedestrian facilities at the POLISAS campus was conducted using two primary metrics: the Pedestrian Performance Index (P-Index) star rating and the Pedestrian Level of Service (PLOS). These metrics provide a comprehensive assessment of the quality, safety, and functionality of the walkways. The results offer valuable insights into the overall condition and effectiveness of the pedestrian infrastructure on campus.

Firstly, the findings from Table 3, which presents the P-Index for 11 walkways in POLISAS's campus, reveal varying conditions in pedestrian safety and amenities. Walkway B stands out with the highest P-Index of 19.84, indicating superior conditions, whereas Walkways E, G, J, and K have the lowest scores at 14.29, suggesting significant room for improvement. On average, the P-Index across all walkways is 16.18 reflects moderate performance across the campus walkways, all of which received a consistent single-star rating. These findings underscore areas of strength as well as opportunities for enhancing pedestrian infrastructure at POLISAS.

Table 3. Summary of P-Index for 11 Walkways in POLISAS's Campus

No	Road Segment	M	S	F	A	P-INDEX (M + S + F + A)	Star Rating
						4	
1	Walkway A	22.16	27.84	16.67	7.14	18.45	★
2	Walkway B	46.80	3.20	22.22	7.14	19.84	★
3	Walkway C	46.02	3.98	16.67	7.14	18.45	★
4	Walkway D	47.32	2.68	6.67	7.14	15.95	★
5	Walkway E	50.00	0.00	0.00	7.14	14.29	★

6	Walkway F	48.60	1.40	4.76	7.14	15.48	★
7	Walkway G	50.00	0.00	0.00	7.14	14.29	★
8	Walkway H	39.68	10.32	0.00	7.14	14.29	★
9	Walkway I	47.99	1.68	16.67	7.14	18.37	★
10	Walkway J	47.47	2.53	0.00	7.14	14.29	★
11	Walkway K	50.00	0.00	0.00	7.14	14.29	★
	Total Average	45.10	4.87	7.60	7.14	16.18	★

Secondly, the evaluation of pedestrian facilities at POLISAS campus, as presented in Table 4, reveals a diverse performance across 11 walkways with respect to Pedestrian Level of Service (PLOS). High-performing walkways such as C, F, G, I, and J, which earned an LOS A rating, provide ample space and minimal congestion, reflecting superior pedestrian conditions. In contrast, walkways A, B, D, E, H, and K, which received an LOS B rating, face moderate challenges due to higher pedestrian flow rates and limited space, particularly evident in Walkway B with a peak flow rate of 47.61 ped/m/min. The overall average space per pedestrian is 21.00 m²/ped, with a flow rate of 18.71 ped/m/min, indicating a balanced but improvable pedestrian infrastructure. The campus-wide average PLOS of B suggests that while the current service level is adequate, there is significant room for improvements in increasing space allocation and reducing congestion to enhance the pedestrian environment.

Table 4. Summary of PLOS for 11 Walkways in POLISAS's Campus

No	Road Segment	Space (m ² /ped)	Flow Rate (ped/m/min.)	PLOS
1	Walkway A	13.00	39.00	LOS B
2	Walkway B	13.00	47.61	LOS B
3	Walkway C	25.00	5.03	LOS A
4	Walkway D	25.00	18.45	LOS B
5	Walkway E	22.00	16.39	LOS B
6	Walkway F	22.00	7.24	LOS A
7	Walkway G	22.00	14.06	LOS A
8	Walkway H	15.00	19.15	LOS B
9	Walkway I	20.00	12.80	LOS A
10	Walkway J	30.00	8.39	LOS A
11	Walkway K	24.00	17.74	LOS B
	Total Average	21.00	18.71	LOS B

4. Conclusion

Through the comprehensive evaluation of pedestrian facilities at the POLISAS campus using both the Pedestrian Performance Index (P-Index) star ratings and the Pedestrian Level of Service (PLOS), several key findings have emerged that underscore both strengths and areas for improvement in the campus infrastructure. The evaluation of pedestrian facilities at POLISAS campus highlights significant strengths and areas requiring improvement. The campus excels in providing spacious and efficient pathways, as indicated by the majority achieving an LOS B rating in Pedestrian Level of Service (PLOS).

However, the overall P-Index score of 16.18 suggests room for improvement in functionality and maintenance standards across walkways. Safety emerges as a critical concern, with many walkways scoring poorly in this category, necessitating immediate enhancements in lighting, signage, and traffic management. Additionally, while functionality shows some deficiencies in amenities like seating and signage, and accessibility ratings indicate basic provision, there is a clear opportunity to enhance these aspects for a more user-friendly and inclusive pedestrian environment at POLISAS campus.

Key recommendations to improve pedestrian facilities at POLISAS campus include implementing immediate safety upgrades on walkways with low scores to enhance security and reduce risks. Enhancing functionality should prioritize adding necessary amenities like seating, signage, and waste bins to better cater to pedestrians. Additionally, improving accessibility features across all pathways will ensure inclusivity for users with varying needs. It is crucial to prioritize regular maintenance on walkways that scored poorly to maintain and elevate overall quality standards campus-wide. These efforts aim to create a safer, more functional, and inclusive environment for all pedestrians at POLISAS.

Acknowledgment

We extend our heartfelt gratitude to everyone who contributed to this research. We are also grateful to POLISAS for providing the essential resources and facilities that made the completion of this research possible. Special thanks to Danial Fakrul bin Yusoff, Nur Amir Irfan bin Nor Azman, and Mohamad Alif Haikal bin Suhaimi for their invaluable assistance with data collection and analysis. Furthermore, we acknowledge the unwavering support of our families and friends, whose understanding and encouragement sustained us during this research endeavour. Lastly, we are profoundly thankful to all the participants who generously shared their time and insights; their contributions were crucial to the success of this study.

References

- Asadi-Shekari, Z., Moeinaddini, M., & Zaly Shah, M. (2014). A Pedestrian Level of Service Method for Evaluating and Promoting Walking Facilities on Campus Streets. *Land Use Policy*, 38, 175-193.
- Benhadou, M., El Gonnouni, A., & Lyhyaoui, A. (2024). Assessing pedestrian level of service on sidewalks in Tangier City, Morocco. *International Journal of Electrical and Computer Engineering (IJECE)*, Vol. 14(No. 1), 1048-1057. <https://doi.org/10.11591/ijece.v14i1.pp1048-1057>
- Hidayat, N., Haryanto, I., & Isheka, R. P. (2023). Evaluation of pedestrian facilities performance. *In Proceedings of the International Conference on Transportation and Infrastructure (ICTI 2023)*, Jakarta, Indonesia, Jun. 2023, vol. 3, no. 1, pp. 45-50. IOP Publishing. [Online]. Available: <https://doi.org/10.1088/1755-1315/1111/1/012345>
- Johnson, A., Smith, B., & Brown, C. (2021). Evaluation of pedestrian pathway facilities in urban traffic environments. *Transportation Research Part A: Policy and Practice*, 123, 45-58. <https://doi.org/10.1016/j.tra.2021.04.003>
- Knoflachner, H., & Hamedinger, A. (2014). A user-oriented approach to re-think Pedestrian Level of Service (PLOS). *Procedia-Social and Behavioral Sciences*, 162, 250-257. <https://doi.org/10.1016/j.sbspro.2014.12.195>
- Ir. Abdul Rahman bin Baharuddin et al. (2014). Manual on Road Safety Facilities, Road Engineering & Geotechnics Branch, Public Works Department Malaysia.
- Nabila Abdul Ghani, Tetsuo Shimizu, Safizahanin Mokhtar. (2015). Assessment of Pedestrian Facilities in Malacca World Heritage Site, Malaysia using P-Index Method. *Journal of The Eastern Asia Society for Transportation Studies*, Vol. 11.
- Park, H., & Oh, J. (2020). Development of a Comprehensive PLOS Methodology for Urban Planning: Case Study of Seoul. *Urban Planning International*, 35(1), 43-56. <https://doi.org/10.1007/s40333-020-00122-8>
- Sisiopiku, V. P., & Akin, D. (2015). Development of pedestrian level of service (PLOS) parameters for midblock crossings on urban arterials. *Journal of Transportation Engineering*, 141(1), Article A4014003. [https://doi.org/10.1061/\(ASCE\)TE.1943-5436.0000743](https://doi.org/10.1061/(ASCE)TE.1943-5436.0000743)

- Smith, A., Johnson, B., & Brown, C. (2021). Assessing pedestrian infrastructure quality in urban areas using the Pedestrian Index Method (PIM). *Journal of Urban Planning and Development*, 147(3), Article 04021017. DOI: 10.1061/(ASCE)UP.1943-5444.0000736.
- Tarekegn Reta Mesfin, & Tolossa Jote Denbi. (2022). Assessment of pedestrian infrastructures of road transport: A case study of Jimma Town. *Journal of Urban Planning and Development*, 148(2), Article 04022001. [https://doi.org/10.1061/\(ASCE\)UP.1943-5444.0000734](https://doi.org/10.1061/(ASCE)UP.1943-5444.0000734)
- Transportation Research Board. (2000). Highway capacity manual (4th ed.). National Research Council

Cultivating a Culture of Trust: Enhancing Organizational Effectiveness in Malaysian Technical Education

Ying-Leh Ling^{1*}, Cynthia Yu Shung Chen² & Charles Muling Libau³

^{1,3}Mathematics, Science and Computer Department, Polytechnic Kuching Sarawak, Malaysia

²School of Education, Humanities and Social Sciences, Wawasan Open University, Malaysia

Abstract

Effective leadership in teaching and professional learning within educational institutions depends on the foundation of trust followers have in their leaders. Extensive research has emphasized the crucial role of trust, yet its dynamic nature and multifaceted dimensions still require further exploration. Although much attention has historically been given to institutional leadership, the role of middle leaders in fostering workplace experiences remains crucial, especially in enhancing employee engagement with the organization. This quantitative study endeavours to ascertain the levels of trust among teaching staff at Polytechnic Kuching Sarawak, gauge their levels of work engagement, and discern any consequential relationship between trust levels, serving as the independent variable, and workplace engagement, the dependent variable. Employing a simple random sampling technique, 71 lecturers participated in this study. Data was collected using a questionnaire that had been adapted from previous research instruments. The findings of this research underscore a significant correlation between trust in middle leaders and the level of engagement among teaching staff within the polytechnic. The cultivation and preservation of communicative spaces by middle leaders have emerged as pivotal virtues, fostering an environment conducive to the development of trust. These conditions, in turn, serve as catalysts for the realization of interactive and effective teaching and learning processes, aligning with the broader goals of educational excellence.

Keywords: Trust, Middle Leaders, Working Engagement

1. Introduction

In workplaces, how people interact with each other, especially regarding authority and teamwork, has been studied for a long time. When organisations have a hierarchy, middle leaders often have a tough job. They need to use their authority while also encouraging cooperation. Their daily interactions with team members and leaders show how tricky it can be to manage relationships in this setup. To keep things running smoothly, middle leaders often use subtle methods like clear budgeting and making responsive decisions when dealing with staff requests. Even though they have authority, middle leaders work alongside colleagues at different levels, which can both challenge and support their role.

The role of middle leaders is important because they have to balance the needs of both senior and junior colleagues. They try to promote teamwork and influence, but sometimes they face challenges, especially from senior staff. Dealing with disruptive behaviour among colleagues is another challenge for middle leaders as they try to keep harmony in the workplace. If they can't handle tough situations, they might have to pass decisions up to higher-ups to show their authority. So, trust is crucial in managing power dynamics, and top management plays a big role in confirming the importance of middle leaders in the hierarchy. This study aims to see if trust in middle leaders affects how engaged teaching staff are at work, especially technical educators.

2. Literature Review

The responsibility of middle leaders is important and increasingly heavy in carrying out the tasks entrusted by top leaders (De Nobile & Ridden, 2014). They play a role in smoothing administrative processes and procedures to ensure the best resource management and personnel performance not only between middle leaders and their colleagues but also between middle leaders and their superiors, as well as among middle leaders themselves (Branson et al., 2016). This situation is not an exception in learning organisations, even middle leaders are always considered as a link to create a strong sense of relationship. In other words, they help people feel more connected to their organisation and promote a sense of involvement in its functioning.

Past researchers have proven the importance of this relationship as the core of middle leadership to understand the complex relationship situations that middle leaders are challenged with. This means that relationships are important for the reconstruction of this role of middle leaders and the role of middle leaders must be reviewed. In this regard, the establishment and maintenance of a profitable relationship between the two parties does not solely depend on the personal arrangement and judgement of middle leaders. Therefore, relationships must be maintained in a culture of reinforcement and reminder where organisational structures, policies and protocols encourage and support relationships.

Research groups are aware of the importance of work engagement among employees as the main driver in talent management and its adaptability depends on various situational factors in the organisation (Kaliannan & Adjovu, 2015). Farid and Karimi's study (2015) also showed a significant correlation between organisational trust and job satisfaction, as well as commitment. This clearly shows the element of trust in the organisation is important in improving performance and helping managers encourage employee engagement and appreciation. Organisational perceptions are basic beliefs that accurately predict job satisfaction and organisational commitment. A strong relationship between mechanisms and factors is essential for the survival and success of working life. On the other hand, mistrust can harm job satisfaction and employee cooperation.

Osborne and Hammoud (2017) have emphasised the need for a strong relationship between employees and their leaders to create a healthy team environment and subsequently increase job satisfaction and organisational productivity. This is because engaged employees will tend to perform better and have a positive impact on the overall performance of the organisation. In Tabak and Hendy's (2016) study, the element of trust is detected as a phenomenon that can be created, enhanced, or hindered by interpersonal relationships and situational factors. Tabak and Hendy (2016) believe that the formation of trust is closely related to the quality of the relationship between leaders and employees.

That is, relational trust can serve as a personal resource available to all employees, resulting from reliable interpretations of behaviour between leaders and employees in the organisation. This clearly explains the element of trust in leadership that has a direct correlation with several work outcomes, such as job satisfaction, organisational commitment, organisational citizenship behaviour, and performance. In other words, engaged employees tend to have a trusting relationship with their supervisor, which leads to better work engagement.

3. Research Methodology

This study uses a quantitative research approach in which processed data is compiled after carrying out an analytical and orderly explanation of the phenomena that occurred (Basias & Pollalis, 2018). Accordingly, this study was carried out in a cross-sectional manner as the researcher did not manipulate the variables and only recorded information. Typically, this design is a census study in which a population is surveyed at one point in time, to describe the characteristics of that population including age, gender, and geographic location, among other characteristics (Cummings, 2018). Random study sampling was used in this study as explained by Kothari (2020), this sampling method is from a finite population, which gives the same probability for each possible combination of selected samples, and each unit among the entire population can be selected. Once a unit is selected as a sample, it cannot occur again in the sample because sampling is without replacement.

A total of 214 technical lecturers were contacted via email to complete an online survey. This number includes engineering lecturers currently serving in institutions. Therefore, 71 responses were received, with a response rate of approximately 33 percent for data analysis purposes. This figure is considered satisfactory based on Masson's (n.d.) suggestion that an acceptable survey response rate is between 5% and 30%. Anything above 30% is considered excellent. While this figure falls slightly above the recommended average response rate of 44.1 percent for online surveys (Wu, Zhao, & Fils-Aime, 2022), it's crucial to recognize that the mere act of expanding the recipient pool doesn't guarantee a heightened response rate. Instead, the key lies in meticulously delineating and refining the target population for survey distribution.

The instrument used is in the form of a set of questionnaires consisting of three parts. Part A refers to the gender of the respondents. Part B uses the McAllister Trust Scale for measuring the trust towards the middle leaders, as well as Part C, which is UWES for the work engagement, to investigate the correlation between the two variables. For Part B, trust in the leader is measured according to two dimensions, which are effect-based trust (five items) and cognition-based trust (six items) which are measured using a six-point Likert scale where 1-Strongly Disagree and 6-Strongly Agree. Next, the simplified version of UWES-9 has been adapted in this study to measure employee engagement, which contains nine items in total consisting of the dimensions of absorption (three items), dedication (three items), and vigour (three items). Each item is rated on a 6-point Likert-type scale ranging from 0 (never) to 5 (always).

4. Research Findings and Discussion

A total of 71 respondents participated in this study consisting of 32 male respondents (45%) and female respondents (55%). All the respondents consisted of technical lecturers who are currently serving in TVET educational institutions located in Kuching. Next, to determine the level of trust towards middle and working engagement, the researcher has analysed and decided that 1.00-3.42 is the lower level, the mean score of 3.43-4.08 is the below-average level, the mean score of 4.09-4.85 is the above-average level, and so on high for a mean score of 4.86-6.00.

Descriptive Findings on Trust Towards Leaders and Working Engagement

The analysis found that two items have been detected as below-average levels where the respondents have the view that middle leaders will respond constructively and caringly if they share a problem ($M=3.80$, $S.D.=1.390$). In addition, most respondents with 69 percent agreed that they made considerable emotional investments in the relationship between leaders and followers ($M=4.07$, $S.D.=1.324$). The item "We would both feel a sense of loss if one of us was transferred and we could no longer work together" has obtained the highest mean score under the affect-based trust dimension which is 3.80 ($S.D.=1.179$).

As for the cognition-based trust dimension, items CBT3 and CBT4 have each been categorised as an above-average level where respondents agree that they can rely on the person not to make the job more difficult by careless work and they also respect most people as coworkers. The analysis also found that most respondents with a rate as high as 67.6 agreed that middle leaders in the workplace are professional and dedicated ($M=3.93$, $S.D.=1.377$). Overall, both dimensions of affect-based trust and cognition-based trust have obtained mean scores as high as 4.19 and 3.98 respectively. This finding has shown that cognition-based trust has a lower position than affect-based trust.

The findings in Table 2 have shown that the dedication dimension for the working engagement variable obtained a mean score of 4.31 ($S.D.=.894$). The analysis found that respondents who were enthusiastic about their jobs were above average. Accordingly, the analysis also showed that the respondents stated that the work done inspires them with a mean score of 4.42 ($S.D.=1.411$). For the dimension of vigour ($M=4.19$, $S.D.=1.042$), the analysis shows that item VII which is "At my work, I feel bursting with energy" has obtained the highest score of 4.56 ($S.D.=1.251$). Interestingly, almost 65 percent of respondents said they felt ready to work with a mean score of only 3.87. The absorption dimension also obtained a mean score of 3.86 ($S.D.=1.032$) detected as a below-average level. In this regard, the analysis also reported that only 55 percent of respondents feel happy when they are working intensely ($S.D.=1.731$).

Inferential Findings on The Correlation Between Trust toward Leaders and Working Engagement

Pearson's correlation analysis has revealed a notable and constructive correlation between trust in middle leaders and work engagement, yielding a substantial coefficient of .578. This finding resonates with prior research efforts (Fard & Karimi, 2015; Kaliannan & Adjovu, 2015; Osborne & Hammoud, 2017), which have consistently demonstrated the influential link between organisational trust and indicators such as job satisfaction and commitment. This study underscores the enduring significance of organisational trust as a catalyst for performance enhancement. It emphasises the pivotal role of managers in fostering an environment where employees feel valued and engaged. The implications extend beyond mere workplace dynamics; they underscore the critical importance of managerial accuracy and perceptiveness in nurturing employee appreciation and fostering sustained work engagement. As organisations continue to prioritise performance improvement, the cultivation of trust emerges as a foundational element in achieving enduring success.

5. Implication and Conclusion

This study delves into the vital components of organisational dynamics that foster a thriving work environment. It emphasises the importance of affect-based trust, which hinges on emotional bonds and mutual competence among colleagues. Middle leaders play a crucial role in nurturing this trust and promoting collaboration, transcending hierarchical boundaries to enhance colleague engagement and unity. At the heart of the discussion lies the connection between trust among colleagues and employee engagement, crucial for enthusiasm and commitment in work.

Educational institutions are urged to prioritise supportive environments and empower middle leaders to facilitate effective communication and professional growth. There's a push for a transformative leadership approach, advocating for shared power and transparent communication to deepen employee engagement and satisfaction. By prioritising these principles, organisations can cultivate positive work cultures and foster sustained success amid changing landscapes.

Table 1: Mean and Standard Deviation on Trust Toward Leaders (N=71)

Table 1. Mean and Standard Deviation of Trust Toward Leaders (N = 72)									
Num.		Item		Likert Scale				Mean	S.D.
		1	2	3	4	5	6		
Variable: Trust toward leaders									
Dimension: Affect-Based Trusts (ABT)								4.19	.8921
ABT 1	We can both freely share our ideas, feelings, and hopes.	2	4	15	20	19	11	4.17	1.2534
ABT 2	I can talk freely to this individual about difficulties I am having at work and know that (s)he will listen.	4	1	9	26	17	14	4.31	1.2828
ABT 3	We would both feel a sense of loss if one of us was transferred and we could no longer work together.	3	1	5	19	29	14	4.58	1.1791
ABT 4	If I shared my problems with this person, I know (s)he would respond constructively and caringly.	3	12	14	17	17	8	3.80	1.3900
ABT 5	I would have to say that we have both made considerable emotional investments in our working relationship.	2	8	12	21	17	11	4.07	1.3237
Dimension: Cognition-Based Trusts (CBT)								3.98	.8448
CBT1	This person approaches his/ her job with professionalism and dedication.	4	8	11	24	14	10	3.93	1.3766
CBT2	Given this person's track record, I see no reason to doubt his/ her competence and preparation for the job.	4	9	13	18	19	8	3.89	1.3892
CBT3	I can rely on this person not to make my job more difficult by careless work.	2	2	2	20	22	23	4.79	1.1822
CBT4	Most people, even those who aren't close friends of this individual, trust and respect him/her as a coworker.	4	7	7	19	22	12	4.18	1.1822
CBT5	Other work associates of mine who must interact with this individual consider him/her to be trustworthy.	23	17	16	8	6	1	2.44	1.3494
CBT6	If people knew more about this individual and his/her background, they would be more concerned and monitor his/her performance more closely (rev). *	2	1	6	20	22	20	4.68	1.1805
Variable: Employee engagement									
Dimension: Absorption								3.86	1.0323
AB1	I feel happy when I am working intensely.	13	13	6	11	20	8	3.51	1.7310
AB2	I am immersed in my work.	3	4	11	18	15	20	4.38	1.4078
AB3	I get carried away when I'm working.	12	10	6	11	24	8	3.69	1.7037
Dimension: Dedication								4.31	.8940
DE1	I am enthusiastic about my job.	3	2	8	16	20	22	4.61	1.3361
DE2	My job inspires me.	3	6	5	21	16	20	4.42	1.4108
DE3	I am proud of the work that I do.	5	11	8	18	21	8	3.89	1.4595
Dimension: Vigor								4.19	1.0415
VII	At my work, I feel bursting with energy.	2	2	8	21	18	20	4.56	1.2505

VI2	At my job, I feel strong and vigorous.	2	7	15	14	21	12	4.14	1.3554
		2.8	9.9	21.1	19.7	29.6	16.9		
VI3	When I get up in the morning, I feel like going to work.	8	9	8	16	19	11	3.87	1.5940
		11.3	12.7	11.3	22.5	26.8	15.5		

*(rev) reversed scored item

References

- Basias, N., & Pollalis, Y. (2018). Quantitative and qualitative research in business & technology: Justifying a suitable research methodology. *Review of Integrative Business and Economics Research*, 7, 91-105.
- Branson, C. M., Franken, M., & Penney, D. (2016). Middle leadership in higher education: A relational analysis. *Educational Management Administration & Leadership*, 44(1), 128-145. <https://doi.org/10.1177/1741143214558575>
- Cummings, C. L. (2018). Cross-sectional design. *The SAGE Encyclopaedia of Communication Research Methods*. Thousand Oaks: SAGE Publications Inc.
- De Nobile, J., & Ridden, P. (2014). Middle leaders in schools: Who are they and what do they do? *Australian Educational Leader*, 36(2), 22-25.
- Fard, P. G., & Karimi, F. (2015). The relationship between organizational trust and organizational silence with job satisfaction and organizational commitment of the employees of the university. *International Education Studies*, 8(11), 219-227. <http://dx.doi.org/10.5539/ies.v8n11p219>
- Harter, J., & Mann, A. (2017). *The right culture: Not just about employee satisfaction*. The Gallup Organization. Retrieved from Employee Engagement vs. Employee Satisfaction and Organizational Culture (gallup.com)
- Kaliannan, M., & Adjovu, S. N. (2015). Effective employee engagement and organizational success: a case study. *Procedia-Social and Behavioral Sciences*, 172, 161-168. <https://doi.org/10.1016/j.sbspro.2015.01.350>
- Kothari, C. R. (2020). *Research methodology methods and techniques*. Willey Eastern Limited.
- Masson, V. L. (n.d.). Your survey response rate. <https://www.kantar.com/inspiration/>
- McAllister, D. J. (1995). Affect-and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of Management Journal*, 38(1), 24-59. <https://doi.org/10.2307/256727>
- Osborne, S., & Hammoud, M. S. (2017). Effective employee engagement in the workplace. *International Journal of Applied Management and Technology*, 16(1), 4. <https://doi.org/10.5590/IJAMT.2017.16.1.04>
- Schaufeli, W. B., & Bakker, A. B. (2003). UWES – Utrecht Work Engagement Scale: Test Manual. Utrecht, The Netherlands: Department of Psychology, Utrecht University.
- Tabak, F., & Hendy, N. T. (2016). Work engagement: Trust as a mediator of the impact of organizational job embeddedness and perceived organizational support. *Organization Management Journal*, 13(1), 21-31. <http://dx.doi.org/10.1080/15416518.2015.1116968>

The Effectiveness of the GDB Compiler: Online Tool for Student Learning in Programming C++

Noor Afzan Ahmad^{1*}, Anis Awi² & Zuraidah Mohd Ramly³

^{1,2 &3}Department of Information Technology and Communication, Politeknik Mersing, Johor, Malaysia

Abstract

The concept of debugging is one of the hardest things for students to understand when it comes to the subject of computer programming, particularly in the C++ language. Identifying and correcting errors in lines of code is a complex process that consists not only of knowledge of programming concepts but also of expertise in using special software designed to facilitate the search for errors. Among all of these tools, the GDB compiler is one of the most dependable choices that serves programmers to locate problems in C++ code and correct them. Online education continues to evolve and offers a new and engaging option for aspiring programmers. This study aims to identify the effectiveness of the GDB compiler as an online tool for student learning in Programming C++. A total of 136 students from semester 2 in the Department of Information Technology and Communication at Politeknik Mersing Johor, who are taking the Programming Fundamentals course, were chosen as respondents for the study. The performance of the students in using the GDB compiler as an online tool in Programming C++ was utilised as quantitative data and analysed using the Statistical Package for the Social Sciences (SPSS) by t-Test and one-way ANOVA. This study contributes to how the GDB Compiler may aid in the learning of the C++ programming language while also attempting an assessment and evaluation of its effectiveness on the teaching process. In the initial stages of knowledge development in the field of programming, it is extremely important to teach students how to work with debugging tools because the demand for programmers remains high.

Keyword: GDB Compiler, Online Tool, Programming C++, Student Learning

1. Introduction

The rise of digital technology has greatly changed how programming is taught. One important tool in this new landscape is the GDB Compiler (GNU Debugger), an online environment designed to help students learn C++ programming. C++ is a vital programming language that helps students understand object-oriented programming. Knowing C++ also makes it easier to learn other, more complex programming languages. However, learning C++ can be challenging because of its complicated syntax and detailed concepts.

The GDB Compiler addresses this by providing a flexible, online platform for coding (Iryna S. Zinovieva et al., 2021). Because its online, students don't need to install any software. They can access the compiler from any device with the internet, making it easy to practise coding anytime and anywhere. This constant access helps students learn more continuously and flexibly (Victor N. Kasyanov et al., 2020).

Anuarbekov, A. (2023) found that one major benefit of this online tool is its interactive debugging feature. Debugging, or finding and fixing errors in code, is a crucial skill in programming. The GDB Compiler makes debugging easier with a user-friendly interface. Students can set breakpoints, step through their code, and see the values of variables in real-time. This helps them understand how their programs work and improves their problem-solving skills.

The compiler includes functions such as syntax highlighting, auto-completion, and code suggestions. Syntax highlighting uses colours to make code more readable by highlighting different code elements. Auto-complete and code suggestions speed up students' correct code writing by giving hints and automatically completing code. These features reduce mistakes and educate students on the proper usage of C++.

Critical feature of the GDB Compiler is its capability to facilitate collaborative learning. Students can readily share their code with peers and instructors, facilitating peer evaluations and collaborative projects. Collaborating on code with peers helps students acquire new knowledge and hone teamwork and communication abilities, which are crucial in the programming industry. Moreover, the GDB Compiler also connects with online resources and tutorials. Students have direct access to documentation, sample codes, and videos from the compiler. This abundance of information encourages self-directed learning, enabling students to delve into subjects extensively and at their own pace. Educators can distribute materials that align with their teaching plan, enhancing the customization of the learning experience (Iryna S. Zinovieva et al., 2021).

2. Literature Review

This study introduces a programming tool on the web designed to help beginners. Programmers are engaged in the process of understanding programming concepts and creating programs. The tool offers a way to include syntax highlighting, code completion, and error detection, among other features meant to simplify programming for beginners. On the other hand, developers have the option of utilising online debuggers that are commonly found on popular mainstream platforms. Languages and Integrated Development Environments such as GDB that offer functionalities for managing the program.

Castillo, et al. (2022) explained that GDB is a highly popular tool for debugging C++ code. Although it is primarily used for interactive debugging with breakpoints, it offers a wide array of features that make it versatile for various purposes, including Runtime Verification. Some of these advanced features include reverse debugging, trampoline-based trace points, and non-stop debugging for multi-threaded programs. Since all of the GDB is in one window, when you are debugging, you cannot see the source code for your program. To view the source code, type “list” or “l”. GDB will print out the source code for the lines around the current line to be executed.

Furthermore, according to Victor N. Kasyanov et al. (2020), the instrument offers a graphic interface that permits users to create basic programs without needing to manually write code. Rewrite the text using the same programming language and with the same number of words. To assess the usefulness of their tool, the authors carried out user research. The research examined inexperienced programmers who utilised the tool to execute programming tasks. The study found that the tool effectively assisted beginners in learning programming principles and constructing programs.

Program Output

The program output will display information recorded by GDB about the terminal modes your program is using. We can direct our program's output using shell redirection with the run command. Figure 1 shows that GDB lets you execute your program and view its results on the console.

3. Methodology

This study utilised a quantitative method to assess the effectiveness of the GDB Compiler, an online tool for learning C++ programming. The study's results were presented through a questionnaire created after a pilot test. The questionnaire included 23 items, divided into two sections: Section A evaluated the respondents' profiles, and Section B measured the effectiveness of the GDB Compiler across four areas: ease of use (items 1-4), functionality (items 5–10), understanding (items 11–15), and satisfaction (items 16–20).

Respondents indicated their agreement on a 5-point Likert scale from strongly disagree to strongly agree. Data was gathered from 136 students enrolled in the second semester of the Diploma of Information Technology and Communication at Politeknik Mersing Johor who were taking the Programming Fundamentals course. Based on Krejcie and Morgan's (1970) guidelines, a sample size of 136 was suitable for a population of 210.

In this study, the Likert scale is used in Section B. Therefore, this section collects data for the research hypothesis. The data was analysed descriptively to see the mean score and standard deviation of the students, a t-test to see the mean score of the students for gender differences, and a one-way ANOVA test to see the mean score of the effectiveness of the GDB Compiler, an online tool for learning C++ programming among students in Politeknik Mersing, Johor. The mean rating is divided into 3 categories: 3.67–5.0 (high), 2.34–3.66 (medium), and 1.0–2.33 (low).

4. Discussion of Analysis and Findings

Table 1 shows the distribution of respondents by gender. There were 136 respondents in this study, 70 respondents were male and 66 respondents were female.

Table 1: Distribution of Respondents by Gender

Gender	Frequency	Percent (%)
Male	70	51.5
Female	66	48.5
Total	136	100.0

Table 2 shows the distribution of respondents by track. It was found that 47 respondents (34.6%) were software development and analysis track, 48 respondents (35.3%) were network track and 41 respondents (30.1%).

Table 2: Distribution of Respondents by Track

Track	Frequency	Percent (%)
Software Development and Analysis	47	34.6
Network	48	35.3
Information Security	41	30.1
Total	136	100.0

Hypothesis 1(H₁): There is no significant difference between the effectiveness of the GDB Compiler as an online tool for learning C++ programming with male and female students.

Table 3 shows the results of the t-Test analysis, which examines the difference in the effectiveness of the GDB Compiler as an online tool for learning C++ programming between male and female students. There is no significant difference in the effectiveness of the GDB Compiler as an online tool for learning C++ programming ($t = 0.867$; $p > 0.05$) between male students (mean = 4.173) and female students (mean = 4.288).

Table 3: Results of t-Test for Differences in an Effectiveness of the GDB Compiler between Male and Female Students

Gender	Number	Mean	Standard Deviation	t Value	Significance 2 tailed (p)
Male	70	4.173	.919	0.867	0.397
Female	66	4.288	.635	0.720	0.387

Hypothesis 2 (H₂): There is no significant difference between the effectiveness of the GDB Compiler as an online tool from the aspect of ease of use, functionality, understanding and satisfaction with track in Department of Information Technology and Communication for learning C++ programming.

The findings of the study show that there is no significant difference in the overall effectiveness of the three tracks in the Department of Information Technology and Communication. Table 4 presents the results of the one-way ANOVA test for each aspect of effectiveness, namely ease of use, functionality, understanding, and satisfaction with the GDB Compiler as an online tool for learning C++ programming, based on the students' tracks. A more in-depth analysis of the findings indicates that there is no significant difference in terms of ease of use ($p = .265$), functionality ($p = .652$), understanding ($p = .214$), and satisfaction ($p = .234$) regarding the effectiveness of the GDB Compiler as an online tool for learning C++ programming across different tracks in the Department of Information Technology and Communication. This is because the significant value for all four aspects of effectiveness exceeds $p > .05$.

Therefore, it can be concluded that the hypothesis of this study is accepted, which states that there is no significant difference in ease of use, functionality, understanding, and satisfaction with the track in the Department of Information Technology and Communication regarding the effectiveness of the GDB Compiler, an online tool for learning C++ programming. This finding is supported by Chandra (2013), the use of new technology in learning is very important to increase the level of student understanding in the teaching session.

Table 4: Results of One-way ANOVA Test Results of Mean Differences in an Effectiveness of the GDB Compiler as an Online Tool for Learning C++ Programming by Track

		Sum of Squares	df	Mean Squares	F	p-Value
Ease of use	Between Groups	7.383	2	3.692	1.503	0.265
	Within Groups	15.632	135	1.164		
Functionality	Between Groups	6.194	2	0.674	0.861	0.652
	Within Groups	14.952	135	0.774		
Understanding	Between Groups	9.495	2	4.657	1.733	0.214
	Within Groups	13.412	135	4.529		
Satisfaction	Between Groups	2.518	2	0.252	1.634	0.234
	Within Groups	10.335	135	3.272		

5. Conclusion and Future Research

This study has underscored the significant benefits of the GDB compiler as an online tool for enhancing student learning in C++ programming. The findings demonstrate that students who utilized the GDB compiler showed marked improvements in their ability to debug code, identify errors, and comprehend programming concepts. The interactive nature of the tool, allowing students to step through code execution and observe variable values in real-time, proved instrumental in bridging theoretical knowledge with practical application.

Positive feedback from students highlighted its user-friendly interface and effectiveness in reinforcing critical problem-solving skills essential for software development. More, et al. (2011) summarised that the tool offers features like syntax highlighting, code completion, and error detection to simplify the programming process for beginners. Moreover, it includes a graphical user interface that enables users to create basic programs without needing to write any code.

Further research is recommended to explore the broader implications and optimise the use of debugging tools in programming education. Longitudinal studies could assess the sustained impact of GDB and similar tools on students' debugging proficiency over time, providing insights into long-term learning outcomes. Comparative studies with other debugging methods would help elucidate the unique advantages and potential drawbacks of different tools. Additionally, investigating the applicability of such tools across diverse student populations and educational settings could enhance their integration into various learning environments. Lastly, exploring the adaptation of similar tools to teach other programming languages beyond C++ would broaden our understanding of their educational efficacy and versatility. By addressing these research avenues, educators can better leverage tools like the GDB compiler to foster more effective and inclusive programming education, equipping students with essential skills for navigating complex software development challenges.

References

- Anuarbekov, A. (2023). *Interactive online debugger for introductory C++ programming courses* (Master's thesis, School of Engineering and Digital Sciences).
- Annamalai, S., & Salam, S. N. A. (2017). A Multimedia Approach towards Learning C Programming: A Discussion from Novice Learners' Perspective. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, 9(2-12), 99-103.
- Castillo, C. R., Marra, M., Bauwens, J., & Boix, E. G. (2022). *Out-of-things debugging: A live debugging approach for Internet of Things*.
- Chandra, F. H., Nugroho, Y. W., & Surabaya, T. (2016). Peran teknologi video dalam flipped classroom. *Dinamika Teknologi*, 8(1), 15-20.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approach*. Sage publications.
- Galindo, J., & Galindo, P. (2019). Teaching computer programming for industrial engineering without teacher. In *Proceedings of Teaching and Education Conferences (No. 8411220)*. *International Institute of Social and Economic Sciences*.
- Heba Y. Abdel-Rahim. (2021). *The effectiveness of online teaching and learning tools*. *Learning and Teaching*, 14(3), 52 - 69.
- Iryna S. Zinovieva, Volodymyr Artemchuk, Andrii Iatsyshyn, O.O. Popov, Valeriia Kovach, Andrii Iatsyshyn, ... O. V. Radchenko. (2021). *The use of online coding platforms as additional distance tools in programming education*. *Journal of Physics*, 1840(1), 12029-12029.
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30, 607-610.
- More, A., Kumar, J., & Renumol, V. G. (2011). Web based programming assistance tool for novices. In *2011 IEEE International Conference on Technology for Education* (pp. 270-273). IEEE.
- Petrillo, F., Soh, Z., Khomh, F., Pimenta, M., Freitas, C., & Guéhéneuc, Y. G. (2016). Towards understanding interactive debugging. In *2016 IEEE International Conference on Software Quality, Reliability and Security (QRS)* (pp. 152-163). IEEE.
- Victor N. Kasyanov, & Elena V. Kasyanova. (2020). *Methods and tools for teaching programming at university*. *Journal of Physics*.

Maker Market Use: Case Survey in Temerloh Community College

Rozallienny Zainal^{1*} & Paliza Deraman²

¹Temerloh Community College, Pahang, By Pass Batu 2, Jalan Temerloh, 28400, Mentakab, Pahang, Malaysia

² Tanjung Piai Community College, No 45-47, Pusat Perdagangan Pontian, 82000, Pontian Johor, Malaysia

Abstract

The Maker Market, a platform that connects students with real-world problems and innovative solutions, has the potential to revolutionize the way students learn Science, Technology, Engineering, and Mathematics (STEM). However, findings from observation show that the level of Maker Market use by students is significantly lower than expected, with many students failing to engage with the platform or using it only sporadically. This is despite the potential benefits of the Maker Market, including improved collaboration and creativity and a more effective way of connecting with industry professionals. Thus, this study aims to determine the influence of these factors. The descriptive design of the correlational type was used, and the study population consisted of 157 students at Temerloh Community College. A questionnaire was used for the collection of data. The data was analysed with the use of frequency counts, percentages, the mean, and the standard deviation. The objective of the research is to assess the awareness level of students regarding the Maker Market in general and student collaboration to join the Maker Market programme. Based on the findings, it was recommended that the college's lecturers and staff should use every opportunity they have to encourage the students to use Maker Market in order to enhance their STEM skills. These findings suggest that many students are already aware of makerspaces on campus and understand their potential. There may be a need to encourage more students to engage with these spaces in more active ways. The fact that fewer than half of the respondents would take a tour or attend a project showcase suggests that there may be barriers or deterrents to deeper engagement.

Keyword: Maker Market, Use of Maker Market, Maker, Education, Technology.

1. Introduction

Makerspace is a physical place to gather people to work on projects with the knowledge and resources given (Wong & Patridge, 2016). In 2015, makerspace was implemented in higher education for academic purposes (Wong & Patridge, 2016) and as a place for students to enhance their learning experience to develop engineering skills and collaboration between different fields (Bill & Fayard, 2017). An individual's background may be different from another. Makerspace has a setting for solving a problem in diverse fields; a group of people share experiences and techniques to generate ideas and solve problems in creating something new (Vecchione, 2020).

Makerspace is a place to give students access to fabrication tools to enhance learning through a hands-on approach and multidisciplinary collaboration. The majority of Makerspace users use it for academic purposes compared to other purposes (Akhtar & Faizul, 2017). In a makerspace, students can utilize state-of-the-art equipment and technology to experiment, prototype, and refine their ideas, gaining hands-on experience and valuable skills in the real world. Higher education can provide students with the opportunities to implement their studies and practice tasks with professional guidance in makerspace (Andrews et al., 2021).

Higher education institutions can play a crucial role in providing students with opportunities to put their learning into practice in a makerspace. By offering students the chance to work on projects and tasks under the guidance of professionals, higher education can help bridge the gap between theory and application. This practical approach can enhance their understanding of complex concepts, foster creativity and critical thinking, and prepare them for successful careers in their chosen fields (Khalifa & Brahimi, 2017).

Continuous staff training and skills are also important to maintain makerspace operations (Pallaris, Zaphiris, & Parmaxi, 2022). along with the rapid changes in technology and equipment such as 3D printers and small single-board computers that have been used in makerspace. Higher education has created a makerspace to encourage students to start businesses following the enthusiasm for entrepreneurship (Liu, 2022). Due to various reasons, makespace is underutilised and has just become a physical place with machines and tools. Student needs and resources should be considered in improving the management of makerspace.

Research on high school students working in makerspaces has yielded significant findings. A recent study revealed that engaging with makerspaces has a profound impact on students' perceptions, inspiring them to become innovators (Zakoth et al., 2023). By providing an environment that fosters creativity and experimentation, makerspaces have been shown to influence students' views of themselves as problem-solvers and inventors (Soomro et al., 2023). This shift in perception can have far-reaching consequences, potentially leading to a more entrepreneurial and innovative mindset among young people (Farritor & Shane, 2017).

2. Objectives

This study is to investigate the perception of Maker Market among Temerloh Community College students. And it is also the purpose of this study to offer basic research to establish the Maker Market's purpose. In this regard, the research design and implications were derived from the following research questions:

1. Do Temerloh Community College students know about Maker Market in general?
2. Would Temerloh Community College students' attend Maker Market's programme?

3. Methodology

Research Design

This study employed a survey research design, which is open-ended questions to obtain transparent responses from students concerning the research questions. Specifically, it focused on evaluating and analysing students' reactions about Maker Market in *Jom Ke Maker Market* programme that they attended. The data will be analysed using frequency, percentage, mean, and standard deviation. This method is appropriate for the study as it aims to reveal the percentage and frequency of the samples. Additionally, it allows for the formal and systematic collection of data

Makerspace is a community center that provides technology, manufacturing equipment, and educational opportunities to the public, such as 3D printers and computer aided design (CAD) software (Akhtar & Faizul, 2017). Although there are various places that offer space to enhance creativity, innovation, and experiential learning, the function of this space has not yet been widely identified by the public. People like to think they are in space with 3D printers, but that is just one aspect of makerspace. The introduction of makerspace to the public is necessary as a support for educational purposes (Ahn & Noh, 2018).

By making these facilities accessible to a broader audience, including students, teachers, and communities, makerspaces can serve as a valuable resource for learning that can benefit the community as a whole. By incorporating makerspaces into their educational experience, students can gain a more comprehensive understanding of STEAM concepts and develop the skills and confidence they need to pursue careers in these fields (Kenshiro & Oyewole, 2021).

Research Population

All Temerloh Community College students are selected to represent all the programs in Temerloh Community College, which are Certificate of Information Technology, Certificate of Furniture Design, Certificate of Building Maintenance, and Certificate of Fashion and Apparel. The total number of students involved are 157 students. The location of the research is Temerloh Community College.

Research Sample

The samples used in this study are the selected students who attend the Jom ke Maker Market programme. The sampling method used according to all classes, there are a total of 157 respondents participating in this study.

Research Instrument

In this study, the research instrument used is an open-ended questionnaire. Questionnaire contains three sections, Section A: Demographic, Section B: General Knowledge about Maker Market and Section C: Program. The responses are analysed by using Statistical Package for Social Sciences (SPSS) version 16.0. The questionnaire has been verified by the expert reviewer.

4. Result and Discussions

The quantitative data were gained from the close- ended questionnaires (scoring rubric) and they are analysed descriptively by using Statistical Package for Social Sciences (SPSS) version 16.0. The data were analysed in terms of the frequency, percentage, mean and standard deviation. The mean interpretation is as follow:

Table 1: Mean Value Interpretation

Mean value	Mean interpretation
1.00 – 1.80	Very low
1.81 – 2.60	Low
2.61 – 3.40	Average
3.41 – 4.20	High
4.21 – 5.00	Very high

(Jainabee & Jamil, 2009)

The demographic details are shown in Table 2:

Table 2: Section A-Respondent Demographic Distribution

No.	Item(s)	Explanation
1	Gender	Male: 92 students (58.6%) Female: 65 students (41.4%)
2	Program	STM: 51 students (32.5%) SFP: 30 students (42.7%) SPB: 67 students (19.1%) SRP: 9 students (5.7%)

In order to respond to the research questions, the elaboration of the data gained from the respondents are as follow:

Table 3: Section B-General knowledge about Maker Market

No.	Sub criteria/ aspect(s)	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Mean	Std. Dev
1	I know the locations of makerspaces on campus.	0 (0 %)	1 (0.6%)	16 (10.2%)	35 (22.3%)	105 (66.9%)	4.55	0.70
2	I am able to get training to use spaces in a timely manner	7 (4.5%)	8 (5.1%)	36 (22.9%)	52 (33.1%)	54 (34.4%)	3.88	1.08
3	I know the hours makerspaces are open on campus	5 (3.2%)	8 (5.2%)	40 (25.5%)	41 (26.1%)	63 (40.1 %)	3.95	1.07
4	I understand the variety of things I can create in a makerspace	3 (1.9%)	4 (5.6%)	23 (14.6%)	56 (35.7%)	78 (45.2 %)	4.19	0.92
5	I have the skills needed to use a makerspace	5 (3.2%)	19 (35.8%)	32 (20.4%)	48 (30.6%)	53 (33.8%)	3.80	1.13
							4.07	0.98

Table 3 shows the responses towards the respondents' view. The mean value proves that the respondents strongly agree that they know the locations of makerspaces on campus where the percentage value is 105 (66.9%). Also, 78 (45.2 %) students strongly agree that they understand the variety of things I can create in a makerspace. The result is parallel with Deborah Keshinro, Olawale Oyewale (2021) where the study shows that 154 (88.0) and 147 (84%) pointed out that they learn new things by using the makerspace.

Table 4: Section C- Maker Market Programme

1	I can use the makerspace conveniently with its flexible time.	4 (2.5%)	12 (7.6%)	36 (22.9%)	44 (28.0%)	61 (38.9%)	3.93	0.92
2	I would build, make, or create more if makerspaces were more available on campus	1 (0.6%)	7 (4.5%)	33 (21.0%)	54 (34.4%)	62 (39.5%)	4.08	0.92
3	I would run maker events in the space	3 (1.9%)	6 (3.8%)	37 (23.6%)	54 (34.4%)	57 (36.3%)	3.99	0.97
4	I would attend hands-on workshops to learn new skills/machines/technologies	1 (0.6%)	4 (2.5%)	32 (20.4%)	60 (38.2%)	60 (38.2%)	4.11	0.86
5	I would attend seminars or presentations by makers/alums that have started companies	0 (0.0%)	7 (4.5%)	38 (24.2%)	54 (34.4%)	58 (36.9%)	4.04	0.89
11	I would take a tour to makerspace	0 (0.0%)	5 (3.2%)	28 (17.8%)	56 (35.7%)	68 (43.3%)	4.19	0.84
6	I would attend maker fairs	1 (0.6%)	4 (2.5%)	28 (17.8%)	60 (38.2%)	64 (40.8%)	4.16	0.85
7	I would attend makerspace gallery showings of projects	0 (0.0%)	7 (4.5%)	28 (17.8%)	56 (35.7%)	66 (42.0%)	4.15	0.87
							4.06	0.92

Table 4 shows the responses towards the respondents' view. The percentage 68 (43.3%) respondents agree that they would take a tour to makerspace. Also 66 (42.0%) respondents would attend makerspace gallery showings of projects. The result is parallel with In-Ja Ahn, Younghee Noh (2018) where the study shows that about (60 people) for 'state support for finding and training of makerspace programs' was the highest, and 'creating dedicated space for a centralised makerspace within local libraries' was 33.9% (56 people), 13.9% (23 people) for 'classifying and operating part of the existing educational program into a type of makerspaces', and 7.9% (13 people) for 'creating public spaces dedicated to makerspace for public libraries,' respectively.

5.0 Conclusions and Recommendations

The usage of Maker Market by students is critical for cultivating essential skills in problem-solving and critical thinking. These skills can be sharpened with the interactions with colleagues and collaborative opportunities that the Maker Market provides. Access to this facility presents students with a chance to develop skills that are invaluable for their future, particularly in STEAM disciplines, potentially influencing societal change. However, effective engagement with the Maker Market hinges on students perceiving its benefits and possessing a predisposition towards innovation and creation. These factors are pivotal in motivating students to utilise the Maker Market as intended, underscoring the importance of perceived usefulness and a positive attitude towards innovation as predictors of student engagement. Based on the findings and the conclusion, the following recommendations are made:

1. Maker Market should be open after office hours or on weekends to make sure students with busy day time schedules, such as those with classes, can still access the tools and resources provided by the Maker Market.
2. To sustain the perceived usefulness of Maker Market among students, it is essential for lecturers to collaborate with trainers, to engage in regular discussions with students about the benefits of using Maker Market. These discussions should highlight the practical advantages and learning opportunities available through the platform. Additionally, establishing specific times for students to visit the Maker Market can help integrate its use into their schedules effectively. By encouraging consistent engagement and providing clear timeframes, lecturers can ensure that students recognize and utilise Maker Market as a valuable platform for their academic and practical development.
3. Maintaining a positive attitude towards innovation among students can be effectively sustained through proactive encouragement from lecturers. By actively motivating and recognizing students who demonstrate creativity, whether through awards, financial support, or public acknowledgment, lecturers can foster an environment where innovation is appreciated rather than discouraged. This approach not only encourages individual creativity but also cultivates a culture of innovation that benefits the entire community.
4. Maker Market provides access to mentors or staff who can assist with projects. In order to ensure that the tools in the makerspace are used effectively, the Maker Market trainer should provide guidance and training on how the different tools can be used and what they are capable of doing with them. If the students have the knowledge and skills in using the tools, they would use them creatively.
5. To maximise the effectiveness of Maker Market, it is crucial for the makerspace trainer or staff who can provide guidance with projects. These trainers or staff play a pivotal role in guiding students on how to use the various tools available within the makerspace. By offering comprehensive training sessions, the trainer ensures that students understand the capabilities of each tool and how to utilise them effectively. When students possess the necessary knowledge and skills to operate these tools proficiently, they are empowered to explore their creativity and undertake innovative projects with confidence. This approach not only enhances the educational experience within Maker Market but also promotes a culture of hands-on learning and practical application of skills.

Acknowledgment

The authors acknowledge everyone who is involved in this study, especially the Director of Temerloh Community College, Mr Mohd Yusof bin Yaziz, colleagues, and all students who contribute to the data.

References

- Ahn, I. J & Noh, Y. (2018). A Study and Survey of the Perception towards Makespaces of the Public Library. *International Journal of Knowledge Content Development & Technology*. 8(2) 5-22. DOI:10.14429/djlit.37.2.10989
- Akhtar, H & Faizul, N (2017). Awareness and Use of Library Makespaces among Library Professionals in India: A Study. *Journal of Library & Information Technology*. 37(2) 84-90.
- Alex, M & Ommolo, A (2019). Makerspaces for Design. 2nd Annual Architecture and EngineeringAt: University of Nairobi.
- Andrews, M. E., Borego, M., Boklage A. (2021). Self-efficacy abd Belonging: The Impact of a University Makerspace. *International Journal of STEM Education*, 8 (24). <https://doi.org/10.1186/s40594-021-00285-0>
- Bala, H & K. Kiran (2023) *Intrinsic motivation as a determinant of perceived usefulness of library maberspace: the influence of learning dimensions*. Malaysian Journal of Library & Information Science, Vol. 28, no. 1, April, 2023: 15-34.
- Bill, V & Fayard, A. E. (2017). Building and Entrepreneurial and Innovative cultural in a University Makerspace. *ASEE Annual Conference & Exposition*. DOI:10.18260/1-2--27985
- Deborah, K & Olawale, O. (2021). *Predictors of Use of School Library Makerspace by Secondary School Students in Ibadan, Nigeria*. Library Philosophy and Practice (e-journal). 5608.
- Farritor & Shane (2017), University-Based Makespaces: A Source of Innovation. *Technology and Innovation. National Academy of Inventor*. 19(1) 389-395(7). DOI: <https://doi.org/10.21300/19.1.2017.389>
- Khalifa, S & Brahim, T (2017). Makerspace: A Novel Approach to Creative Learning. *Learning and Technology Conference (L&T): The MakerSpace from Imagining to Making*. 43-48. DOI:10.1109/LT.2017.8088125
- Liu, J. (2022). Research on the Construction of Digital Platform of University Maker Space under the Perspective of Big Data. *International Conference on Education, Network and Information Technology*. Liverpool, United Kingdom DOI: 10.1109/ICENIT57306.2022.00023
- Pallaris, G., Zaphiris, P., Parmaxi, A. (2022). Mapping the Landscape of Makespaces in Higher Education: An Inventory of Research Findings. *Interactive Technology and Smart Education*, 21(1) 1-20. <https://www.emerald.com/insight/publication/issn/1741-5659>
- Soomro, S. A., Casakin, H., Nanjappan, V., Georgiev, G. V. (2023). Makerspaces Fostering Creativity: A Systematic Literature Review. *Journal of Science Education and Technology*, 32, 530-548. <https://doi.org/10.1007/s10956-023-10041-4>
- Vecchione, A. (2020) *Makerspace Culture and its Impact on Learning: Makespaces in Practice: Succesful Models for Implementation*. American Library Association, Chicago.
- Wong, A & Partridge, H. (2016). Making as Learning: Makespaces in Universities. *Australian Academic & Research Libraries*, 47 (3), 1-17. DOI:10.1080/00048623.2016.1228163
- Zakoth, D., Mauroner, O & Emes, J (2023). The role of Makespaces in Innovation Processes: An Exploratory Study. *Places and Spaces of Collaborative R&D and Innovation: Physical, Virtual and Cognitive Contexts*. 54(2) 398-428. <https://doi.org/10.1111/radm.12594>

The Usefulness of Steps to Effective Presentation (StEP) for Beginners Module in Improving Student Presentation Skills at Sarikei Community College

Lesta Engkamat^{1*}, Mohammad Zahir Mohd Yazid², Ngu Toh Onn³, & Ying-Leh Ling (Ph. D)⁴

^{1,2,3}Kolej Komuniti Sarikei, Malaysia

⁴Politeknik Kuching Sarawak, Malaysia

*Lesta Anak Engkamat, lesta.engkamat@gmail.com

Abstract

This study aims to identify the usefulness of StEP for Beginners module that was developed to enhance student presentation skills at Sarikei Community College. The analysis study on the need for StEP for Beginners module shows that students are not confident and have weak body language and vocals during presentations. The respondents to this study consist of 43 students from the first semester at Sarikei Community College. Data collection was conducted using a questionnaire instrument and a presentation rubric. The questionnaire consists of four sections, which include usefulness, ease of use, ease of learning, and user satisfaction. The presentation rubric consists of two components, which include body language and voice. The questionnaire analysis indicated that the mean score for the usefulness of this module was at a high level. The researchers also found improvements in student presentation skills based on the data collected using the presentation rubric. The obtained data will be considered for further improvement of StEP for Beginners module.

Keywords: StEP for Beginners Module, Presentation Skills, Usefulness

1. Introduction

The educational approach practiced in community colleges throughout Malaysia is based on Outcome Based Education (OBE). The learning process focused on learning outcomes, including knowledge, skills, and values that students will acquire upon completion of their studies and apply in their careers (Kang, 2021). Effective communication is a key component that graduates need to master in order to perform tasks in their careers, in addition to having skills in their chosen field. According to Shahrir et al. (2016), communication skills are defined as the ability to convey information effectively and efficiently, divided into two attributes: oral communication and written communication.

The sub-attributes of oral communication include clarity of ideas, confidence in ideas, effectiveness and articulation of ideas, understanding and answering questions, and appropriateness of delivery to the audience level. To assess these sub-attributes, proposed assessments include presentation, role play, drama, and demonstration. According to Nabihan and Mohd Effendi (2022), presentations are a commonly used method to assess students' communication skills. Students' ideas can be conveyed to lecturers through presentation slides, even if their presentation skills are weak. Weak presentation skills resulted in students failing to achieve maximum marks. This is because lecturers assess not only cognitive aspects but also affective aspects during the presentation.

2. Problem Statement

According to statistics released by JobStreet in 2018, among the main reasons graduates failed to secure employment were weak communication skills and a lack of convincing personalities and characters (Nur Sheilla & Zuber, 2022). Most graduates, when starting their careers, lack preparation and working skills, especially communication and self-competence skills. This weakness occurs because these skills are not taught in class (Nor Hazwani & Sheerad, 2020). Students find presentation can be a challenging activity, whether it is done inside or outside the classroom (Muthusamy, 2019). Studies conducted at institutions of higher education in Malaysia also found that students face difficulties in presenting, especially in front of an audience (Marcus & Leong, 2015; Abdelmadjid et al., 2017).

The reason students struggled with presentations was due to a lack of tips and presentation practice provided to them. This makes them feel less confident in presenting. According to Mohammad Osman, Amirul, and Mohammad Aminur (2016), without proper presentation skills and guidance, students find it difficult to present, especially first-semester students. Therefore, researchers believe that students need to be exposed to basic presentation skills at the beginning of their studies. According to Nabihan and Mohd Effendi (2022), students feel nervous when facing the audience during a presentation. To overcome nervousness, pressure, and lack of confidence during presentation, training and repetition processes must be carried out to enhance students' confidence and presentation skills. Based on a study conducted at Sarikei Community College (Mohammad Zahir et al., 2022), 75% of student respondents felt unconfident during the presentation.

The study also found that 41.6% of students did not know the criteria for being a good presenter. Based on interviews with lecturer respondents, students did not have good presentation skills. Students read from presentation slides and lack appropriate body language and vocal tone during the presentation. Structured observation findings support the lecturers' perception that students are weak in terms of hand movements, intonation, and voice speed. As a result of the study, researchers have developed StEP for Beginners module to guide students to improve their presentation skills. Therefore, this study aims to analyze the usability of StEP for Beginners module content that has been developed.

3. Research Objectives

The objective of this study is to identify the usability of StEP for Beginners module in improving students' presentation skills among first semester students at Sarikei Community College. The findings of this study will be used to improve contents inside the module.

4. Research Methodology

Research Design

Researchers used the Design and Development Research (DDR) approach to develop StEP for Beginners module for first semester students at Sarikei Community College. DDR is a systematic and comprehensive method for developing models or curricula that begins with needs analysis, design, development, and evaluation of the resulting product (Ridhuan & Rabihah, 2020). Data for the needs analysis phase were collected using questionnaires and interviews with twelve first semester students and six lecturers from Sarikei Community College. The collected data were then analyzed to identify students' weaknesses in presentations based on the perceptions of students and lecturers. For the design and development phase, data collected in the needs analysis stage served as the primary reference to ensure that the developed module could help students to improve their presentation skills.

Therefore, this research study will report data on the usability of the developed module, which constitutes the evaluation phase of this research. Data were collected based on the presentation rubric and questionnaire for StEP for Beginners module.

Study Sample

The respondents consist of 43 first semester students from Sarikei Community College, representing 89.5% of the population. According to Nielsen (1993), for usability assessment techniques using questionnaires, the minimum number of respondents is 30 people.

Research Instrument

The instrument used to test the usability of StEP for Beginners module is an adaptation of the Usefulness, Satisfaction, and Ease of Use (USE) questionnaire (Lund, 2001). This questionnaire consists of four parts: usefulness, ease of use, ease of learning, and satisfaction. The usability questionnaire uses a five-point Likert scale. All usability data findings were analysed using quantitative methods. The administered data were analyzed descriptively using the Statistical Package for Social Sciences (SPSS) for Windows software to determine the minimum values and standard deviations. Descriptive statistics were used in this study because the generated data can be considered as summaries of the entire dataset. Interpretation of the mean scores is based on Mean Statistic Level Interpretation by Landell (1997) as shown in Table 1.

Table 1: Landell's (1997) Mean Statistic Level Interpretation

Mean Score	Interpretation
1.00 – 2.33	Low
2.34 – 3.67	Average
3.68 – 5.00	High

5. Findings

Usefulness Questionnaire

Table 2 shows the mean scores and standard deviations for the usefulness items of StEP for Beginners module.

Table 2: Mean Scores and Standard Deviations for Usefulness Items

Usefulness	Mean	Standard Deviations
StEP for Beginners module is useful in presentations.	4.23	0.812
StEP for Beginners module helps me be more effective in presentations.	4.07	0.910
Presentations become easier after using StEP for Beginners module.	4.05	0.899

Based on data in Table 2, study findings indicate that all usefulness items show high values of mean score. This indicates that StEP for Beginners module has fulfilled its purpose to help respondents improve their presentation skills. Respondents also agreed that this module makes their presentations easier and more effective.

Ease of Use

Table 3 shows the mean scores and standard deviations for the ease of use items of StEP for Beginners module.

Table 3: Mean scores and Standard Deviations for Ease of Use Items

Ease of Use	Mean	Standard Deviations
StEP for Beginners module is easy to use.	4.40	0.695
StEP for Beginners module is user-friendly.	4.19	0.794
StEP for Beginners module provides easy presentation tips.	4.42	0.731
I can use StEP for Beginners module without guidance from lecturers.	3.77	1.02

I enjoy using StEP for Beginners module as a guide in presentations.	4.05	0.899
I can improve weaknesses in presentations using StEP for Beginners module.	4.14	0.861

Based on data in Table 3, usability in terms of ease of use also show high values of mean score. This indicates that the StEP for Beginners module is easy to use. Respondents agreed that the module is user-friendly, and provided tips that were easy to follow, helping them to improve their weaknesses in presentation.

Ease of Learning

Table 4 shows the mean scores and standard deviations for the ease of learning items of StEP for Beginners module.

Table 4: Mean scores and standard deviations for ease of learning items

Ease of learning	Mean	Standard Deviations
The tips from StEP for Beginners module are easy to learn.	4.26	0.978
I can easily remember the tips from StEP for Beginners module.	4.00	0.951
I can learn to use StEP for Beginners module more quickly by attending training workshops.	4.14	0.990
I can become proficient in presentations using StEP for Beginners module.	3.77	0.895

Based on data in Table 4, usability in terms of ease of learning also shows high values of mean score. This indicates that StEP for Beginners module is easy to learn. Respondents can become proficient in presentations because of the tips provided are easy to remember. However, respondents believe they can master this module quickly by attending StEP for Beginners training workshop rather than studying individually.

Satisfaction

Table 5 shows the mean scores and standard deviations for the satisfaction items of StEP for Beginners module.

Table 5: Mean Scores and Standard Deviations for Satisfaction Items

Satisfaction	Mean	Standard Deviations
I am satisfied with the content of StEP for Beginners module.	4.26	0.902
Using StEP for Beginners module is very enjoyable.	4.23	0.895
StEP for Beginners module serves as a guide in presentations as I desired.	3.95	0.872
StEP for Beginners module is a good presentation guide.	4.19	0.824
Using StEP for Beginners module facilitates presentation delivery.	4.12	0.851
I need to get StEP for Beginners module.	3.93	0.768
I will recommend StEP for Beginners module to other friends.	4.35	0.813

Based on data in Table 5, satisfaction level also shows high values of mean score. This indicates that respondents were satisfied with the content of StEP for Beginners module. Respondents agreed that this module is able to guide and facilitate their presentation delivery. Therefore, respondents feel the need to acquire this module and recommend it to others.

Presentation Rubric

Based on the 43 students studied during the StEP for Beginners training workshop, researchers found that the students' presentation scores improved after using the StEP for Beginners module compared to scores before using the module. All students score more than 80 marks during presentation assessment.

6. Discussion

StEP for Beginners module serves as a learning tool aimed at enhancing presentation skills of students at Sarikei Community College, especially those in the first semester. According to Ardhyantama, Ananda, & Sugiyono (2022), learning media are tools that can assist in learning skills necessary for academic success. Mahsuri (2019) also emphasizes that learning media should play a role in conveying messages and information that aid students in their learning process. Therefore, this module provides tips on presentation skills that are often overlooked by students during presentations, such as hand gestures and vocal intonation. To assess the usefulness of this module, a presentation assessment rubric is provided to identify students' strengths and weaknesses in presentations.

The rubric was designed based on role-playing and assignments assessment in the Malaysian Studies course offered at Sarikei Community College. The module is divided into two main parts: body language and vocal, with each main part divided into four smaller sections. This aims to facilitate students to use StEP for Beginners module. Based on West Chester University (2024), a module should be divided into several parts to make learning content easily understood by students. Additionally, the module should include an introduction, objectives, content, and exercises to assess learning outcomes. Furthermore, this module is designed in A5-sized for easy carrying and reference before presentation. StEP for Beginners module is highly flexible, allowing students to learn presentation skills anywhere and anytime without restrictions.

This aligns with Chantarasombat & Rooyuenyong's (2020) assertion that students should have the freedom to receive and learn something, because each individual learning curve is different. The developed module is easy to use and features in this module can help students easily master presentation skills. For example, the use of colours images aids students' understanding of module contents. According to Utami (2020), use of visual media can maximize student learning. Additionally, visual media can focus students' attention, facilitate understanding of learning materials, and illustrate facts and information. Based on presentation rubric scores, the research team agreed that students' presentation skills improved after using StEP for Beginners module, especially in terms of hand movements and vocal intonation. However, based on researchers' perspective, there is still room for improvement as some students need to control their speaking speed, while some rush through their presentations.

7. Conclusion

The study conducted by researchers found that the usefulness of StEP for Beginners module is at a high level. Students find the module easy to use and learn. It helps them improve their presentation skills. Students also agreed that they need the module as a guidance in presentation and recommend it to other students. As a conclusion, the findings of this research enable the application of this module at Sarikei Community College because the module's content can help to enhance the presentation skills of first semester students.

References

- Abdelmadjid Benraghda, Raha Radzuan, & Zuraina Ali. (2017). Impediments to delivering oral presentations in english among malaysian esp undergraduates. *English for Specific Purposes World*, 53.
- Ardhyantama, V., Ananda, R. A., & Sugiyono, S. (2022). Pengembangan media booklet untuk meningkatkan hasil belajar matematika materi segi banyak. *Jurnal Ilmiah Kependidikan*, 9(3), 254–264.

- Chantarasombat, C., & Rooyuenyong, W. (2020). The development of learning module of educational administration and educational institute for students in master of education degree in thailand. *World Journal of Education*, 10(3), 19–32. <https://doi.org/10.5430/wje.v10n3p19>
- Kang, H. C. (2021). Konsep pendidikan berasaskan hasil (outcomebased education). Institut Pendidikan Guru Malaysia. Kementerian Pendidikan Malaysia.
- Landell, K. (1997). Management by menu. Wilay and Sms Inc.
- Lund, A. M. (2001). Measuring usability with the use questionnaire. *Usability Interface*, 8(2), 3-6
- Marcus, K. G. W., & Leong, L.M. (2015). Causes of academic oral presentation difficulties faced by students at a polytechnic in sarawak. *The English Teacher*, 44(3).
- Mohammad Zahir Mohd Yazid, Lesta Engkamat, Ngu, T.O. & Ling, Y.L. (2022). Needs analysis of steps to effective presentation (step) module for beginners in improving the mastery of presentation skills among sarikei community college students. *Malaysia International Convention on Education Research & Management*, 77-85.
- Muthusamy, A. (2019). The importance of presentation skills in institutions of higher learning. Sunway University Press.
- Nabihan Mohd Hamid & Mohd Effendi Ewan Mohd Matore. (2022). Isu dan cadangan terhadap penilaian pembentangan komunikasi dalam kalangan pelajar tvet: suatu pemerhatian awal. *Malaysian Journal of Social Sciences and Humanities*, 7. <https://doi.org/10.47405/mjssh.v7i3.1359>
- Nielsen, J. (1993). Usability Engineering (morgan kau). America Press. <https://doi.org/10.1145/1508044.1508050>
- Nor Hazwani Halim & Sheerad Sahid. (2020). Kemahiran kesediaan kerja, efikasi sendiri, tingkah laku keusahawanan dan eksplorasi kerjaya dalam kalangan graduan (work readiness skills, self-efficacy, entrepreneurial behavior and career exploration among graduates). *Akademika*, 90(S3).
- Nur Sheilla Saida Abdullah & Zuber Abd Majid. (2022). Kebolehpasaran modal insan lepasan institusi pengajian tinggi di malaysia: isu dan strategi. *Malaysian Journal of Social Sciences and Humanities*, 7(8). <https://doi.org/10.47405/mjssh.v7i8.1615>
- Shahrir Abdullah et al. (2016). Rubrik pngk bersepadu (icgpa): panduan pentaksiran hasil pembelajaran. Kementerian Pendidikan Tinggi.
- Utami, Y. S. (2020). Penggunaan media gambar untuk meningkatkan hasil belajar siswa dalam pembelajaran ipa. *Jurnal Pendidikan Dan Konseling*, 2(1), 104-109.
- West Chester University. (2024). *Best Practices for Developing Content Modules and Module Pages*.

The Perception of Mechatronic Engineering Diploma Students at Polytechnic Sultan Azlan Shah Towards the Implementation of Interactive Augmented Reality (AR) Visualization for Autonomous Vehicle Robots

Ninie Farahana Kamarulzaman^{1*}, Nur Raihana Sukri² & Limi Chong³

¹Jabatan Kejuruteraan Mekanikal, Politeknik Sultan Azlan Shah, Behrang, Perak, Malaysia

²Jabatan Kejuruteraan Mekanikal, Politeknik Banting Selangor, Banting, Selangor, Malaysia

³Jabatan Kejuruteraan Mekanikal, Politeknik Kota Kinabalu, Kota Kinabalu, Sabah, Malaysia

*niniefarahana@psas.edu.my

Abstract

Developing attractive learning experiences that are convenient to use and meet the diverse learning needs of polytechnic students is challenging. However, advances in simulation technologies, such as augmented reality (AR) and virtual reality (VR), enable such alterations. This study aims to investigate the perceptions of Mechatronic Engineering Diploma Students at Polytechnic Sultan Azlan Shah towards the implementation of interactive Augmented Reality (AR) visualization for Autonomous Vehicle robots. Therefore, the lecturers at Sultan Azlan Shah Polytechnic have used AR product visualization methods to bring out better learning outcomes through engagement and interactivity. This study used a Likert-scale questionnaire for data collection. Data was collected through an online questionnaire, which was sent to 36 students in the second and fourth semesters of the Mechatronics Engineering Diploma via Google Form in April 2024. All of the participants have completed the questionnaire. Six elements were evaluated: effectiveness, enjoyment, the response of usefulness, satisfaction, individual impact, and continued use. The descriptive analysis found that the continued use element got the highest average value of 4.847, while effectiveness and individual impact got the lowest average of 4.757. This study found that the Diploma in Mechatronic Engineering students at PSAS have a positive perception of the use of augmented technology in their teaching and learning processes. It also provides clear information that students believe this augmented technology will be effective and enjoyable to use, and they would likely suggest to lecturers that they continue using AR in the future. This study contributes to the understanding of the effectiveness of using AR technology in the context of teaching and learning among lectures.

Keywords: Student Perception, Augmented Reality, Descriptive Analysis, Mechatronic

1. Introduction

Augmented Reality (AR) holds significant importance in teaching and learning today due to its ability to enhance traditional educational methods by overlaying digital content onto the real world. By bringing abstract concepts to life, AR applications create a more engaging learning experience compared to traditional methods. AR integrates learning into real-world contexts, enabling students to apply their knowledge in practical situations. By making learning enjoyable and memorable, AR can increase student motivation and retention of information. When students are actively engaged in the learning process, they are more likely to retain what they have learned and apply it in future contexts. This survey was conducted to obtain the views and perceptions of Diploma in Mechatronics Engineering students at Polytechnic Sultan Azlan Shah regarding the implementation of Interactive AR Visualization for Autonomous Vehicle Robots. Knowing the students' perceptions is important for improving the quality of teaching and learning. By understanding students' perceptions, lecturers can plan better strategies, motivate students, increase their engagement, and create a better learning environment.

2. Literature Review

This section reviews previous studies that have been done to provide an in-depth understanding of AR and further the effect of using AR in teaching and learning in improving understanding and creating a better learning environment (Duan et al., 2018).

Augmented Reality

AR is a technology that combines virtual elements with the real world, creating an interactive and immersive experience. Since its introduction, AR has shown significant potential for making the learning process more active, effective, and meaningful. This is because its advanced technology enables users to interact with virtual and real-time applications and brings natural experiences to the user (Farhah et al., 2015). This technology improves what users see, hear, and feel, bringing aspects of the virtual world into the physical world. Computer-generated sensory input, such as sound, video, graphics, or GPS data, enhances all these components. Virtual and augmented reality are also supported in a wide range of industries, including maintenance, teaching, design, and reconnaissance (Arasu et al., 2018). Dargal et al. (2023) mention that the goal of AR is to alter how real-world visuals are perceived by superimposing digital data on top of them. Real-time information can be augmented with the real world.

The goal of AR is to embrace the outdoors and develop a creative and effective paradigm for every application. AR technologies can be broadly categorised into two categories: software algorithms needed to integrate the augmentations with the real world and hardware, which mostly consists of various screens and sensors. Software and hardware were combined to create AR-based prototyping techniques (Nam et al., 2003). AR has altered our lives in previously unbelievable ways. Unity, Vuforia, ARToolKit, Google ARCore, Android Studio, and AR Spark Studio are some of the most popular AR application development tools. Unity is the most popular game engine for producing games and AR apps (Parekh et al., 2020). Zhao Du et al. (2022) explain that AR is a potentially disruptive technology that improves the user experience and revolutionises marketing. Most AR applications are currently supplied via mobile devices, but this will change when hands-free wearables such as head-mounted displays or smart glasses become more popular. Though many people are familiar with simple AR entertainment applications like Snapchat filters and the game Pokémon Go, AR is already being used in far more significant ways in both consumer and business-to-business situations. AR allows individuals to process both physical and digital information at the same time, reducing the need to think about integrating these two. This boosts our capacity to process information quickly and accurately, make judgments, and complete tasks efficiently.

Augmented Reality in Teaching and Learning

AR has been increasingly integrated into teaching and learning environments due to its ability to enhance the educational experience in various ways. The use of AR in education can help students in understanding lessons in various ways. Sameer Mosa (2022) examines the effects of employing QR codes as an AR tool to improve student performance in Saudi education. The findings suggest that students who used QR codes in their education scored better than those who did not, and they did not encounter any technical difficulties in incorporating technology into their learning processes. AR also benefits teachers by allowing them to examine their students' learning processes and find areas for improvement. The goal is to provide students with highly tailored learning information that will allow them to learn more quickly, easily, and effectively. Students may be more engaged in their learning process since AR allows for human and content engagement. They could be given the option to improve the learning content and even become content creators by leaving positive or negative feedback. Furthermore, AR presentation layers may provide improved understanding and access to social knowledge (Kraut et al 2015).

According to Cerqueira et al. (2012), there are various benefits to employing augmented reality techniques for teaching. AR, for example, helps reduce misconceptions caused by students' incapacity to visualise concepts such as chemical bonds by allowing for comprehensive visualisation and object animation. AR also offers the advantage of enabling macro or micro visualisation of objects and concepts that would otherwise be invisible to the human eye. Farhah et. al. (2015) shows that AR technology has the potential for further development in education. This is due to the advantages and benefits of AR features, which can engage students in learning processes and help them enhance their visualisation skills. The features can also assist teachers in effectively explaining and ensuring that pupils understand what they are learning. Joanne et. al. (2019) concludes that using AR videos in class outperforms handouts in terms of learning performance and efficiency, as well as offering a positive learning experience. According to Young et. Al. (2020), AR brings a variety of benefits to online learning, mobile learning, and blended learning, including immersive learning experiences and a more engaging learning environment.

3. Methodology

This study used a survey method that employed quantitative data to analyse the results. It utilised a Likert scale questionnaire as a research instrument. A total of 36 respondents participated in this study. The respondents were students in semester two and semester four of the Diploma in Mechatronics Engineering programme at Politeknik Sultan Azlan Shah. AR visualisation for autonomous vehicle robots interactive learning was integrated into courses such as Industrial Automation.

The questionnaire was divided into two parts. Part A consisted of the respondents' demographic information, while Part B comprised six elements containing 24 questions regarding students' perceptions of the implementation of interactive AR visualisation for autonomous vehicle robots. The six elements that were evaluated were effectiveness, enjoyment, usefulness, satisfaction, individual impact, and continued use. For data collection, a five-point Likert scale was used with the following interpretations:

- 5: Strongly agree
- 4: Agree
- 3: Not sure
- 2: Disagree
- 1: Strongly disagree

In addition, the reliability of the research instrument was measured using the Cronbach's Alpha coefficient value which was analysed using the Statistical Package for Social Science (SPSS) version 27. The interpretation of the Cronbach's Alpha reliability coefficient score is as in Tab.1.

Table 1: Cronbach's Alpha Score Interpretation

Reliability Coefficient	Interpretation of Reliability
0.90 – 1.0	Very good and effective
0.70 – 0.89	Good and acceptable
0.60 – 0.70	Acceptable
< 0.60	Items need to be fixed
< 0.50	Items should be dropped

Source: Yunusa et. al. (2014)

The data analysis involved was a descriptive statistical analysis using The Statistical Package for The Social Science IBM SPSS version 27. The interpretation of the mean score was shown in Tab.2.

Table 2: Mean Score Interpretation

Mean Scale	Level
1.00 – 1.50	Disagree
1.51 – 2.50	Slightly agree
2.51 – 3.50	Moderately agree
3.51 – 4.50	Agree
4.51 – 5.00	Strongly agree

Source: Bringula et. al. (2012)

4. Results and Discussions

Reliability Test

Tab.3 shows the Cronbach's Alpha coefficient values for the questionnaire instrument used. The reliability test of the instrument indicates that the Cronbach's Alpha coefficient, α , for each element in the questionnaire ranges between 0.910 and 0.982, while the α value for the overall items in the questionnaire is 0.990. This indicates that the questionnaire instrument is very good for use in this study.

Table 3: Instrument Reliability Test

Elements in Questionnaire	Cronbach's Alpha, α	Number of Item, N
Effectiveness	0.926	4
Enjoyment	0.959	4
Response of Usefulness	0.973	4
Satisfaction	0.910	3
Individual Impact	0.978	5
Continuous Use	0.982	4
The perception of students towards the implementation of interactive AR visualization for Autonomous Vehicle robots	0.990	24

The Perception of Students Towards the Implementation of Interactive AR Visualisation for Autonomous Vehicle Robots

a. Effectiveness

Based on Tab.4, the overall mean for the effectiveness element is an impressive 4.7569, indicating a high level of effectiveness. This strong evidence demonstrates that interactive AR visualisation is highly effective for learning about autonomous vehicle robots, significantly enhancing understanding and engagement.

Table 4: Mean and Standard Deviation for Effectiveness

Elements in Questionnaire	Mean	Standard Deviation	Interpretation
Using AR can help me get more information about autonomous vehicle robots.	4.72	0.566	Strongly agree
Using AR can help me get information about autonomous vehicle robots faster.	4.83	0.378	Strongly agree
Using AR can increase my interest in autonomous vehicle robots and the course taught.	4.69	0.525	Strongly agree
I think that AR is easy to use.	4.78	0.422	Strongly agree
Effectiveness	4.75	0.433	Strongly agree

b. Enjoyment

For the enjoyment element, Tab.5 shows that the overall mean for the enjoyment element is 4.7986. This compelling data strongly suggests that students find learning about autonomous vehicle robots through AR highly enjoyable.

c. Usefulness

Tab.6 shows an impressive overall mean score of 4.7569 for the usefulness element, indicating a high level of perceived value. This result strongly suggests that students agree that using AR in teaching and learning is extremely useful and beneficial, significantly enhancing their learning performance regarding autonomous vehicle robots.

Table 6: Mean and Standard Deviation for Usefulness

Elements in Questionnaire	Mean	Standard Deviation	Interpretation
Interactive visuals in AR allow me to understand autonomous vehicle robots.	4.71	0.572	Strongly agree
Interactive visuals in AR allow me to create a self-learning process.	4.75	0.500	Strongly agree
Interactive visuals in AR make me achieve learning goals.	4.77	0.490	Strongly agree
Interactive visuals in AR make me more active and enthusiastic in learning.	4.78	0.485	Strongly agree
Usefulness	4.7569	0.49094	Strongly agree

d. Satisfaction

The overall mean score for the satisfaction element is 4.8056, indicating a high level of satisfaction, as shown in Tab.7. This compelling finding suggests that the majority of students are highly satisfied with the use of AR in teaching and learning.

Table 7: Mean and Standard Deviation for Satisfaction

Elements in Questionnaire	Mean	Standard Deviation	Interpretation
Overall, I am satisfied with Interactive AR Visualization for Autonomous Vehicle Robots.	4.83	0.378	Strongly agree
The AR I have used has lived up to my expectations.	4.75	0.554	Strongly agree
I am happy with the experience I got when using AR.	4.83	0.378	Strongly agree
Satisfaction	4.8056	0.40922	Strongly agree

e. Individual Impact

The overall mean score for individual impact is an impressive 4.7778, as shown in Tab.8, indicating a significant level of impact. This compelling discovery strongly suggests that students overwhelmingly agree on the profound impact of using AR in teaching and learning about autonomous vehicle robots.

Table 8: Mean and Standard Deviation for Individual Impact

Elements in Questionnaire	Mean	Standard Deviation	Interpretation
AR can increase my motivation to attend lectures and implement learning.	4.81	0.467	Strongly agree
AR can improve my learning performance.	4.78	0.485	Strongly agree
AR allows me to understand learning material quickly.	4.74	0.505	Strongly agree
I feel my productivity increases when using AR.	4.75	0.500	Strongly agree
AR can help my lecture activities.	4.81	0.401	Strongly agree
Individual Impact	4.7778	0.45300	Strongly agree

f. Continued Use

Tab.9 reveals a mean score of 4.8472 for the continuous usage element, signifying a notably high level. This robust evidence underscores students' consensus that the integration of AR should be sustained, as they distinctly prefer AR over alternative learning methods.

Table 9: Mean and Standard Deviation for Satisfaction

Elements in Questionnaire	Mean	Standard Deviation	Interpretation
I will continue to use AR over offline learning methods.	4.83	0.378	Strongly agree
If given a choice of learning method, then I would choose to use AR.	4.86	0.351	Strongly agree
I would suggest to lecturers to continue using AR.	4.86	0.351	Strongly agree
I will ask the lecturer to use AR for a more enjoyable and effective learning process.	4.83	0.378	Strongly agree
Continuous	4.8472	0.35495	Strongly agree

5. Conclusion

Based on the analysis, this study concludes that the use of AR visualisation in teaching and learning autonomous vehicle robots provides significant benefits to students. The continuous usage element received the highest rating of 4.8472, indicating that students overwhelmingly agree that the use of AR should be continued and that they prefer using AR over other learning methods. These findings are consistent with a study by Joanne et. al. (2019), which concluded that using AR videos in class outperforms handouts in terms of learning performance, efficiency, and overall positive learning experience.

Furthermore, this study also revealed that the effectiveness and usefulness element received the lowest average rating of 4.7569, indicating potential for improvement in the effectiveness and usefulness of AR. This underscores an opportunity to enhance the implementation of AR to further optimise student learning and engagement. These conclusions provide crucial insights for instructors: the use of AR in teaching and learning can significantly enhance students' learning experiences, increase their motivation, and stimulate their interest. It also emphasises the importance of improving the effectiveness and usefulness of AR methods, such as through the provision of relevant AR activities. By actively engaging students and providing them with enjoyable learning experiences, AR visualisation can strengthen their understanding and proficiency in autonomous vehicle robots.

Acknowledgment

This research would not have been possible without the support and cooperation of the faculty and staff at Polytechnic Sultan Azlan Shah. Their assistance and guidance were invaluable in completing this study.

References

- Duan, G., Han, M., Zhao, W., Dong, T., & Xu, T. (2018, May). Augmented reality technology and its game application research. In *2018 3rd International Conference on Automation, Mechanical Control and Computational Engineering (AMCCE 2018)* (pp. 701-705). Atlantis Press.
- Saidin, N. F., Halim, N. D. A., & Yahaya, N. (2015). A review of research on augmented reality in education: Advantages and applications. *International education studies*, 8(13), 1-8.
- Arasu, D., AnisBasharuddin, S., ZulailaZulShukor, N., & Zainon, W. M. N. (2018). A Review on Augmented Reality Technology. *International Journal of Emerging Research in Management and Technology*, 7(22), 10-23956.

- Dargan, S., Bansal, S., Kumar, M., Mittal, A., & Kumar, K. (2023). Augmented reality: A comprehensive review. *Archives of Computational Methods in Engineering*, 30(2), 1057-1080.
- Nam, T. J., & Lee, W. (2003, April). Integrating hardware and software: augmented reality based prototyping method for digital products. In *CHI'03 extended abstracts on Human factors in computing systems* (pp. 956-957).
- Parekh, P., Patel, S., Patel, N., & Shah, M. (2020). Systematic review and meta-analysis of augmented reality in medicine, retail, and games. *Visual computing for industry, biomedicine, and art*, 3, 1-20.
- Du Z, Liu J, Wang T. Augmented Reality Marketing: A Systematic Literature Review and an Agenda for Future Inquiry. *Front Psychol*. 2022 Jun 16; 13:925963. doi: 10.3389/fpsyg.2022.925963. PMID: 35783783; PMCID: PMC9244620.
- AlNajdi, S. M. (2022). The effectiveness of using augmented reality (AR) to enhance student performance: using quick response (QR) codes in student textbooks in the Saudi education system. *Educational technology research and development*, 70(3), 1105-1124.
- Kraut, B., & Jeknić, J. (2015, May). Improving education experience with augmented reality (AR). In *2015 38th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)* (pp. 755-760). IEEE.
- Cerqueira, C., & Kirner, C. (2012, June). Developing educational applications with a non-programming augmented reality authoring tool. In *EdMedia+ Innovate Learning* (pp. 2816-2825). Association for the Advancement of Computing in Education (AACE).
- Yip, J., Wong, S. H., Yick, K. L., Chan, K., & Wong, K. H. (2019). Improving quality of teaching and learning in classes by using augmented reality video. *Computers & Education*, 128, 88-101.
- Young, G. W., Stehle, S., Walsh, B. Y., & Tiri, E. (2020). Exploring virtual reality in the higher education classroom: Using VR to build knowledge and understanding. *Journal of Universal Computer Science*, (8), 904-928.
- Bringula, R. P., Batalla, M. Y. C., Moraga, S. D., Ochengco, L. D. R., Ohagan, K. N., & Lansigan, R. R. (2012). School choice of computing students: A comparative perspective from two universities. *Creative education*, 3(06), 1070.
- Yunusa, F. A. N., Rahimc, M. B., Yasinb, R. M., & Rusd, R. C. (2014). Kesahan dan Kebolehppercayaan Instrumen Pemindahan Pembelajaran berdasarkan Pendekatan Model Rasch: Kajian Rintis. *TVEIS 2014*, 74

An Analysis of Grammatical Errors in Students' Written Assignment: A Thorough Look at Dialogue Writing

Nor Azma Manan^{1*} & Lukman Hakimi Ahmad²

¹General Studies Department, Temerloh Community College, Malaysia.

²General Studies Department, Bera Community College, Malaysia.

*Nor Azma Manan

Abstract

Producing a piece of writing requires certain skills that someone needs to master. Based on the observation, community college students often face challenges in producing written assignments, particularly in dialogue writing, whether in their practice or in graded-continuous assessment. The problems were evident in their grammatical aspects, such as the incorrect use of articles, spelling errors, and wrong or misused words. The objectives of this research were to (1) identify the grammatical errors in students' written assignments; (2) analyse the grammatical errors in terms of frequencies and percentages; and (3) provide possible recommendations to improve the students' performance in writing. This study employed both qualitative and quantitative methods. 90 dialogues were collected based on purposive sampling, which covered various courses: Certificate of Information Technology, Certificate of Fashion and Apparel, Certificate of Furniture Design, and Certificate of Building Maintenance. Data analysis was conducted manually by calculating the frequency and percentage. Findings showed that students need to practice more on English writing, refer to models, and use English in their daily activities. The pedagogical implications of this research were to give insights to curriculum developers, students, and lecturers about the importance of writing appropriately. It was also to guide students about the fundamental grammatical aspects of writing. Future research may focus on the factors that affect students' performance in writing.

Keywords: Writing, Assignment, Grammatical Errors, Pedagogical Implications

1. Introduction

In today's world, English is one of the prominent languages to be mastered by all. Naved (2022) explained the six importance of English: the language used worldwide, the vital language used in education, widely used in physical and electronic sources, travelling, business, and most film productions. This is due to the importance of "everyday communication, academia, business, and entertainment" (Naved, 2022). There are four language skills in English, which are listening, speaking, reading, and writing. These language skills are essential to enhancing the learners' ability to achieve communicative competence (Sadiku, 2015).

Looking at writing as one of the language skills, it is an active, productive skill that requires the learners to express their ideas in words. There are many text types that consist of different structures. For example, recount, narrative, procedure, information report, explanation, and exposition (Hasibuan, 2017). One of the language features that is the main focus of this study is dialogue, which falls under narrative. As stated by Hasibuan (2017), the framework of dialogue comprises orientation, which is the introduction of the characters and the setting; complication, which is the problem faced by the character; and last but not least, resolution, which indicates the end of the dialogues.

Even though writing up a dialogue seems like a simple and easy task, the grammatical elements should not be neglected. Many researchers have conducted studies on identifying and looking at the grammatical errors made by students, either internationally or locally. In an international study by Ibrahim and Ibrahim (2020), for instance, he clarified that the participants made errors in terms of the singular or plural form, verb tense, preposition, subject or verb agreement, article, spelling, verb form, capitalization, wrong or misused words, and also missing words. Fitrawati and Safitri (2021, p. 76) admitted that there are 8 domains of common errors made by the participants, including “verbs, nouns, prepositions, pronouns, adverbs, determiners, adjectives, and conjunctions.” Putri, Rosalia, and Sujoko (2014, p. 380) added that students have trouble with “preposition, agreement, tenses, and article.”

In Malaysia, a study by Singh, Singh, Abd Razak, and Ravinthar (2017) found that students often make errors in subject-verb agreement, tenses, and complex sentence construction. Ghabool, Edwina, Kashaf, and Musa (2012) stated that students have problems with punctuation, while Normazidah Che Musa, Koo, and Hazita Azman (2012) outlined that student have trouble using articles, to-be verbs, and subject-verb agreement.

Based on the observation, the researcher found that the most common grammatical errors made by the students at Temerloh Community College are articles, spelling, wrong or misused words, and others. These are the problems that need to be addressed, and this study needs to focus on these grammatical errors made by the students to help them produce an accurate piece of writing. To relate to the problems among students in writing dialogue, the general objective of this study is to look at the common grammatical errors made by the students in graded-continuous assessment. The objectives of this research are to:

- a) identify the grammatical errors in the students’ written assignment.
- b) analyse the grammatical errors in terms of frequencies and percentages.
- c) provide possible pedagogical recommendations to improve the students’ performance in writing

2. Methodology

Research instrument and data collection

This is a descriptive study of the grammatical errors in students’ written assignments and depicts their pedagogical implications. Gay (2012) explained that the descriptive technique entails gathering information to address queries about the present situation of the respondents involved in the study. In addition, Gall et. al. (2007) proposed that a thorough description of educational occurrences was part of the descriptive approach. In this study, the data was analysed based on frequency and percentage. This method was suitable for this study as it revealed the number of occurrences, which was the percentage and frequency of the samples. It was also used to collect the data formally and systematically.

This research used quantitative and qualitative methods. For the qualitative method, the researcher analysed 90 dialogues written by the students. The dialogue was written by the students as their assignment for Continuous Assessment. Meanwhile, for quantitative data, the researcher used the checklist to identify the number of errors made and the percentage (adapted from Ibrahim & Ibrahim, 2020), as well as the checklist of Quality Interpretation (adopted from Fitriawati & Safitri, 2021) to classify the interpretation of the error’s frequency and percentage.

In conducting the error analysis, this study has employed Gass and Selinker (1994, p. 67) six rules: collecting data, identifying errors, classifying errors, quantifying errors, analysing the source of errors, and remediating the errors. These steps in error analysis were crucial for language instructors to help them improve their teaching and learning and to provide ways to help the students become better writers (Corder & Ellis, 1994).

Research Population

The selected students were based on those who took SUE 10011 (Communicative English) and SUE 20021 (Workplace English), as the samples were taken from their current continuous assessment. These students represented all programs at Temerloh Community College. They were from the Certificate of Information Technology, Certificate of Furniture Design, Certificate of Building Maintenance, and Certificate of Fashion and Apparel. The total number of students involved was 90 students. The location of the research was Temerloh Community College.

Research Sample

The samples used in this study were the students who took SUE 10011 and SUE 20021. There were 61 students who took SUE 10011 and 29 students who took SUE 20021. The sampling method used is purposive sampling, where the samples are chosen purposefully to achieve the objectives of the study. Tongco (2007, p.147) outlined that purposive sampling is a “non-random technique that does not need underlying theories or a set number of informants.” This is due to the fact that the researcher chose a whole number of samples involved in the institution that took English.

For SUE 10011, the classes involved were SPB 2A, SPB 2B, STM 2A, STM 2B, and SFP 1, while for SUE 20021, the classes were SFP 2, STM 3, SRP 2, and SPB 3. They consisted of mixed races (i.e., Malay, Indian, and Chinese) and mixed genders (i.e., male and female). The topic of the dialogue for SUE 10011 was Invitation, while for SUE 20021 the topic was Making Appointment. The students who took SUE 20021 have taken SUE 10011 during the previous semester. All of them have undergone 14 weeks of face-to-face English courses.

Data Analysis Procedure

The researcher calculated the data manually to get a more accurate result. Using software alone is not encouraged, as the software could not detect some parts of it. Two types of checklists were used in this study:

- (a) a checklist was used to identify the grammatical errors made by the students
- (b) the Seven Likert Scale of Quality was used to indicate the interpretation of the percentage.

Table 1: Checklist to identify the grammatical errors

Item	Types of error	No. of errors	Percentage (%)
1	Singular/ Plural form		
2	Verb Tense		
3	Preposition		
4	Subject/ Verb Agreement		
5	Article		
6	Spelling		
7	Verb form		
8	Capitalization		
9	Wrong/ Misused word		
10	Missing word		
11	Others (please specify)		
12	Total		

(Adapted from Ibrahim & Ibrahim, 2020)

Table 2: Quality Interpretation of Error Frequency Percentage

Error Frequency Percentage (%)	Interpretation
0	Exceptional
1-10	Excellent
11-25	Very Good
26-40	Good
41-55	Fair
56-80	Poor
81-100	Very poor

(Adopted from Fitriawati & Safitri, 2021)

Every script for SUE 10011 was labelled with C1-C61, while SUE 20021 was labelled with W1-W29.

3. Results and Discussion

Below are the results of the analysis for SUE 10011 and SUE 20021:

Analysis of SUE 10011

Table 3: Analysis of SUE 10011

Item	Types of error	No. of Errors	Percentage (%)	Percentage After Rounded (%)	Interpretation of Error Frequency Percentage
1	Singular/ Plural form	4	1.8	2	Excellent
2	Verb Tense	20	9	9	Excellent
3	Preposition	10	4.5	5	Excellent
4	Subject/ Verb Agreement	12	5.4	5	Excellent
5	Article	5	2.3	2	Excellent
6	Spelling	38	17.1	17	Very good
7	Verb form	23	10.4	10	Excellent
8	Capitalization	3	1.4	1	Excellent
9	Wrong/ Misused word	67	30.2	30	Good
10	Missing word	19	8.6	9	Excellent
11	Others (please specify)				
	Pronouns	2	0.9	1	Excellent
	Punctuation	10	4.5	5	Excellent
	Code-switching	1	0.5	1	Excellent
	Illogical statement	1	0.5	1	Excellent
	Incomplete information	6	2.7	3	Excellent
	Modal verbs	1	0.5	1	Excellent
12	Total	222			

Table 3 shows that there are a total of 222 errors made by the respondents. The errors that mostly happened in the students' scripts were wrong or misused words that encompassed 30.2% (n=67), followed by spelling errors (17.1%, n= 38) and verb form (10.4%, n=23). Almost one-fourth of the errors (8.6%, n= 19) are missing words, preceded by subject-verb agreement (5.4%, n=12) and punctuation (4.5%, n=10), which is one of the additional errors. The rest of the errors had the least number, which were incomplete information (2.7%, n= 6), articles (2.3%, n=5), singular or plural form (1.8%, n=4), and capitalization (1.4%, n=3). The other additional errors found by the researcher are pronouns (0.9%, n=2), code-switching and illogical statements (0.5%, n=1), and last but not least, modal verbs (0.5%, n=1). Looking at the interpretation of error frequency percentage, the majority of the grammatical errors belong to the excellent category, which included the singular or plural form, verb tense article, preposition, subject or verb agreement, verb form, capitalization, missing words, and other additional categories such as pronouns, punctuation, code switching, illogical statements, incomplete information, and modal verbs. Meanwhile, spelling and wrong or misused words have very good and good interpretations, respectively.

From this result, the researcher found out that most of the grammatical errors made by the students are wrong or misused words (n=67), followed by spelling errors (n=38). This is most likely because of the background of the respondents, who were second language learners, and most of them were unfamiliar with English words. This is in line with Rosa (2018) who mentioned that learners have a higher potential to make errors in their second language as compared to their mother tongue. This is also supported by Singh, Singh, Abd Razak and Ravinthar (2017), who claimed that students who study a second language will most probably commit errors without realising it as they have limited knowledge about the language. SUE 10011 is also their first encounter with English at a higher institution after they passed secondary school. Hence, they need time to adjust themselves and become familiar with the English terms used in writing and the college's assessment system. For wrong or misused words, Lunsford and Lunsford (2008) mentioned that this error was found in 877 papers (n=3080) and was listed as the most common formal error in 2006.

Meanwhile, the least common grammatical errors found in the script are code- switching, illogical statements, and modal verbs. The errors found are as below:

Table 4: Examples of errors

No of script	Types of errors	Examples of sentences
C16	Code switching	<i>Saya masih belajar di Malaysia.</i> Since 8 months ago. [I'm still studying in Malaysia]
C24	Illogical statement	I'd like to invite you to my birthday party, <i>30 Feb</i> 3 p.m. [30 February at 3 p.m.]
C24	Modal verbs	There is a reason why I call you today, I <i>will</i> like to invite you to my birthday party... [would]

Overall, there is not much variation in terms of the interpretation, most probably because of the number of scripts collected as well as the length of the essay (dialogue) itself. The researcher feels that the errors made are tolerable at the level of the students, where most of them are at the beginner and intermediate levels, specifically A1 and A2 (CEFR level).

Analysis for SUE 20021

Table 5: Analysis of SUE 20021

Item	Types of error	No. of errors	Percentage (%)	Percentage after rounded (%)	Interpretation of error frequency percentage
1	Singular/ Plural form	16	11.6	12	Very good
2	Verb Tense	2	1.4	1	Excellent
3	Preposition	14	10.1	10	Excellent
4	Subject/ Verb Agreement	8	5.8	6	Excellent
5	Article	14	10.1	10	Excellent
6	Spelling	41	29.7	30	Good
7	Verb form	0	0	0	Exceptional
8	Capitalization	1	0.7	1	Excellent
9	Wrong/ Misused word	9	6.5	7	Excellent
10	Missing word	16	11.6	12	Very good
11	Others (please specify)				
	Pronouns	1	0.7	1	Excellent
	Punctuation	9	6.5	7	Excellent
	Sentence out of context	6	4.3	4	Excellent
	Spacing	1	0.7	1	
12	Total	138			

Table 4 shows a total of 138 errors made by the respondents. The researcher found out that the most common error that occurred in the script analysed was spelling (29.7%, n=41). This is followed by singular or plural form and missing words that cover 11.6% respectively (n= 16). Prepositions and articles take the third place, which is 10.1% (n=14). The rest of the grammatical errors which are wrong or misused words and punctuation have a percentage of 6.5% (n=9), whereas subject or verb agreement is 5.8% (n=8), and sentence out of context is 4.3% (n=6). The fewest grammatical errors in the scripts are verb tense (1.4%, n=2), while capitalization, pronouns, and spacing are 0.7% (n=1).

The analysis shows ten grammatical errors with excellent interpretation; verb tense, preposition, subject or verb agreement, article, capitalization, wrong or misused word, pronouns, punctuation, sentence out of context and spacing. Meanwhile, singular or plural forms and missing words have very good interpretations. Last but not least, spelling has a good interpretation. From the result, it can be seen that spelling is the most common grammatical error found in the respondents' script. The examples of spelling errors are *bagle* [bangle], *corrent* [current], *apointment* [appointment] and *wenesday* [Wednesday]. This result is similar to Ibrahim and Ibrahim (2020), which is 26% (n=40/153). Brooks (1964:168) as cited in Wati & Nursyaebah (2017) stated that "spelling is of relatively minor importance as far as reading is concerned; it becomes a major factor in the productive skill of writing". This statement shows the importance of spelling to ensure that readers understand the message or the idea conveyed, particularly in dialogue writing.

On the other hand, missing words and singular or plural forms have the same percentage. The examples of errors found are as below:

Table 6: Examples of errors

No of Script	Types of Errors	Examples of Sentence
W1	Missing word	<i>Wow, affordable price!</i> [Wow, what an affordable price!]
W5	Missing word	<i>Don't forget your appointment</i> [Don't forget about your appointment]
W9	Missing word	<i>Thank you for making appointment</i> [Thank you for making up the appointment]
W22	Singular/ Plural form	<i>Hello, this Habib Goldsmith Shop, may I help you</i> [Hello, this is Habib Goldsmith Shop, may I help you?]
W3	Singular/ Plural form	<i>Hello, good morning. I'm Yashina, one of the staff at Habib Goldsmith.</i> [Hello, good morning. I'm Yashina, one of the staffs at Habib Goldsmith]

The fewest errors found in the analysis are capitalization, pronouns, and spacing. The examples of errors are as below:

Table 7: Examples of errors

No of script	Types of errors	Examples of sentence
W13	Capitalization	<i>Hi, this is Mary and harith.</i> [Harith]
W29	Pronouns	<i>Mrs. need to register...</i> [You]
W10	Spacing	<i>Welcome, but donot miss the date and time.</i> [do not]

These are the minor errors found during the analysis. The errors made in terms of capitalization, pronouns and spacing do not change the meaning of the sentence and it is still understandable even though the errors are made. These errors might possibly happen because of ignorance and direct translation from their mother tongue (i.e., errors in pronouns) or perhaps they are working fast until they do not realise the errors that they have made (i.e., errors in capitalization and spacing).

4. Conclusion, Implications and Direction for Future Research

Chin (2000) outlined a few suggestions to improve students' writing skills, particularly in grammar:

- a. Encourage the concept of peer editing, where the students need to exchange their scripts with their friends. The teacher will facilitate throughout the process so that they will know the areas to improve
- b. Teach grammar in context, not in isolation
- c. The teacher should give feedback after marking and ask students to make corrections
- d. Implement grammar-like activities such as writing conferences, quizzes, grammar lessons, reading and rewriting model essays, and peer response groups

The analysis of errors plays a crucial role in identifying the grammatical issues that students find challenging and informing the teacher about the areas they should concentrate on. Plus, it also informs the instructor to vary the teaching methods and gives more extensive exercises on grammar to the students. This is due to the function of the grammar itself in the sentence, which smooths the reading and adds to the pleasure of reading a piece of text. The main limitation of this study is that it only focused on the data gained from Temerloh Community College and cannot be generalised to other populations. Future research may focus on the factors that affect students' performance in writing.

Acknowledgment

The authors acknowledge everyone who is involved in this study, especially the Director of Temerloh Community College, Mr. Mohd Yusof bin Yaziz, colleagues, and all participants who contribute to the data.

References

- Corder, S.P., and Ellis, Rod. (1994). Second Language Acquisition: Learners' Errors and Error Correction in Language Teaching. <http://www.proz.com/translationarticles/articles/633/>.
- Chin, B. A. (2000). *The role of grammar in improving students' writing*. Sadlier: Oxford.
- Fitrawati & Safitri, D. (2021). Students' Grammatical Errors in Essay Writing: A Pedagogical Grammar Reflection. *International Journal of Language Education*, 5(2), 74-88.
- Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Educational Research: An Introduction*. NY: Pearson, Allyn & Bacon.
- Gass, S. M., & Selinker, L. (1994). Second language acquisition: An introductory course. NY: Lawrence Erlbaum Associates, Inc.
- Gay, L. R., Mills, G., & Airasian, P. W. (2012). *Educational Research: Competencies for Analysis and Applications*. United States: Pearson Education.
- Ghabool, N., Edwina, M., & Kashef, H. S. (2012). Investigating Malaysian ESL students' writing problems on conventions, punctuation, and language use at secondary level. *Journal of Studies in Education*, 2(3), 131-143. <https://doi.org/10.5296/jse.v2i3.1892>
- Hasibuan, K. (2017). Teaching Writing as Productive Skills. <https://media.neliti.com/media/publications/244085-teaching-writing-as-productive-skills-8b60050c.pdf>
- Ibrahim, M.M.M. & Ibrahim, A.I. (2020). An Analysis of Grammatical Errors in Academic Writing of EFL Students. *Asian Journal of Social Science and Management Technology*, 2(6), 81-90.
- Lunsford, A. A., & Lunsford K.J. (2008). Mistakes are a Fact of Life: A National Comparative Study. *College Composition and Communication*, 59(4), 781-806.
- Naved, Z. (April 21, 2022). *6 Reasons Why Knowing English Is Important in Today's World*, Owlcation, The Arena Media Brands, LLC.
- Normazidah Che Musa, Lie K.Y., & Hazita Azman. (2012). Exploring English Language Learning and Teaching in Malaysia. *GEMA Online Journal of Language Studies*, 12(1), 35-51.

- Sadiku, L.M. (2015). The Importance of Four Skills Reading, Speaking, Writing, Listening in a Lesson Hour. *European Journal of Language and Literature Studies*, 1(1), 29-31.
- Singh, C.K.S., Singh, A.K.J., Abd Razak, N. Q., & Ravinthar, T. (2017). Grammar Errors Made by ESL Tertiary Students in Writing. *English Language Teaching*, 10(5), 16-27.
- Putri C., Rosalia S., Sujoko S. (2014). An Error Analysis on Dialogue Script Written by the Second Grade Students of SMPN 8 Surakarta. *Jurnal Pendidikan Bahasa Inggris Universitas Sebelas Maret*, 2(3), 380-387
- Rosa, E. (2018). Grammatical Errors Analysis in Students' Writing of Narrative Text at the Second Grade Students of SMA Muhammadiyah Rambah. [Unpublished Master's Thesis]. Islamic University of Riau.
- Tongco, M.D.C. (2007). Purposive Sampling as a Tool for Informant Selection. *Ethnobotany Research and Applications*, 5, 147-158.
- Wati, A., & Nursyaebah. (2017). No Title. *An Analysis of Grammatical Errors in Student' Writing Recount Text*, 102. Jawa Timur: English Education Department

The Development of Switchless for Multi-Level User

Mohd Saifuddin Ahmad^{1*}, Muhammad Ahmad Kamal² & Maheran Sulaiman¹

¹Mechanical Engineering Department, Politeknik Nilai, Malaysia.

²Mechanical Engineering Department, Politeknik Port Dickson, Malaysia.

* Mohd Saifuddin Ahmad

Abstract

This research focuses on the development and use of IoT module sets. The switchless kit innovation is based on the Internet Controlled Switch via smartphone. A rocker switch is commonly used to light an electric bulb. In demand of new technology, IoT (Internet of things) is a developing technique that is more useful to control or monitor appliances via the internet. Nowadays, many smart home and office appliances are connected to smart switch boxes that enable users to control their appliances anytime and anywhere. The switchless kit innovation is developed to switch on the light through a smartphone interface. The lamp is connected to the WiFi network using an ESP32 microcontroller. Arduino 1.8.19 is implemented in ESP32, and it can be accessed through mobile applications. An electric light controller is designed using a Remote XY based on the ESP32 microcontroller. This system only applies if the condition of the AC voltage originating from the local power supply is ON. The control system is managed using the RemoteXY interface, and the C programming language is used for coding and execution. This tool works on a WiFi connection. This innovation was found to be very efficient, practical, and cost-saving for electricity. This switchless light control system can make it easier for users to cut electricity usage. The IoT module set is being used for training sessions and was found to be very user-friendly for secondary school students, higher education, and trainer training. The IoT technology is being empowered amongst students, and lecturers are aligning with the IR 4.0 revolution by attending training that enables students to apply this technology in their final year projects.

Keyword: IoT, switchless, NodeMCU ESP32

1. Introduction

The digital development in Malaysia today shows various positive outputs in line with the rapid global digital advancement. Various efforts have been implemented to upgrade the Internet system in the country, including wired connections, wireless connections, and broadband technology. This upgrading is important not only to support key sectors but also to encourage the country's potential to open up more avenues for various new developments supported by Internet technology among Malaysian society in general. One positive development we can observe is the growth of IoT technology, which is gaining attention from various sectors. It also stimulates Malaysia to devise various efforts and strategies to enhance the feasibility of IoT in the country (Maryadi, 2021).

Meanwhile, the National TVET Policy 2030 has outlined clear objectives to achieve Malaysia's goal of becoming a developed country driven by a skilled workforce through responsive, flexible, and inclusive TVET programs. Accordingly, the need to apply the latest technology is very important, especially for polytechnic graduates. The Internet of Things (IoT) technology is one area of expertise that needs to be mastered by polytechnic institutions, particularly in the field of engineering, and it has even crossed into areas like modern agricultural development or smart farming.

Therefore, existing modules and skills need to be continuously improved to achieve the targets set under the Polytechnic Transformation 2023–2030, where Polytechnics in Malaysia aim to become centers for reskilling, upskilling, and advanced education, offering the latest TVET education that meets job market needs.

The creation of up-to-date modules will meet the current needs of the programs offered. Through the latest IoT learning modules and the innovations produced, it will add value and provide basic knowledge and skills to students, particularly in the field of engineering. The development of the Switchless Kit module and innovations in the teaching and learning process are key elements to ensuring that every student has a basic idea of creating a final product. This is very useful and important to ensure that the Student Final Project can produce products in line with the developments of Industrial Revolution 4.0 (IR4.0) (Somantri, 2019).

2. Problem Statement

The lack of skills and knowledge in Internet of Things (IoT) technology among students and educators poses a significant barrier to preparing the younger generation for the Fourth Industrial Revolution. Despite awareness of IoT's importance across various sectors, educational institutions face several challenges in the following aspects:

Outdated Curriculum: Many educational institutions have not updated their curricula to include the latest developments in IoT technology (Basuki, 2020). A curriculum that does not align with current technological advancements results in students not acquiring the up-to-date knowledge and skills needed in the job market. Without regular updates, students will lack exposure to new technologies and practical applications.

Lack of Equipment and Infrastructure: Insufficient laboratory equipment, IoT devices, and necessary infrastructure for teaching and learning IoT prevent students from receiving adequate practical training. This hinders their understanding of real-world IoT applications. Institutions may also lack the funds to purchase advanced equipment necessary for teaching the latest IoT topics.

Training and Professional Development for Educators: Many educators lack the necessary knowledge and skills in IoT technology due to a lack of training and professional development programs. This makes it difficult for them to teach IoT topics effectively. Without continuous training, educators cannot keep up with the rapid advancements in IoT technology and apply them in their teaching.

Funding and Support: Insufficient funding and support from the government and industry also hinder the introduction and expansion of IoT education. Inadequate investment in this sector hampers curriculum development, infrastructure, and necessary training. Educational institutions may face financial constraints that prevent them from providing quality IoT education.

Awareness and Interest: Despite growing recognition of IoT's importance, there is still a lack of awareness and interest among students and parents regarding career potential in this field. Without sufficient awareness and interest, efforts to integrate IoT into education will be limited. Educational institutions need to work harder to promote the benefits and career opportunities in IoT. Addressing these issues requires a comprehensive approach, including updating curricula, providing adequate equipment and infrastructure, ongoing training for educators, and sufficient funding and support from the government and industry. With a coordinated effort, IoT education can be enhanced to equip students with the skills needed to succeed in the Fourth Industrial Revolution (IR4.0) (Ardanza, 2019).

Objective

Therefore, the objective of this study is to:

- Designing IoT learning kits: Switchless Kit.
- Producing IoT learning kits: Switchless Kit.
- Developing phased learning modules for the kit.

3. Methodology

Product Design



Figure 3.1: Product Design

<p>PCB Buzzer</p> <p>Pin header for Buzzer connection.</p>	<p>LED circuit (red, green, yellow)</p> <p>Pin header for connection.</p>
<p>240V Lamp</p> <p>Switch for 240v lamp.</p>	<p>5V 2A Power Supply Unit</p>
<p>Circuit Breaker</p>	<p>3-Pin Plug and Connector</p>

Figure 3.2: Hardware Module1

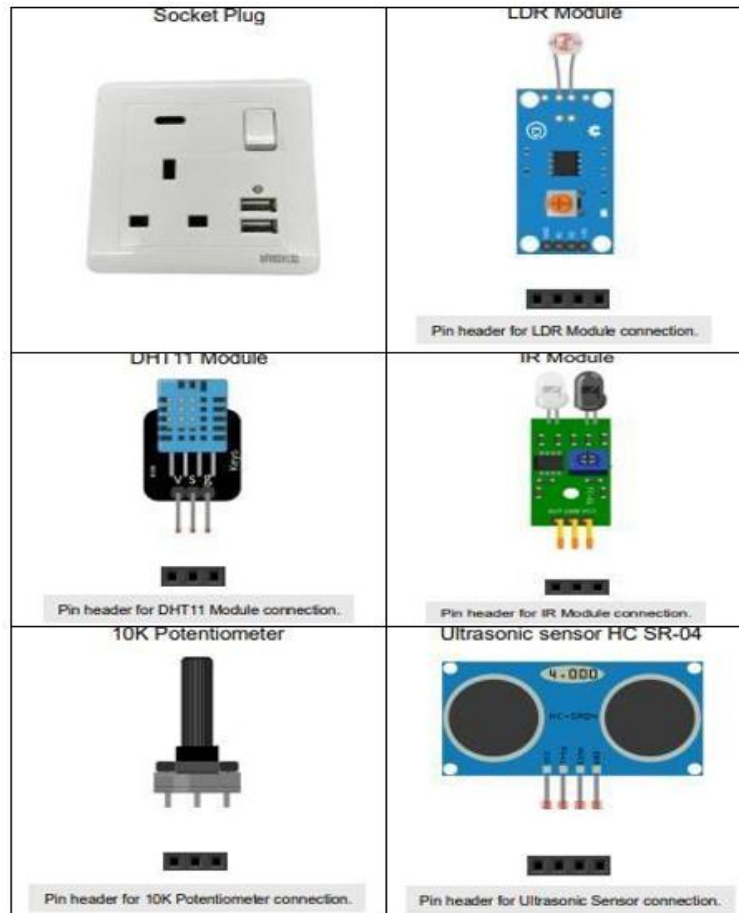


Figure 3.3: Hardware Module 2

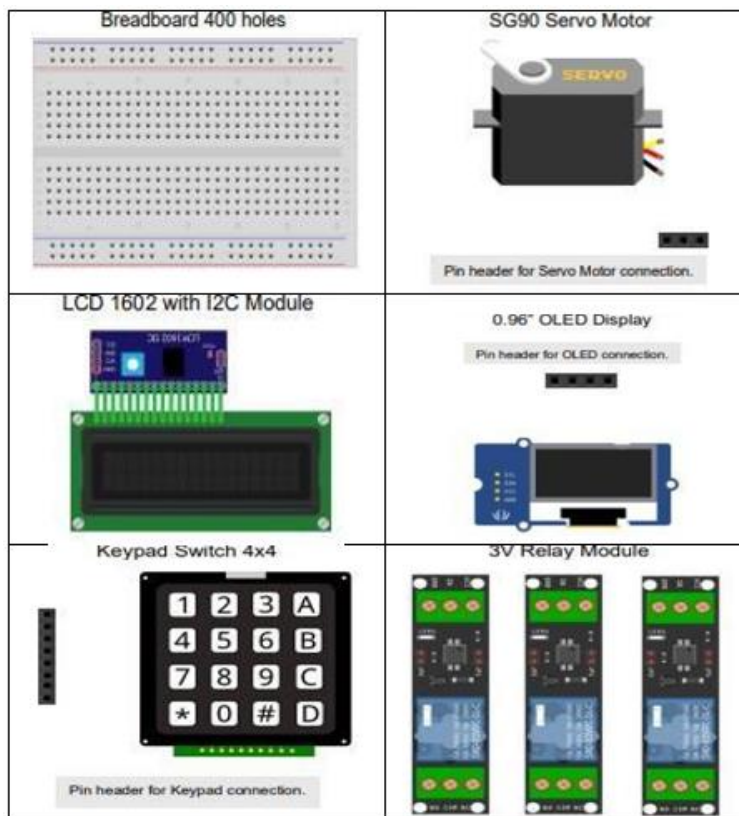


Figure 3.4: Hardware Module3

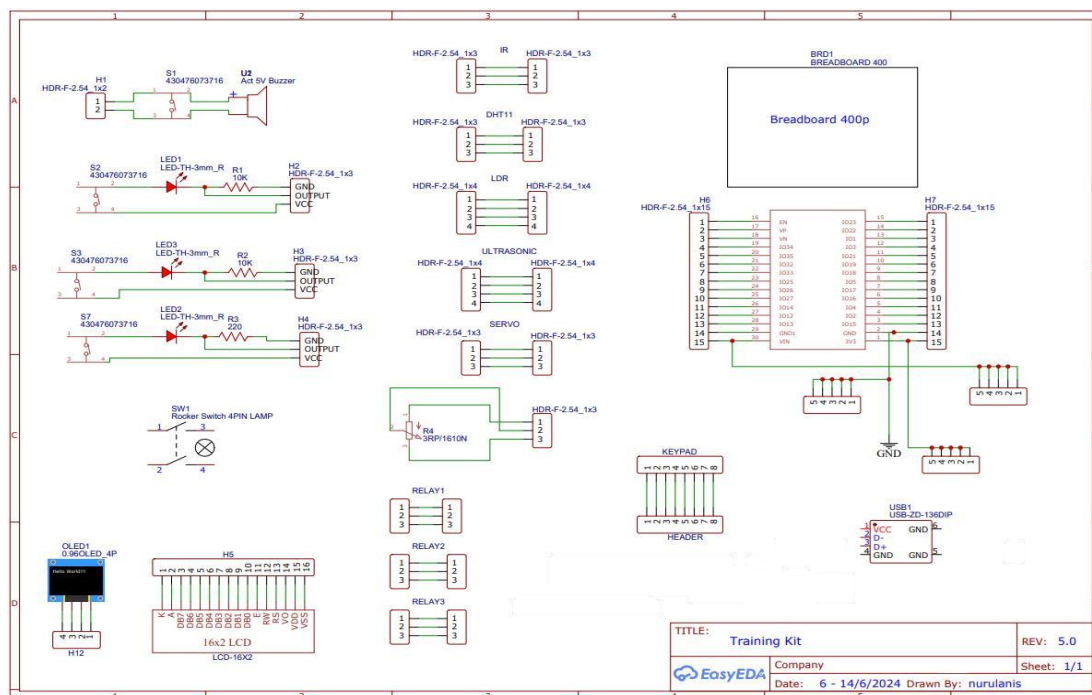


Figure 3.5: Schematic Diagram

Target users

The training kit is frequently used in the teaching and learning process, particularly in vocational education to meet learning goals. Vocational education is designed to meet the demands of the job market and plays a positive role in generating goods and commodities with economic value in the productive work sector. There are several target users for this training kit:

- i. Student (Final year student, school)
- ii. Lecturer
- iii. Industry

Development of Modules

Example Tutorial: 3V Relay Module In this tutorial, we will learn how to interface a 3V relay module with an ESP32 to control higher voltage devices like lamps, fans, or other appliances. Relays allow a low voltage control signal to switch a higher voltage circuit on and off, making them useful for home automation projects.

Step 1: Circuit Connection

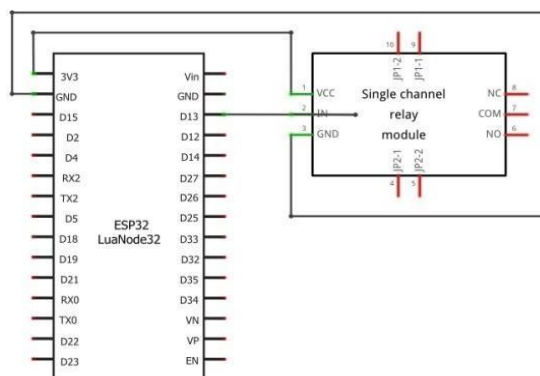


Figure 3.6: Circuit Connection

Step 2: Hardware Connection

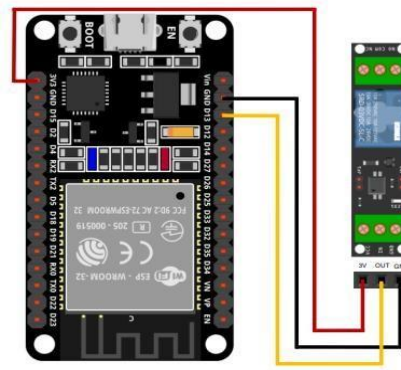


Figure 3.7: Circuit Connection

Step 3: Upload Coding

```
File Edit Sketch Tools Help
sketch_jul03b $
int relayPin = 13;

void setup() {
  pinMode(relayPin, OUTPUT);
}

void loop() {
  digitalWrite(relayPin, HIGH);
  delay(1000);
  digitalWrite(relayPin, LOW);
  delay(1000);
}
```

Figure 3.8: Upload Coding

Result: The LED built into the relay will be blinking every 1 second = 1000ms

4. Analysis of Effectiveness

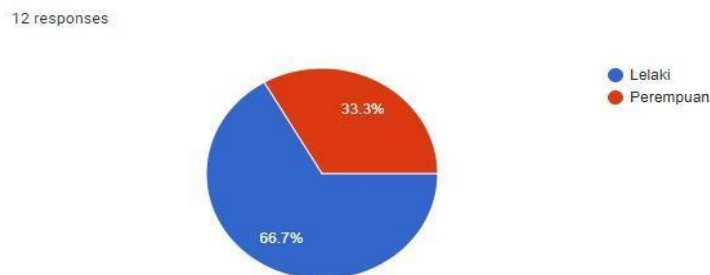


Figure 4.0: Background of Respondent (Gender)

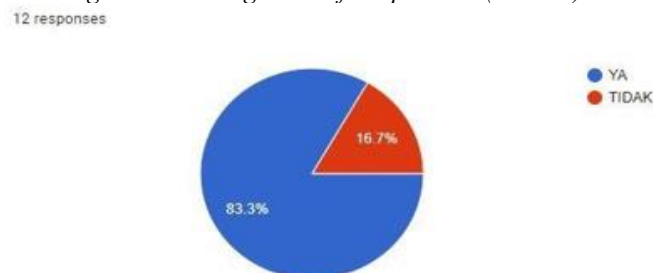


Figure 4.1: Background of Respondent (Internet Access)

12 responses

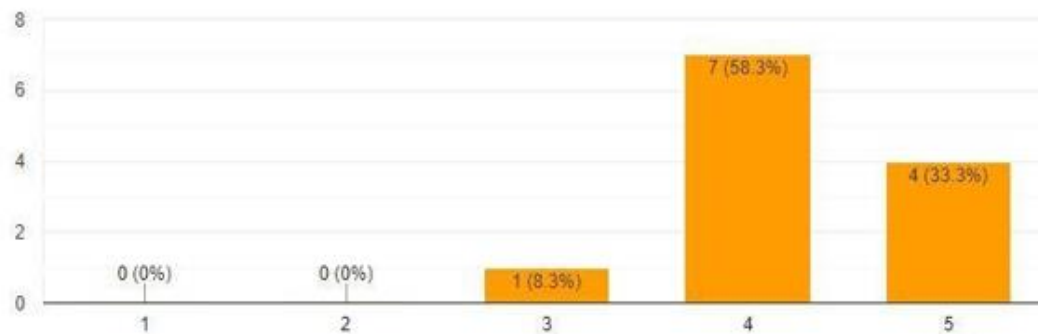


Figure 4.2: Background of Respondent (This innovative IoT kit is easy to use)

12 responses

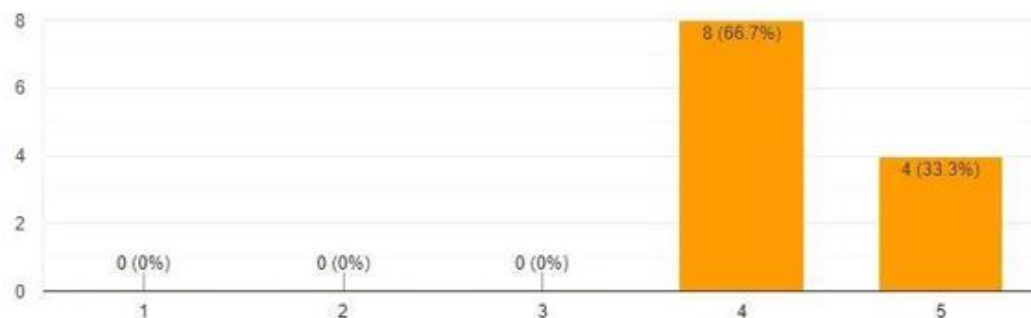


Figure 4.3: Background of Respondent (The presentation of the IoT interface of this kit is very interesting)

12 responses

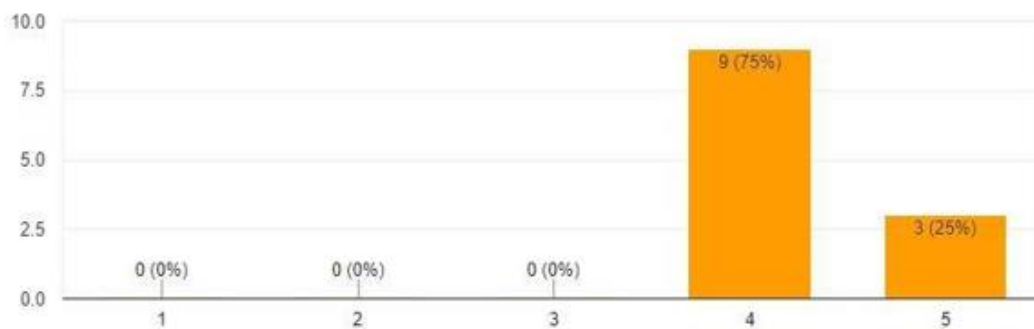


Figure 4.4: Background of Respondent (User Friendly)

12 responses

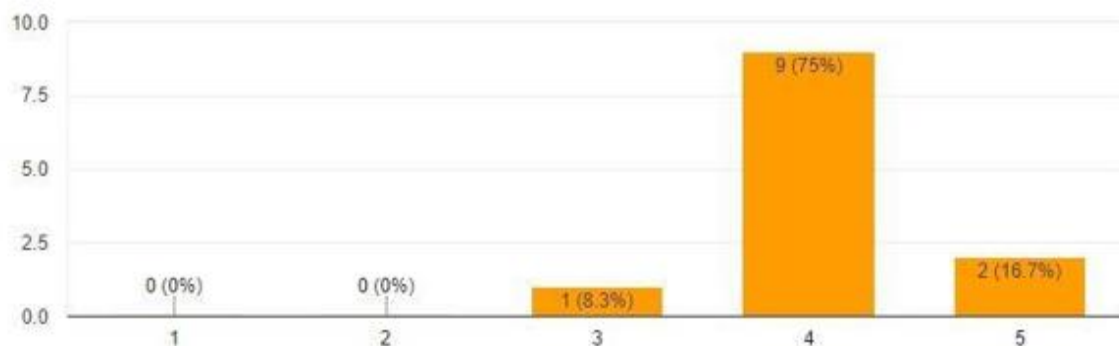


Figure 4.5: Background of Respondent (I can easily understand the concept and working steps of IoT-based innovation production)

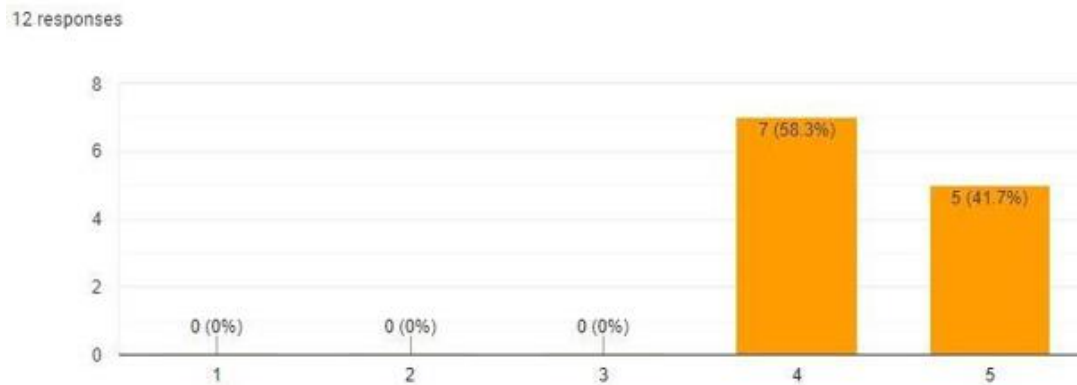


Figure 4.6: Background of Respondent (I am very excited and enjoy learning IoT technology)

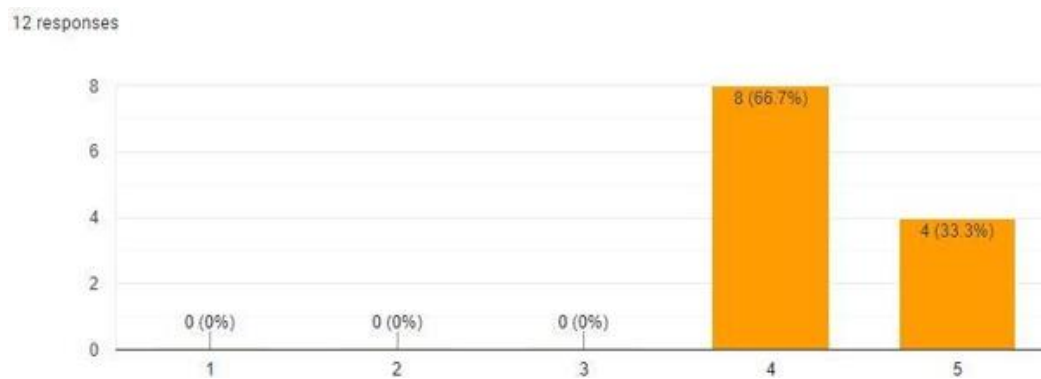


Figure 4.7: Background of Respondent (I can adapt to this kind of learning).

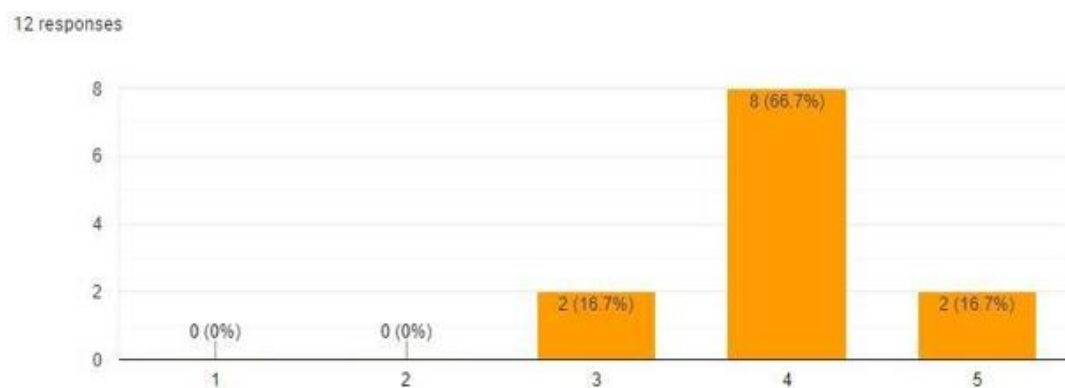


Figure 4.8: Background of Respondent (This IoT kit is very helpful to improve understanding while following a short training course)

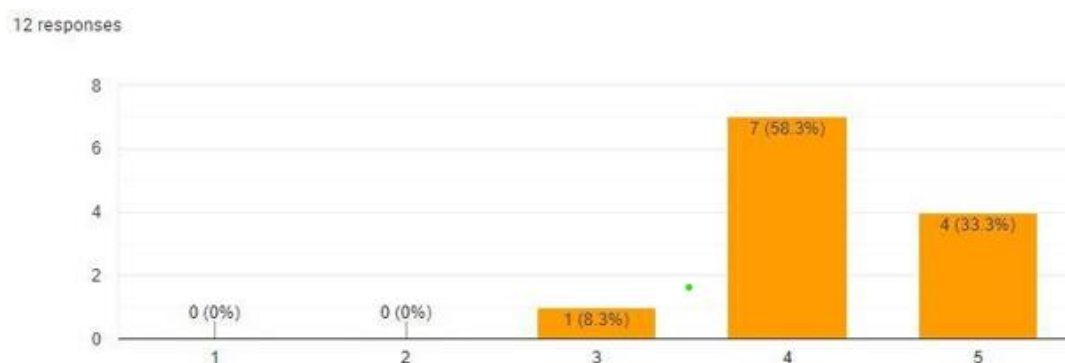


Figure 4.9: Background of Respondent (This IoT kit makes learning more interesting and easier for a beginner).

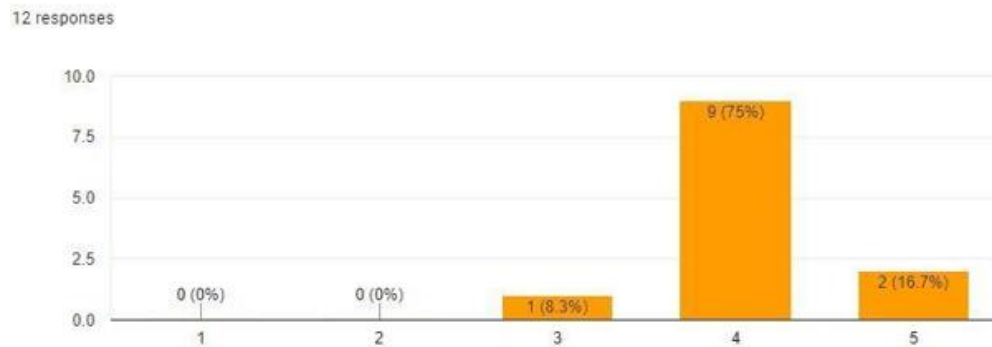


Figure 4.10: Background of Respondent (This IoT kit allows me to focus more during the training course)

5. Summary

According to the study conducted through the Swichless Kit product, it is expected to meet the current needs of education and skills related to Internet of Things (IoT) technology and thereby successfully achieve the government's aspiration for the implementation of Industry Revolution 4.0 (IR4.0).

References

- Basuki, I., & Widodo, A. (2020). The Effect of Participation in Scientific Research and Conference on Vocational Teachers' Competence. In *2020 Third International Conference on Vocational Education and Electrical Engineering (ICVEE)* (pp. 1-4). IEEE. <https://doi.org/10.1109/ICVEE50212.2020.9243179>
- Maryadi, T., Pramono, H., Hatmojo, Y., & Prianto, E. (2021). Development of Human Machine Interface (HMI) Training Kit as A Learning Media for Industrial Automation Engineering Practical Courses. *Journal of Physics: Conference Series*, 1737(1), 012047. <https://doi.org/10.1088/1742-6596/1737/1/012047>
- Ardanza, A., Moreno, A., Segura, Á., de la Cruz, M., & Aguinaga, D. (2019). Sustainable and flexible industrial human machine interfaces to support adaptable applications in the industry 4.0 paradigm. *International Journal of Production Research*, 57(12), 4045-4059. <https://doi.org/10.1080/00207543.2019.1572932>
- Somantri, Y., Wahyudin, D., Pratama, R., Nugraha, T., & Husni, M. (2019). An affordable Internet of Things Training Kit for practical work of industrial automation. *Journal of Physics: Conference Series*, 1402(3), 033079. <https://doi.org/10.1088/1742-6596/1402/3/033079>

Portable Solar Kit as a Teaching Tool for the Course SEE 10013: Electrical Fundamental of Certificate of Electrical Technology Programme

Muhamad Hafiz Abd Razak ^{1*}, Jamil Sharipuddin ² & Mohd Soffian Abdul Samat ³

^{1,2,3}Certificate of Electrical Technology, Kuantan Community College, Pahang, Malaysia

Abstract

Photovoltaic is the most effective method of generating electricity by using solar cells to convert energy from sunlight or solar energy into a flow of electrical energy electrons. The use of solar energy as an example of a renewable energy source is the simplest example that can be shown to students during the teaching and learning session of the course see 10013: Electrical Fundamental. However, due to high-cost constraints, the process of converting solar energy into electricity is difficult to demonstrate to students. Portable solar kit is a teaching tool developed to take advantage of the use of renewable energy which is sunlight to meet the needs of the teaching and learning process for students. A set of questionnaires was used as a research instrument to determine the effectiveness and suitability of the portable solar kit being used as a teaching tool for the course SEE 10013: Electric Fundamental in Certificate of Electrical Technology at Kuantan Community College. During the implementation phase, a total of 27 students of semester 1 session 2 2023/2024 have been chosen as the sample for this study. The results of the study show that the overall mean score is 4.12 with a high level of tendency. Based on the findings of the study, it can be concluded that the portable solar kit is suitable as a teaching tool for the topic sources and generation of electricity, especially to explain regarding renewable energy.

Keywords: Teaching Tool, Renewable Energy, Portable Solar Kit.

1. Introduction

In the world of education, exposure to renewable energy has been given to students since elementary school. However, the level of student awareness of renewable energy is still low (Illias et al., 2020). Teaching methods that are only based on the content of textbooks or written notes only reduce the interest of students to understand the information about renewable energy. The use of more effective methods needs to be implemented to ensure that knowledge about renewable energy can be spread more widely.

Solar energy is one of the renewable energy sources that are easy to obtain. Being a source of energy obtained from sunlight, solar energy technology is becoming popular in Malaysia as more and more solar farms are opened. Solar panels that use photovoltaic cells are the most effective method of producing electricity from solar cells. Photovoltaic technology is able to convert the energy from sunlight into electricity and then supplying the energy to the electrical equipment for daily use.

Problem Background

Renewable energy sources such as wind, waves, water, biomass and solar are actively being explored to ensure the production of clean energy that does not pollute the environment. Students of the Electrical Technology Certificate Program (STE) were exposed to this new energy as early as at the first semester under the course SEE 10013: Electric Fundamentals. However, there is a constraint in the learning process at Kuantan Community College, which is the absence of tools that can convert from renewable energy to electricity.

The explanation and demonstration of how electricity is generated from renewable energy is only done through video screenings. Practically showing electricity generated from renewable energy is also not possible. This lack has caused students to not be exposed to renewable energy in a realistic and practical way.

The Portable Solar Kit was developed by Kuantan Community College's Electrical Technology Certificate course lecturer to ensure that the teaching and learning process of topics related to the source and generation of electricity runs smoothly and practical can be done to improve student understanding. Indirectly, students are also given realistic and practical exposure so that they can feel the real atmosphere of handling renewable energy using fully equipped solar energy technology.

Research Objective

This study and research are conducted with two (2) objectives;

- i. Develop a teaching tool (ABM) that are suitable for use in the teaching and learning process of electricity sources and generation.
- ii. Produce a teaching tool (ABM) that can increase students' understanding regarding renewable energy.

Research Question

This study was conducted based on the following questions.

- i. To what extent the Portable Solar Kit teaching tool are able to attract students' interest in learning the topic of electricity sources and generation.
- ii. How effective is the use of the Portable Solar Kit in learning the SEE 10013: Electric Fundamental in Certificate of Electrical Technology Program course?

Research Scope

The study was conducted on students of the 1st semester of the Electrical Technology Certificate Program, Kuantan Community College.

Importance of The Study

The findings of this study are expected to:

- i. Organizations will be aware of the importance of providing student aids that work to facilitate the process of teaching demonstration of renewable energy.
- ii. Information to lecturers about the need to diversify teaching techniques and not rely solely on text-based explanations.
- iii. Providing information to builders about the effectiveness of the Portable Solar Kit in improving students' understanding of renewable energy.
- iv. Able to produce students who are skilled and confident in learning the field of renewable energy.

2. Literature Study

The main source of electricity in Malaysia comes from coal and gas sources (Hadi, et al, 2022). The world is expected to experience problems with the supply and demand of energy for each type of material by 2030 as reported by (IEA-OES2005). Solar energy is one of the renewable energies that have the potential to be highlighted to address the growing world energy demand problem (Firdaus et al, 2012). The demand for photovoltaic solar installations is increasing from users who indirectly create companies related to the solar industry.

Government policies that support the development of renewable energy cause demand for the solar industry to increase (Mughal et al., 2018). With the increase in demand for solar indirectly opens job opportunities in the solar installation industry. Industry experts believe that a training tool should be developed for use by the industry to train new employees on the basics of photovoltaic solar installation systems (Mohamed, et, al, 2019). Ranjit, Anas, & Subramaniam (2012) stated that learning kits are suitable for use as teaching aids in fields involving technology and engineering.

In the process of developing this Portable Solar kit teaching aid innovation product, the ADDIE design model was used as a reference (Rosset, 1987). The use of the ADDIE Model as a catalyst for ideas to develop innovation in teaching strategies has long been applied (Gure, 2019, & Tseng, 2019). Among the advantages of developing innovation products based on the ADDIE model is that it is simpler and more organized (Piskurich, 2015). The ADDIE model is suitable for use in the development of innovative products because the development process is easier because it has a clear direction (Manan, Embi and Mahamod, 2010). There are five important steps in the development of innovative products based on the ADDIE model, namely analysis, design, development, evaluation and implementation.

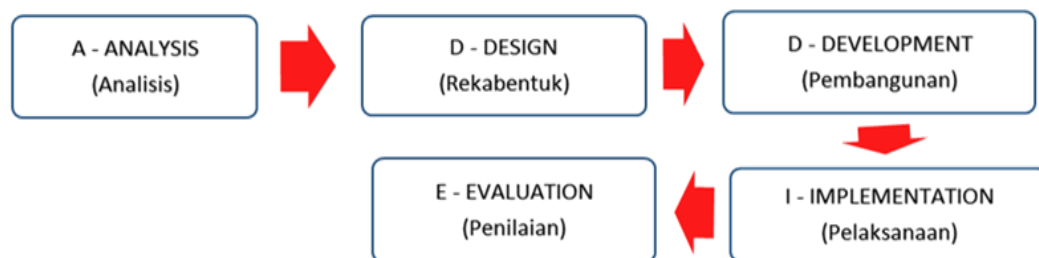


Figure 1: ADDIE Model

3. Metodology

Development Phase

Portable Solar Kit was developed with several factors in mind. The first factor is the ability to move from one place to another during the teaching and learning demonstration process to students. This Portable Solar Kit is designed to be smaller so that it can be carried anywhere easily. The use of a wheeled trolley makes it moveable without using a lot of energy.

The second factor that is considered is the ability to make connections to understand the connection process for solar circuits. In a solar circuit, the use of several devices is necessary to ensure that a stable voltage can be produced. The use of connectors or wires is to make it easier for students to connect the circuit to the terminal and avoid damage to the terminal. In addition, the operation of this Portable Solar Kit is also divided into 2 modes of operation which are 12-volt solar system mode and 24-volt solar system mode where the 12 Volt Mode is the connection of 2 batteries in parallel to provide power supply for mobile devices such as mobile phones chargers while the 24 Volt mode is a battery connection in series for the purpose of providing supplies for lighting circuits and fans.

Evaluation Phase

Is an important phase in design research and development (Amin et al, 2022). Effectiveness assessment and usability assessment are among the types of assessment that can be used in the assessment phase of a product's development study. (Saedah et al., 2020) asserted that the research findings from the evaluation phase can be used as a validation process for the developed product. The study conducted to evaluate the effectiveness of this Portable Solar Kit is a descriptive study. The survey instrument used to review the effectiveness of the Portable Solar Kit is a questionnaire.

This questionnaire was distributed to the respondents to find out their perception of the developed product. The sample of this study is 27 students in semester 1 of Kuantan Community College's Electrical Technology Certificate Program session 2 2023/2024 who took the SEE 10013: Electric Fundamentals course. A set of questionnaires containing 9 questions was distributed to the respondents. Likert scale as in table 1 is used in this survey study.

Table 1: Likert Scale

Scale	Description
1	Strongly Disagree
2	Disagree
3	Not Sure
4	Agree
5	Strongly Agree

The findings from the questionnaire will be analyzed into the form of a mean score to see the level of tendency. The determination of the level of bias is based on the mean score as shown in table 2.

Table 2: Tendency Level Mean Score

Mean Score	Tendency Level
1.00 – 2.33	Low
2.34 – 3.67	Moderate
3.68 – 5.00	High

(Source: Landell, 1997)

4. Research Findings

The results of the respondents' responses through the questionnaire were analyzed into a mean score. The results of the mean score have been projected into the level of tendency as in table 3.

Table 3: Results of Mean Score and Tendency Level

No.	Question Item	Mean Score	Tendency Level
1.	The use of the Portable Solar Kit can increase my knowledge in the topic of Renewable Energy.	3.87	High
2.	use of the Portable Solar Kit helped me better understanding in the process of generating electricity from solar energy.	4.32	High
3.	use of the Portable Solar Kit helped me understand the importance of Renewable Energy to preserve the environment.	3.91	High
4.	The Portable Solar Kit makes the concept of learning Renewable Energy easier and easier to understand.	4.14	High
5.	The Portable Solar Kit makes the Renewable Energy learning process more interactive, interesting and not boring.	4.43	High
6.	The method of using the Portable Solar Kit can save my learning time.	3.80	High
7.	The use of the Portable Solar Kit can increase my motivation to learn the topic of Renewable Energy	4.29	High
8.	Portable Solar Kit is a Learning Tool that is small in size and easy to store and use	4.06	High
9.	I am ready to share the use of the Portable Solar Kit with other friends.	4.23	High
Findings Average		4.12	High

From table 3 above, question 1 is the Portable Solar Kit's ability to increase knowledge about renewable energy, students' tendency is at a high level with a mean score reading of 3.87. Questions 2, 3 and 4 relate to students' understanding of the concept of how renewable energy is produced and its importance in preserving the environment, the average mean score for these 3 questions is 4.12 which is at a high level of tendency. For question 5 with a mean score of 4.43

and question 6 with a mean score of 3.80, most students agree that Portable Solar Kit can make class teaching more interesting as well as save learning time.

Question 7 is about how the Portable Solar Kit can increase students' motivation to learn about renewable energy. With a mean score of 4.28, with students being able to see for themselves how electricity from solar energy is produced, they agree that this practical method can increase motivation to learn about renewable energy. Question 8 with a mean score of 4.06 wants to know the students' opinion regarding the size of the Portable Solar Kit, with a wheeled design and an appropriate size that makes it easy to move this product to facilitate the student's practical process. Question 9, most students agree to share the use of Portable Solar Kit with friends because the mean score reading shows 4.23.

5. Research Discussion

Table 4 shows the average mean score for the questionnaire given to students along with the average level of tendency to use the Portable Solar Kit.

Table 4: Mean Average Score and Effectiveness Level

Total Mean Score	4.12
Average Level of Tendency of the Effectiveness of using Portable Solar Kit.	High

Based on table 4, the overall mean score that represents the level of knowledge, understanding, interest and motivation of students and the opinion of students regarding the design of Portable Solar Kit is 4.12 which the effectiveness is at a high level. Indirectly, the reading of the mean score shows that the Portable Solar Kit is suitable for use as a teaching tool during the teaching and learning process of renewable energy sources and generation.

6. Conclusion

In conclusion, practical demonstration methods that show how energy is produced can help students better understand the learning content. Not only focused on the field of electricity, learning through theoretical methods does not allow the student's mind to explore widely. The lecturers' initiative in diversifying teaching and learning methods to increase students' understanding and interest should be commended. Encouragement from the organization is also very important in injecting the lecturers with enthusiasm to always try to find a way to improve teaching and learning techniques and conditions.

References

- Amin, S. F. M., Sharif, S., Taat, M. S., Madjapuni, M. N., & Mariappan, M. (2022). Implementasi Pemeriksaan Kebolegunaan Menggunakan Kaedah Penilaian Pakar Dalam Fasa Penilaian Modul Robot M-Solat. *International Journal of Education*,
- Muhammad-Sukki, F., Munir, A. B., Ramirez-Iniguez, R., Abu-Bakar, S. H., Yasin, S. H. M., McMeekin, S. G., & Stewart, B. G. (2012). Solar photovoltaic in Malaysia: The way forward. *Renewable and Sustainable Energy Reviews*, 16(7), 5232-5244.
- Hadi, A. A. A., Yasin, M. A. M., Abd Rahim, M. F. A., & Saadon, E. I. S. (2022). Simulasi Reka Bentuk Penjejak Solar Dwi-paksi dengan Pengesan Cuaca. *Multidisciplinary Applied Research and Innovation*, 3(2), 391-397.
- Gure, G. S. (2019). Primary School Teachers' Competencies for Designing the Instructional Strategies in Teaching on Addie Model. *Think India Journal*, 22(14), 13820-13828.
- Illias, H. A., Ishak, N. S., & Alam, N. A. M. N. (2020). Awareness of Secondary School Students in Petaling Jaya Malaysia Towards Renewable Energy. *International Journal of Renewable Energy Research (IJRER)*, 10(4), 1645-1654.

- Landell, K. (1997). *Management by menu*. London: Wilay and Sms Inc.
- Manan, FA. Embi, MA. & Mahamod, Z. (2010) Kerangka Pembangunan dan Penilaian Modul Belajar Cara Belajar Bahasa Melayu Pelajar Asing Institusi Pengajian Tinggi Malaysia. *AJTLHE: ASEAN Journal of Teaching and Learning in Higher Education*, 2 (2). pp. 64-76.
- Mohamed, N., Nashir, I. M., & Hamid, N. F. A. (2019). Kajian Keperluan Alat Latihan Sistem Solar Fotovolta bagi Memenuhi Keperluan Industri di Malaysia. *International Journal of Humanities Technology and Civilization*, 1, 40-48.
- Mughal, S., Sood, Y. R., & Jarial, R. K. (2018). A Review on Solar Photovoltaic Technology and Future Trends. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 4(1), 227-235.
- Piskurich, G. M. (2015). *Rapid Instructional Design: Learning ID Fast and Right*. John Wiley & Sons.
- Ranjit, S. S. S., Anas, S. A., Subramaniam, S. K., Tan, C. F., & Chuah, S. H. (2010). Development of Solar Educational Training Kit. *Intern. J. of Eng. and Innov. Tech*, 2(3), 25-28.
- Rossett, A. (1987). *Traning Needs Assessment*. Englewood Cliffs: Educational Technology Publications.
- Saedah Siraj, Muhammad Ridhuan Tony Lim Abdullah, & Rozaini Muhamad Rozkee. (2020). *Pendekatan Penyelidikan Rekabentuk dan Pembangunan*. Universiti Pendidikan Sultan Idris.

Compact Solar Fish Dryer

Siti Saleha Abdul Azis^{1*}, Mohamad Asyraf Othoman² & Adzuikeen Nordin²

¹Kolej Komuniti Pasir Salak, Perak Darul Ridzuan, Malaysia

²Politeknik Ungku Omar, Perak Darul Ridzuan, Malaysia

*saleha@kkpsa.edu.my

Abstract

There are three methods commonly used for fish drying which are sun drying, oven drying, and cabinet-type dryers with controlled heat and air circulation. In the programme structure of Sijil Pemprosesan dan Kawalan Mutu Makanan Kolej Komuniti Pasir Salak, students in semester 1 used food dehydrator machine in the subject of Processing Fish Products and Marine Products. The machine takes 10 to 30 hours to produce dried fish. The machine needs to be in a switch on mode for a long time without monitoring due to end of learning session and office hour. Food dehydrator machines are prohibited from operating after office hours and without monitoring person for safety purpose. The objective of this study is to develop a compact solar fish dryer which can increase the drying efficiency, reducing costs, and enhancing portability. This dryer used aluminum as a frame and a clear polycarbonate panel as a cover. It's equipped solar powered fan to assist the drying process. Data on temperature, air humidity and airflow are taken throughout the drying period. The weight of the fish before and after drying is calculated to determine the fish recovery rate. The drying time was about 36 hours with a temperature between 35 and 38 degrees. The recovery rate of fish after drying is 75%. Dried fish produced in this compact solar fish dryer is preferred because it is clean, protected than contamination and safety.

Keywords: Compact Solar Dryer, Fish Drying, Recovery Rate

1. Introduction

In Kolej Komuniti Pasir Salak, the program structure of the Sijil Pemprosesan dan Kawalan Mutu Makanan requires students in the 1st semester to study a module in Processing Fish Products and Marine Products, which consist of the subtopic production of dried fish. These practical sessions run in five hours. Usually, each practical session consists of 8 groups. Each group will produce six dried fish.

Fish are a diverse group of aquatic animals that are found in both freshwater and saltwater environments. Fish are integral to ecosystems, economies, and human nutrition. Efforts to preserve and sustainably manage fish populations are crucial for maintaining these benefits for future generations. Fish products or other raw materials are very perishable if not stored in the right temperature. Bacterial growth and decomposition and spoilage can occur which can shorten the shelf life (Speranza et al, 2021).

Its quality and safety must be maintained during the process of capture, storage, processing and packaging. Along with the advancement of food processing technology, various methods have been introduced for long-term storage of food products without minimally affecting the organoleptic properties. Fish preservation is crucial to extend the shelf life of fish and prevent spoilage. Various methods have been developed overtime, each with its advantages and limitations.

To prevent deterioration, there are various storage and preservation methods for storing raw material products for a long shelf life. The most common fish preservation methods like sun drying are the most traditional method, where fish is spread out in the sun. This method is simple and

cost-effective but dependent on weather conditions and can lead to contamination. Drying fish using old methods requires the monitoring and handling of many workers especially if there is a change in weather.

The drying method helps by reducing the moisture in the fish but it will be a problem when it rains or the weather is not hot. Drying under sunlight also takes a long time i.e., 10-15 hours. Mechanical drying uses artificial heat sources to dehydrate fish. It's faster and more controlled than sun drying but requires more energy and equipment. Solar drying combines sun drying with greenhouse-like structures to enhance drying efficiency and protect fish from contamination. Another method for preserving fish is salting. This method when the fish is coated with dry salt and left to cure. Salt draws out moisture, inhibiting bacterial growth (Tavares et.al, 2021).

Solar drying is a process that utilizes solar energy to remove moisture from food products, thereby preserving them for extended periods. This method leverages the heat generated by the sun to evaporate water from the food, reducing its moisture content to levels that inhibit the growth of microorganisms, such as bacteria and mold, which can cause spoilage. There are some types of solar dryer like direct solar dryers, indirect solar dryers and hybrid solar dryers. The solar dryer can make the food more exposed directly to sunlight, usually placed in an enclosure with a transparent cover.

The enclosure traps heat and creates a greenhouse effect. The creation of a solar dryer is important to ensure that the drying area is not contaminated by animals or insects that can interfere with the taste, quality of the fish and ensure the safety of the dried fish (Rubani et al, 2023). Fish dried in a solar dryer was found to be better than fish dried in the open sun. It can be distinguished in terms of drying time, texture and colour (Al. Ismaili, A et al, 2021).

During the practical learning session for the Fish and Marine Products Processing module, the oven dryer needs to be turned on according to the set time. However, the oven dryer cannot be in the on mode at all times which leads to safety issues. The machine takes 10 to 30 hours to produce dried fish. The machine needs to be in a switch on mode for a long time without monitoring due to end of learning session and office hour.

Food dehydrator machines are prohibited from operating after office hours and without monitoring person for safety purpose. In addition, the limitation of the number of oven dryers is also a problem because there are other subjects that require the use of the same equipment. Therefore, a compact solar fish dryer has been developed which solve congestion of equipment use, besides can increase the drying efficiency, reducing costs, and enhancing portability.

2. Methodology

Overall dimension of compact solar fish dryer that has been built is shown as in Fig. 1. Dimension of final product approximately 77 cm in height, 122 cm in width, and 61 cm in depth. This compact solar fish dryer that has been built consists of two parts that can be disassembled. First is a foldable base made of an aluminum. Second is a drying area equipped with pair of solar power fans to facilitate airflow and improve drying efficiency. Aluminum square hollow is used as the frame of drying area. This aluminium material was chosen because it was light, corrosion resistant and suitable for portable device. Polycarbonate sheets is used as cover of drying area to prevent the dry fish from being exposed to rain, insect, and dust. It's also included with multiple removable stainless-steel trays to hold fish samples as shown in Fig. 2.



Figure 1: Overall Dimension of Final Product (A:122cm, B:61cm, C: 23cm, D: 77cm)



Figure 2: Multiple Removable Stainless-Steel Trays to Hold Fish Samples with Solar Powered Fan

The experiment is conducted in a tropical region with (latitude 4.13, longitude 100.9) and altitude: 23 m above mean sea level at Kolej Komuniti Pasir Salak Perak. The testing area was surrounded by residential houses, schools, and government buildings. This compact solar dryer is placed in an open area with no obstructions to sunlight and oriented to face the sun for maximum exposure throughout the day. Fish samples are placed evenly on the drying trays to ensure uniform drying.

The preparation of dried fish involves three main processes which are cleaning, dry salting and disposal excess salt and fish slime. The fish will be cleansed and removed from the stomach, then it will be split like a butterfly to make it easy to dry all parts. Fish washed and weighed before salting. Coarse salt of 40% of fish weight used with place it between the arrangements of fish in a sealed container. The fish then marinated overnight before washing to remove excess salt and fish slime. The initial weight and moisture content of the fish samples will be taken to ensure the initial weight and place the prepared fish fillets on the trays inside the drying area.

The drying process is conducted out from 08:00 until 17:00, while data is taken from 09:00 until at 16:00. Temperature and humidity inside the drying area is monitored. Digital thermometers and hygrometers are used to measure temperature and humidity hourly. Fish samples are weighed at the beginning and end of each drying day to determine weight loss. Electronic Scale is used for accurate weight measurements of fish samples.

The quality of dried fish produced after salting and drying process evaluated by acceptance testing (preference test) using a hedonic scale five points by 10 respondents. Five determination parameters the set quality is color, aroma, texture, taste, and overall acceptance. When the test is conducted, respondents served with dry fish together the evaluation form. Fish quality is evaluated based on the following parameters as shown Tab. 1.

Table 1: Five Point Hedonic Rating Scale

Scale	Range	Description
5	4.5-5.0	Like extremely
4	3.5-4.49	Like slightly
3	2.5-3.49	Neither like nor dislike
2	1.5-2.49	Dislike slightly
1	1.0-1.49	Dislike extremely

3. Results and Discussion

Fig. 3 and Fig. 4 shows the temperature and relative humidity difference between ambient and inside drying area. Maximum ambient temperature recorded is 38 °C with relative humidity 58%. Then inside drying area maximum temperature is 43 °C with 40% relative humidity. Based on the graph when the temperature increases relative humidity decreases. The decrease in relative humidity is also assisted by a pair of solar fans that ensure proper air circulation inside drying area.

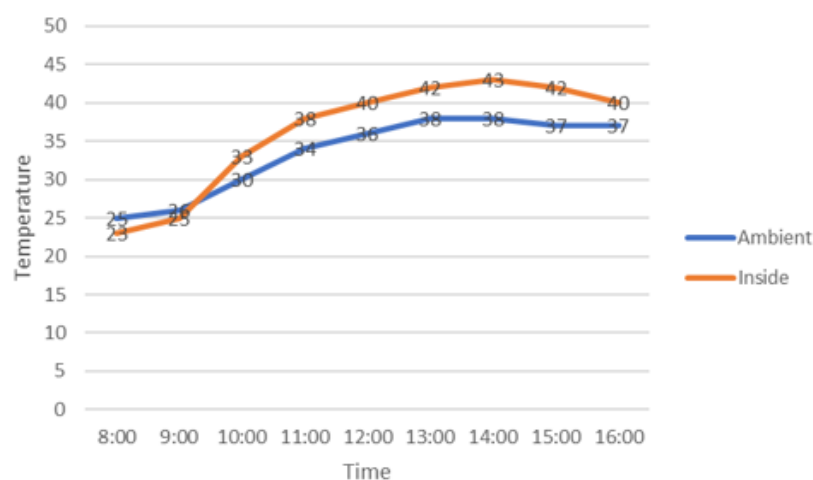


Figure 3: Temperature Difference Between Ambient and Inside Drying Area

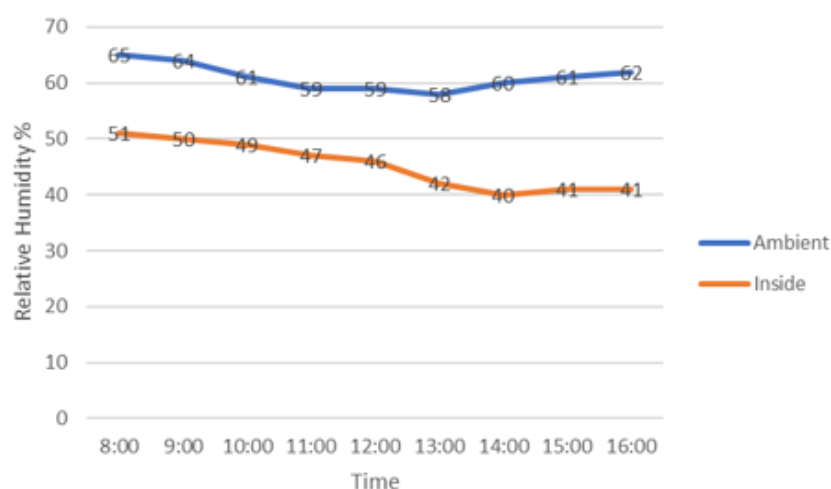


Figure 4: Relative Humidity Difference Between Ambient and Inside Drying Area

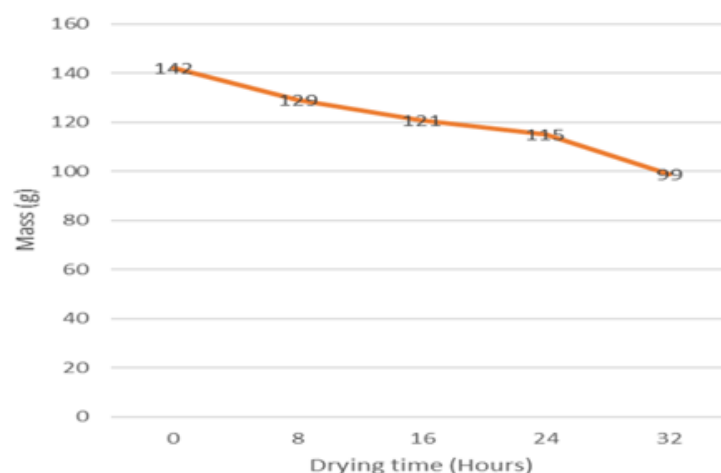


Figure 5: Average Change in Mass of Dried Fish Against Time

Fig. 5 shows the average change in mass of dried fish against time. 16 fish with an average weight of fish after salting is 142g. After going through a period of 36 hours of drying the average weight of the fish is 99g. The recovery rate of fish after drying is 75%. Recovery rate is calculated based on fish weight after drying over fish weight after salting.

Tab. 2 shows the result of preference test done by 10 respondents using five-point hedonic scale. In terms of colour, the preferred scale is 3.8, aroma with 3.5, texture with 4.0 and taste with scale 3.8. Therefore, the overall scale is 3.7 or 'Like Slightly' for the preference test. Sulieman and Allaahmed (2012) mentioned the TVN value, was found to have an inverse relationship with the sensory score of the dried fish products, that is the sensory score decreased with the increment of the TVN value of the fish products.

Table 2: Preference Test of the Quality of Dried Fish

Colour	Aroma	Texture	Taste	Overall
3.8	3.5	4	3.8	3.7

4. Conclusion

Experimental results indicate that the compact solar fish dryer is capable of reducing the moisture content of fish to desired levels within a reasonable timeframe. The integration of solar-powered fans improves airflow and enhances drying uniformity. The quality assessment of the dried fish reveals that the compact solar fish dryer effectively preserves the is colour, aroma, texture, taste, and nutritional content of the fish. This method reduces the risk of contamination, ensuring the production of high-quality dried fish suitable for consumption and storage. Utilizing solar energy for fish dehydration significantly reduces the reliance on conventional energy sources, contributing to environmental sustainability. The low operational costs and minimal maintenance requirements make the solar dryer an economically viable solution for small-scale fish processors and communities in remote areas.

While the research has demonstrated the potential of the compact solar fish dryer, several challenges and limitations were encountered. The efficiency of the compact solar fish dryer is influenced by weather conditions, with reduced performance during cloudy or rainy days. The initial cost of materials and construction may be a barrier for some users, although this is offset by the long-term savings and benefits. The development of a compact solar fish dryer presents a promising solution for sustainable fish preservation. This research has laid the groundwork for

future innovations and applications of solar drying technology, contributing to food security and economic development in regions with abundant solar resources. By addressing the identified challenges and building on the successes of this project, the solar fish dryer has the potential to become a widely adopted method for efficient and sustainable fish preservation.

Acknowledgment

We would like to express our deepest gratitude to all those who contributed to the successful completion of this research project on the development of a compact solar fish dehydrator. Our heartfelt thanks go to the participants and collaborators who generously shared their time, expertise, and resources to support this research. Their contributions have enriched our understanding and facilitated the practical implementation of the compact solar fish dryer.

References

- Speranza, B., Racioppo, A., Bevilacqua, A., Buzzo, V., Marigliano, P., Mocerino, E., ... & Sinigaglia, M. (2021). Innovative preservation methods improving the quality and safety of fish products: Beneficial effects and limits. *Foods*, 10(11), 2854.
- Tavares, J., Martins, A., Fidalgo, L. G., Lima, V., Amaral, R. A., Pinto, C. A., ... & Saraiva, J. A. (2021). Fresh fish degradation and advances in preservation using physical emerging technologies. *Foods*, 10(4), 780.
- Rubani, S. N. K., Zakaria, N., Hamzah, N., & Ariffin, A. (2023). Automatic Salt Fish Drying Machine Development Process Using MEDP. *Research and Innovation in Technical and Vocational Education and Training*, 3(1), 087-095.
- Al-Ismaili, A. (2021). A review on solar drying of fish. *Journal of Agricultural and Marine Sciences [JAMS]*, 26(2), 1-9.
- Suliman, H. A., & Allaahmed, A. A. (2012). Effect of antimicrobial properties of pepper fruit on some spoilage organisms of Sudanese wet-salted fermented fish (fassiakh) product. *World's Veterinary Journal*, (1), 5-10.

Tahap kemahiran, Kefahaman dan Minat Pelajar Melalui Bengkel Penghasilan Produk Berinovasi sebagai Program Pembelajaran Sepanjang Hayat

Ariffuddin Ibrahim^{1*} & Juliyanna Aliman²

^{1&2}Politeknik Merlimau, Kementerian Pendidikan Tinggi,
 77300 Merlimau, Melaka, Malaysia
 *ariffuddin@pmm.edu.my

Abstrak

Unit Pembelajaran Sepanjang Hayat, PMM telah mengadakan Bengkel Penghasilan Produk Berinovasi dimana pengisiannya yang terdiri daripada teknik merekabentuk, pengekodan, pemasangan dan pengujian robot ESP32 berkawalan jauh. Responden juga dilatih untuk memilih dan menggunakan bahan, alat, serta teknik yang sesuai dalam merancang dan membuat produk inovatif. Peserta kajian adalah 100 pelajar semester 2 iaitu 60 pelajar lelaki dan 40 pelajar perempuan Jabatan Kejuruteraan Elektrik, Politeknik Merlimau, Melaka (PMM). Instrumen soal selidik telah digunapakai menggunakan Skala Likert lima tahap. Sebanyak 3 aspek konstruk kajian iaitu kemahiran, kefahaman dan minat yang terdiri daripada 7,5 dan 5 item. Analisis menggunakan perisian Statistical Package for Social Science (SPSS) Versi 25 secara deskriptif. Daripada interpretasi skor min, semua item dalam bahagian kemahiran adalah di antara 4.33 hingga 4.78, bahagian kefahaman (4.29 hingga 4.41) dan bahagian minat (4.15 hingga 4.31), berada pada tahap yang tinggi. Nilai skor min menunjukkan tahap kemahiran, kefahaman dan minat yang tinggi saling berkaitan dan membantu pencapaian pelajar dalam penghasilan produk. Secara keseluruhan, Bengkel Penghasilan Produk Berinovasi dapat meningkatkan kemahiran, kefahaman, dan minat pelajar dalam berinovasi, yang pada akhirnya menyokong pembelajaran sepanjang hayat mereka.

Abstract

The Lifelong Learning Unit, PMM held an Innovative Product Development Workshop where the content consisted of the techniques of designing, coding, assembling and testing remote-controlled ESP32 robots. Respondents are also trained to select and use appropriate materials, tools, and techniques in designing and making innovative products. The study participants consisted of 100 semester 2 students, 60 male students and 40 females from the Department of Electrical Engineering, Politeknik Merlimau, Melaka (PMM). The questionnaire instrument was using Likert scale with five-levels. Three aspects of the research construct, namely skills, understanding and interest, each consisting of 7,5 and 5 items. Statistical Package for Social Science (SPSS) Version 25 were used to extract data from questionnaires descriptively. The mean score interpretation showed all items in all items in the skill section between 4.33 to 4.78, the understanding section (4.29 to 4.41) and interest section (4.15 to 4.31), is at high level. This mean score shows the skills are at the high level, understanding and interest that are interrelated and help student achievement in product development. Overall, the Innovative Product Development Workshop can increase students' skills, understanding, and interest in innovation, which ultimately supports their lifelong learning.

Kata kunci: Penghasilan Produk Berinovasi, Pembelajaran Sepanjang Hayat, Kursus Arduino

1. Pengenalan

Politeknik merupakan salah satu IPTA yang menawarkan kursus sepenuh masa dan pelbagai kursus pendek. Semua pelajar dan semua lapisan masyarakat berpeluang meningkatkan kemahiran dan

pengetahuan dengan mengikuti kursus pendek di politeknik dan kolej komuniti seluruh Malaysia melalui program Pembelajaran Sepanjang Hayat (PSH). Kaedah pelaksanaan PSH merangkumi kaedah formal iaitu kerja kursus dan kerja berpasukan, pembangunan professional dan kaedah tidak formal. (C. L. Tan & Morris, 2006). Meningkatkan pengetahuan, kemahiran dan kebolehan diri sendiri, sosial atau berkaitan pekerjaan adalah antara tujuan utama menyertai PSH (C. Tan, 2017).

PSH merupakan cara menjana ekonomi negara dan meningkatkan kemahiran pekerja (Kanwar et al., 2019). Individu berusia 15 tahun ke atas dan sedang bekerja mendapat peluang kedua untuk melanjutkan pengajian melalui program PSH secara formal dan non-formal bagi meningkatkan kemahiran, pengetahuan dan kompetensi (Kementerian Pengajian Tinggi, 2011). Pendidik perlu memiliki ciri-ciri berikut iaitu menguasai mata pelajaran dan kaedah pengajaran, memahami peringkat dan keperluan semasa dalam perkembangan pelajar dan menyayangi pelajarannya. Teknik pengajaran, kemahiran yang dipandu, disamping penggunaan teknologi terkini menjadi antara pendorong bagi melahirkan pelajar yang berkualiti dan bertaraf global.

Dalam penyelidikan ini, antara persoalan kajian adalah seperti berikut:

- i. Sejauhmanakah kemahiran dapat ditingkatkan melalui Bengkel Penghasilan Produk Berinovasi?
- ii. Sejauhmanakah pemahaman dapat ditingkatkan melalui Bengkel Penghasilan Produk Berinovasi?
- iii. Sejauh manakah minat dapat ditingkatkan melalui Bengkel Penghasilan Produk Berinovasi?

Unit Pembelajaran Sepanjang Hayat, PMM telah mengadakan Bengkel Penghasilan Produk Berinovasi dimana pengisiannya yang terdiri daripada teknik merekabentuk, pengekodan, pemasangan dan pengujian robot ESP32 berkawalan jauh. Responden juga dilatih untuk memilih dan menggunakan bahan, alat, serta teknik yang sesuai dalam merancang dan membuat produk inovatif.



Rajah 1: Suasana Bengkel Penghasilan Produk Berinovasi yang telah Diadakan

2. Kajian Literatur

Program PSH berperanan penting bagi memberi nilai tambah kepada kemahiran dan kualiti kehidupan di sesebuah kawasan dan komuniti. PSH secara umumnya mengetengahkan konsep pembelajaran secara sendiri dengan penentuan sendiri berkaitan perkara yang ingin dipelajari, kaedah pembelajarannya dan dimana perkara tersebut akan dipelajari serta difahami bagi memenuhi permintaan bidang professional (Marie Blaschke, 2012; Qanbari Qalehsari et al., 2017). Sektor TVET adalah salah satu faktor kemajuan Malaysia dan memacu ke arah negara berpendapatan tinggi. TVET merupakan tonggak mendepani kemajuan IR4.0 dengan menyediakan pekerja berkemahiran tinggi (Ismail & Hassan, 2019).

Penggunaan ICT dalam kurikulum, pembelajaran fleksibel dan mod pelbagai serta dalam penilaian adalah antara kaedah penyampaian pembelajaran (Herd & Richardson, 2015). Strategi pembelajaran yang pelbagai akan menarik, melancarkan dan memberi impak jika dipraktikkan oleh pengajar. Bahan bantu mengajar atau kaedah pengajaran yang sesuai dan berkesan, aktif dan seronok memberi kesan kepada tahap pemahaman pelajarnya. Prestasi pelajar akan terkesan apabila kaedah ini dilaksanakan (Marzuki, 2005).

Inovasi ditakrifkan sebagai kaedah baharu yang digunakan untuk mencipta produk baharu dan menambah baik produk sedia ada sehingga dapat mewujudkan pasaran dan perniagaan baharu oleh Schumpeter (1934). Pengetahuan adalah salah satu faktor penentu inovasi yang berlaku (Suffarruddin et al., 2021). Percambahan idea baharu akan mencetuskan inovasi produk apabila spesifikasi tertentu mengalami pembaharuan atau penambahbaikan (OECD, 2005).

3. Metodologi

Instrumen soal-selidik merupakan cara efektif untuk mendapatkan maklumbalas. Populasi yang disasarkan adalah pelajar semester dua di Jabatan Kejuruteraan Elektrik, PMM. Jadual Krejcie dan Morgan (1970) menjadi panduan kepada jumlah sampel. 100 pelajar iaitu 60 lelaki dan 40 perempuan telah dipilih secara rawak sebagai responden kajian. Borang soal-selidik telah diedarkan kepada semua responden tersebut. Jadual 1 menunjukkan bahagian yang terdapat di dalam soal-selidik.

Jadual 1: Maklumat dan Bahagian dalam Soal-selidik

Konstruk	Maklumat
Bahagian A	Maklumat diri responden
Bahagian B	Maklumat berkenaan kemahiran
Bahagian C	Maklumat berkenaan kefahaman
Bahagian D	Maklumat berkenaan minat

Dalam soal-selidik, skala Likert lima tahap telah digunakan yang bermula dari nilai 1=Sangat Tidak Setuju(STS), 2=Tidak Setuju(TS), 3=Tidak Pasti(TP), 4=Setuju(S) dan 5=Sangat Setuju(SS) (Mohd Najib Abdul Ghafar, 1999). Bagi mengukur kebolehpercayaan atau konsistensi dalaman item soal-selidik, pekali Cronbach Alpha (α) telah digunapakai. Nilai pekali kebolehpercayaan, $\alpha > 0.7$ adalah indikator yang menunjukkan item soal-selidik adalah boleh dipercayai dan diterima. Dalam soal-selidik, sebanyak 3 aspek konstruk kajian iaitu kemahiran, kefahaman dan minat dengan masing-masing terdiri daripada 7, 5 dan 5 item. Jadual 2 menunjukkan Penilaian Kebolehpercayaan Konstruk Item Soal-Selidik ini.

Jadual 2: Penilaian Kebolehpercayaan Konstruk Item Soal-Selidik

Dimensi	Jumlah item	Nilai Alpha (α)	Tafsiran
Kemahiran	7	0.737	Boleh dipercayai
Kefahaman	5	0.948	Boleh dipercayai
Minat	5	0.967	Boleh dipercayai

4. Dapatan

Data telah dianalisis secara statistik deskriptif menggunakan SPSSv25. Demografi responden telah dianalisis secara deskriptif menggunakan bilangan dan peratus. Nilai sisihan piawai dan min digunakan untuk mengenalpasti tahap kemahiran, kefahaman dan minat responden selepas menyertai bengkel. Jadual 3 menunjukkan tafsiran nilai min yang berdasarkan nilai min daripada soal-selidik seperti panduan oleh Mohd. Majid (1999).

Jadual 3: Tafsiran Nilai Min

Nilai min	Tafsiran Nilai Min
1.00-2.33	Rendah
2.34-3.67	Sederhana
3.68-5.00	Tinggi

Profil Responden

Jadual 4 menunjukkan sejumlah 100 responden di mana 60% adalah pelajar lelaki dan selebihnya 40% merupakan pelajar perempuan. Pelajar-pelajar yang terlibat adalah dikalangan bangsa Melayu 60%, Cina 15% dan India 25%.

Jadual 4: Profil Responden Kajian

Profil	Bilangan	Peratus (%)
Jantina		
Lelaki	60	60
Perempuan	40	40
Bangsa		
Melayu	60	60
Cina	15	15
India	25	25

Tahap kemahiran pelajar yang dicapai melalui Bengkel Penghasilan Produk Berinovasi

Jadual 5: Tahap Kemahiran Pelajar yang Dicapai melalui Bengkel Penghasilan Produk Berinovasi

Bil	Item	Kekerapan dan peratus					Skor Min	Sisihan Piawai	Aras Setuju
		STS	TS	TP	S	SS			
1	Pelajar mahir dalam bidang elektronik, robotik dan sistem terbenam	0	0	6	47	47	4.41	0.605	Tinggi
2	Pelajar mahir mengenalpasti jenis sensor yang sesuai digunakan.	0	0	4	37	59	4.55	0.575	Tinggi
3	Pelajar mahir membuat penyambungan litar menggunakan pengawal mikro dan memahami lembaran data komponen elektronik	0	0	6	55	39	4.33	0.587	Tinggi
4	Pelajar mahir mengendalikan pengawal mikro seperti Node MCU ESP32, Arduino Uno dan Arduino Nano.	0	0	6	32	62	4.56	0.608	Tinggi
5	Pelajar mahir mengintegrasikan elemen aturcara, komponen elektronik dan pengawal mikro	0	0	5	12	83	4.78	0.524	Tinggi
6	Pelajar mahir menaip aturcara menggunakan perisian Arduino IDE	0	0	2	47	51	4.49	0.541	Tinggi
7	Pelajar mahir membaikpulih dan membuat modifikasi	0	0	0	47	53	4.53	0.502	Tinggi
Skor min keseluruhan							4.52	0.563	Tinggi

Nilai peratus, sisihan piawai, min, dan interpretasi skor bagi kemahiran pembelajaran yang dicapai melalui Bengkel Penghasilan Produk Berinovasi ditunjukkan dalam Jadual 5. Melalui SPSS, item 5 menunjukkan skor min tertinggi iaitu 4.78 dan sisihan piawai 0.524. Item 5 iaitu 5%, 12% dan 83% pelajar memilih tidak pasti, bersetuju dan sangat bersetuju bahawa pelajar mahir dalam mengintegrasikan aturcara, komponen elektronik dan pengawal mikro. Item 4 adalah kedua tertinggi apabila mencatatkan skor min 4.56 dan 0.608 bagi sisihan piawai. Sebanyak 6%, 32% dan 62% pelajar memilih tidak pasti, setuju dan sangat setuju dengan pernyataan bahawa pelajar mahir mengendalikan pengawal mikro NodeMCU ESP32, Arduino Uno dan Arduino Nano. Item 3 mendapat skor min terendah iaitu 4.33 dan sisihan piawai 0.587. Dapat disimpulkan bahawa

semua item dalam bahagian kemahiran mencatatkan skor min pada tahap tinggi iaitu 4.33 hingga 4.78.

Tahap kefahaman pelajar yang dicapai melalui Bengkel Penghasilan Produk Berinovasi

Jadual 6: Tahap Kefahaman Pelajar yang Dicapai melalui Bengkel Penghasilan Produk Berinovasi

Bil	Item	Kekerapan dan peratus					Skor Min	Sisihan Piawai	Aras Setuju
		STS	TS	TP	S	SS			
1	Kursus ini banyak membantu dalam kefahaman kepada pelajar untuk menghasilkan projek	0	0	5	52	43	4.38	0.582	Tinggi
2	Kaedah penilaian melalui penghasilan projek lebih difahami	0	0	4	63	33	4.29	0.537	Tinggi
3	Penghasilan projek yang dibangunkan secara berkumpulan dapat menggalakkan pertukaran idea dan pendapat dikalangan pelajar	0	0	0	59	41	4.41	0.494	Tinggi
4	Melalui penghasilan projek pelajar yakin boleh membangunkan projek-projek yang seumpamanya dimasa hadapan.	0	0	1	60	39	4.38	0.508	Tinggi
5	Kaedah pembelajaran berasaskan masalah melalui penghasilan projek akan mempengaruhi kenahiran TVET pelajar	0	0	0	65	35	4.35	0.479	Tinggi
Skor min keseluruhan							4.36	0.520	Tinggi

Jadual 6 menunjukkan peratus min, sisihan piawai dan interpretasi skor min tahap kefahaman pelajar yang dicapai melalui Bengkel Penghasilan Produk Berinovasi. Hasil analisa menunjukkan item 3 mencatat skor min tertinggi iaitu 4.41 dan sisihan piawai 0.494. Seramai 59% dan 41% responden memilih setuju dan sangat setuju bahawa penghasilan projek secara berkumpulan dapat menggalakkan pertukaran idea dan pendapat dikalangan pelajar. Item 1 dan 4 adalah kedua tertinggi iaitu 4.38 skor min dan sisihan piawai 0.582 dan 0.508. Item 2 mencatatkan skor min terendah iaitu 4.29 dengan sisihan piawai 0.537. Angka menunjukkan semua item dalam bahagian kefahaman berada pada tahap tinggi. Antara 4.29 hingga 4.41. Nilai skor min ini menunjukkan tahap kefahaman yang tinggi merupakan faktor yang mempengaruhi dan membantu pencapaian pelajar ketika penghasilan produk.

Tahap minat pelajar yang dicapai melalui Bengkel Penghasilan Produk Berinovasi

Jadual 7 menunjukkan peratus min, sisihan piawai dan interpretasi skor min tahap kefahaman pelajar yang dicapai melalui Bengkel Penghasilan Produk Berinovasi. Hasil Analisa menunjukkan item 2 mencatat skor min tertinggi iaitu 4.31 dan sisihan piawai 0.465. Seramai 69% dan 31% responden memilih setuju dan sangat setuju dengan kenyataan bahawa pelajar tetap teruja menyiapkan projek dalam tempoh masa ditetapkan walaupun menghadapi pelbagai kesukaran. Item 3 mencatat skor kedua tertinggi dengan skor min 4.29 dan sisihan piawainya 0.456. Item yang mendapat skor terendah iaitu Item 1 dan 4, masing-masing 4.15 dan sisihan piawai 0.57. Nilai skor min ini menunjukkan semua item dalam tahap tinggi iaitu antara 4.15 hingga 4.31. Kesimpulannya, tahap minat yang tinggi berupaya membantu pencapaian pelajar dalam penghasilan produk.

Jadual 7: Tahap Minat Pelajar yang Dicapai melalui Bengkel Penghasilan Produk Berinovasi

Bil	Item	Kekerapan dan peratus					Skor Min	Sisihan Piawai	Aras Setuju
		ST	TS	TP	S	SS			
1	Pelajar berusaha untuk menyiapkan projek sehingga berjaya	0	0	10	65	25	4.15	0.575	Tinggi
2	Pelajar teruja menyiapkan projek dalam tempoh masa yang ditetapkan walaupun menghadapi pelbagai kesukaran	0	0	0	69	31	4.31	4.465	Tinggi
3	Pelajar bangga dengan usaha sendiri	0	0	0	71	29	4.29	0.456	Tinggi
4	Penglibatan dan kerjasama daripada ahli kumpulan sangat membantu dalam penghasilan projek	0	0	10	65	25	4.15	0.575	Tinggi
5	Pelajar berusaha membuat carian melalui carian maklumat atas talian (cth Youtube, jurnal) dan buku rujukan untuk menyiapkan projek	0	0	6	65	29	4.23	0.548	Tinggi
Skor min keseluruhan							4.230	0.524	Tinggi

5. Kesimpulan

Dapatan kajian menunjukkan bahawa kefahaman, kemahiran dan minat responden adalah saling berkait. Ini dapat dibuktikan dimana min skor diperolehi adalah tinggi. Dapatan ini membuktikan bahawa minat, kefahaman dan kemahiran yang tinggi adalah faktor yang mempengaruhi pencapaian pelajar dalam menghasilkan sesuatu produk. Di antara ketiga-tiga aspek, didapati aspek kemahiran memperoleh skor tertinggi manakala aspek minat berada pada kedudukan terendah. Daripada perbandingan tersebut, dapat disimpulkan bahawa ilmu pengetahuan dan kemahiran yang lengkap dan mencukupi serta disokong penggunaan teknologi seiring perkembangan semasa perlu ada pada setiap tenaga pengajar. Langkah ini adalah untuk memastikan generasi Z yang berusia 10 hingga 24 tahun tertarik menjadi generasi yang menghasilkan produk dan bukan sekadar sebagai pengguna sahaja. Pemahaman pelajar terhadap konsep dan proses inovasi dapat dibantu apabila pelajar mempelajari tahapan penting dalam pengembangan inovasi, seperti mengenalpasti masalah, menjana idea, merancang dan menguji produk. Secara keseluruhan, Bengkel Penghasilan Produk Berinovasi dapat meningkatkan kemahiran, kefahaman, dan minat pelajar dalam berinovasi, yang pada akhirnya menyokong pembelajaran sepanjang hayat mereka.

Rujukan

- Ismail, A. A., & Hassan, R. (2019). Technical competencies in digital technology towards industrial revolution 4.0. *Journal of Technical Education and Training*, 11(3), 55–62. <https://doi.org/10.30880/jtet.2019.11.03.008>
- Ismail, A. A., & Hassan, R. (2019). Technical competencies in digital technology towards industrial revolution 4.0. *Journal of Technical Education and Training*, 11(3), 55–62. <https://doi.org/10.30880/jtet.2019.11.03.008>
- Kanwar, A., Balasubramanian, K., & Carr, A. (2019). Changing the TVET paradigm: new models for lifelong learning. *International Journal of Training Research*, 17(sup1), 54–68. <https://doi.org/10.1080/14480220.2019.1629722>
- Marie Blaschke, L. (2012). Heutagogy and Lifelong Learning: A Review of Heutagogical Practice and Self-Determined Learning. In *A Review of Heutagogical Practice and Self-Determined Learning Blaschke* (Vol. 13, Issue 1)
- Mohd Najib Abdul Ghafar. (1999). *Penyelidikan Pendidikan*

- Organisation for Economic Co-operation and Development., & Statistical Office of the European Communities. (2005). *Oslo manual: guidelines for collecting and interpreting technological innovation data*. Organisation for Economic Co-operation and Development
- Qanbari Qalehsari, M., Khaghanizadeh, M., & Ebadi, A. (2017). Lifelong learning strategies in nursing: A systematic review. *Electronic Physician*, 9(10), 5541–5550. <https://doi.org/10.19082/5541>
- Suffarruddin, S. H., Jaafar, M., & Rahman, S. (2021). The capability of product innovation implementation in homestay program at Peninsular Malaysia. *Jurnal Pengurusan*, 61. <https://doi.org/10.17576/pengurusan-2021-61-09>
- Tan, C. (2017). Lifelong learning through the SkillsFuture movement in Singapore: challenges and prospects. *International Journal of Lifelong Education*, 36(3), 278–291. <https://doi.org/10.1080/02601370.2016.1241833>
- Tan, C. L., & Morris, J. S. (2006). Undergraduate College Students, Laptop Computers, and Lifelong Learning. *The Journal of General Education*, 54(4), 316–338. <https://doi.org/10.1353/jge.2006.0013>

Stakeholders Perspectives on Industry Engagement Sessions in Final Year Project (FYP) Title Refinement

Aminah Bibi Bawamohiddin^{1*}, Munirah Abdullah¹ & Nor Hanani Mohd Yusoff¹

^aDepartment of Information Communication and Technology, Politeknik Ungku Omar, Malaysia

*aminahbibi@puo.edu.my

Abstract

This study examines stakeholder perspectives on the effectiveness of industry engagement sessions within Final Year Project (FYP) programs for Diploma in Information Technology students. These sessions aimed to refine FYP titles and foster broader interaction between students and industry professionals in tracks such as Software and Application Development, Information Security, and Networking Systems. Participants – students, supervisors, and industry panel members – rated various aspects of these sessions using a Likert scale. The research explores how these sessions contribute to enhanced FYP ideas, industry collaboration, and graduate employability. Descriptive statistical analysis revealed generally high stakeholder satisfaction, with industry panel members unanimously endorsing the sessions' benefits. Students reported significant improvements in project development and understanding of marketability. While acknowledging potential workload increases, supervisors recognized the value of the sessions. This research emphasizes the importance of stakeholder collaboration in optimizing FYP outcomes and proposes directions for future improvements and research.

Keywords: Final Year Project (FYP), industry engagement sessions, student-industry interaction, stakeholder perceptions, FYP Title.

1. Introduction

Final Year Projects (FYPs) represent a cornerstone of higher education curricula, offering students a platform to apply theoretical knowledge to real-world challenges (Morales-Botello et al., 2023). In disciplines such as Information Technology (IT), Computer Science, and related fields, FYPs are pivotal in cultivating technical expertise, analytical thinking, and project management skills. The relevance of these projects extends beyond academic achievement; they are instrumental in enhancing graduate employability by aligning educational outcomes with industry demands (Mardis et al., 2018; Succi, C., & Canovi, 2020).

Collaboration between academic institutions and industry partners has become increasingly emphasized as a means to bridge the gap between classroom learning and practical industry applications. Research underscores that such collaborations expose students to valuable insights into real-world practices, thereby preparing them more effectively for professional roles (Mavri, Aekaterini et al., 2023; Taş, E, 2024). For instance, Ngonda et al. (2022) and Xu and Zhang (2024) demonstrated that students engaged in industry-supervised projects exhibit significant improvements in both technical competencies and employability skills.

This study focuses on the student-supervisor-industry panel interaction program, a structured initiative designed to foster collaboration between students and industry professionals. This interaction allows students to present their FYP ideas to industry experts, who provide direct feedback to refine projects and enhance their marketability. By evaluating this program from the perspectives of students, industry panels, and supervisors, this research aims to provide a comprehensive assessment of its effectiveness, identifying its benefits and areas for improvement.

Through systematic data collection and analysis from these key stakeholders, this study seeks to enhance the quality and relevance of FYPs. Ultimately, this research aims to contribute to the preparation of graduates who are well-equipped to meet the evolving demands of the modern workforce. Beyond educational outcomes, fostering closer ties between academia and industry is vital for mutual enrichment and innovation in professional practice.

2. Methodology

This study employed a quantitative methodology to collect and analyze data on the effectiveness of industry engagement sessions in the Final Year Project (FYP) program. Data were collected through structured questionnaires administered to three distinct participant groups: students, supervisors, and industry panel members. The questionnaires were meticulously designed to assess various aspects relevant to each group's role and experience within the program. Participants provided their responses using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), allowing for a quantitative measurement of their perceptions and attitudes towards the program.

Participants and Sessions

The study included 45 students enrolled in the Diploma Information Technology, distributed across three tracks: Information Security (IS), Software and Application Development (SAD), and Networking Systems (NS). The study was conducted concurrently across three separate computer laboratories, each representing one of these tracks, within the institutions. Each laboratory session accommodated a maximum of three students per track. The industry engagement sessions were conducted online, with each session lasting approximately 30 minutes per student group. Concurrent sessions were held for each track, allowing industry professionals to interact directly with students from their respective disciplines. This setup facilitated focused discussions and feedback tailored to the specific requirements and challenges within each track.

Procedure

During the online industry engagement sessions, students presented their FYP ideas to the industry panel, which consisted of professionals from diverse sub-disciplines within each track. The panel members then provided constructive comments, suggestions, and feedback based on their industry experience. This interactive process aimed to refine students' project ideas and enhance their understanding of market demands and practical applications.

Data Collection

Structured questionnaires were employed immediately following each industry engagement session to gather data from participants. These questionnaires were meticulously designed to evaluate various aspects of the session's effectiveness, focusing on the clarity and relevance of feedback provided by the industry panel, the perceived impact on enhancing FYP ideas, and overall satisfaction with the interaction format. Student Questionnaires: Students responded to questions across seven key aspects, assessing the program's influence on refining their FYP ideas, opportunities for interaction with industry panels, and their grasp of project marketability.

Industry Panel Questionnaires: Panel members were surveyed on six core aspects, examining the program's efficacy in enhancing student project ideas from an industry perspective, the necessity of industry collaboration, and the suitability of online implementation. Supervisor Questionnaires: Supervisors provided feedback on six key aspects, including the clarity of students' project ideas post-session and their overall satisfaction with the colloquium format.

Following data collection, descriptive statistical analysis was conducted to synthesize the responses. Average scores were computed for each question across participant groups to offer a comprehensive overview of their perceptions. The results indicated a high level of satisfaction across all participant groups, with industry panel members uniformly endorsing the program's benefits and its relevance for future iterations. Students reported substantial improvements in project development and understanding of marketability, while supervisors recognized the program's value despite concerns regarding workload implications. The average scores from the questionnaires are summarized in Tables 1, 2, and 3.

This quantitative survey methodology provided a structured framework to comprehensively capture and analyze participant perspectives within the FYP program. It facilitated the identification of program strengths and areas for improvement, thereby offering valuable insights to inform future enhancements and research directions in similar educational contexts.

Table 1: Student Perceptions of the FYP Industry Engagement Session

Question	Average Score
This colloquium helped my supervisee group clarify their FYP ideas	4.67
Interaction with the industry/outsider panel benefited my supervisee group	4.67
The timing of this colloquium was appropriate	4.67
This colloquium was burdensome to me as a supervisor	1.67
This colloquium should be held again in the future	4.67
Overall, this colloquium benefited my supervisee group and myself as a supervisor	4.67
This colloquium helped my supervisee group clarify their FYP ideas	4.67

Table 2: Industry Panel Member Perceptions of the FYP Industry Engagement Session

Question	Average Score
I believe this program is beneficial for helping students improve their FYP ideas from an industry perspective	5.00
Industry collaboration is necessary for enhancing students' FYP ideas	5.00
FYPs with marketability potential can enhance graduate employability	5.00
The program is suitable for online implementation	4.67
Overall, the program is beneficial	5.00
I am interested in participating as an industry panel member in the future	5.00

Table 3: Supervisor Perceptions of the FYP Industry Engagement Session

Question	Average Score
This colloquium helped my supervisee group clarify their FYP ideas	4.67
Interaction with the industry/outsider panel benefited my supervisee group	4.67
The timing of this colloquium was appropriate	4.67
This colloquium was burdensome to me as a supervisor	1.67
This colloquium should be held again in the future	4.67
Overall, this colloquium benefited my supervisee group and myself as a supervisor	4.67
This colloquium helped my supervisee group clarify their FYP ideas	4.67

3. Discussion

The findings of this study provide valuable insights into the perceptions and experiences of students, industry panels, and supervisors regarding the Final Year Project (FYP) program. This section discusses key findings, compares them with existing literature, and explores their implications for practice and future research. Students overwhelmingly viewed the FYP program positively, highlighting its role in enhancing their project ideas ($M = 4.82$) and providing

opportunities for interaction with industry panels ($M = 4.82$). These aspects are crucial as they contribute to students' understanding of real-world applications and potential employability post-graduation. The high ratings indicate that students perceive the program as beneficial in bridging academic learning with practical industry perspectives, aligning with previous studies emphasizing the importance of experiential learning (Ahmed et al., 2022).

The feedback from industry panels underscores the program's effectiveness in fostering industry-relevant skills and perspectives among students ($M = 5.00$). The unanimous agreement on the need for industry collaboration ($M = 5.00$) and the potential employability impact of FYPs ($M = 5.00$) highlights industry's recognition of the program's value in preparing graduates for the workforce. This aligns with research advocating for closer ties between academia and industry to enhance graduates' readiness and career prospects (Monteiro et al., 2021).

Supervisors reported positive outcomes in terms of clarifying project ideas ($M = 4.67$) and recognizing the overall benefits of the program ($M = 4.67$). However, concerns about the program's timing and its perceived burden on supervisors ($M = 1.67$) suggest areas for improvement. These concerns could have significant implications for student outcomes and project quality, as overburdened supervisors may have less time and energy to provide detailed guidance and support. Addressing these concerns through tailored support mechanisms and professional development opportunities for supervisors can enhance their engagement and support for students throughout the FYP process (Razali, 2020).

The varying perspectives on online program delivery ($M = 4.67$) indicate a need for optimizing virtual platforms and engagement strategies to better facilitate learning and collaboration. Enhancing digital infrastructure and incorporating feedback from stakeholders can improve the efficacy of online program components, ensuring equitable access and engagement for all participants.

4. Implications and Direction for Future Research

This section discusses directions for future research related to the Final Year Project (FYP) program, examining the practical implications of the study's findings and highlighting key limitations. A notable limitation is potential response biases, with participants possibly providing socially desirable answers. Additionally, the small sample size, especially among supervisors and industry panel members, may limit the generalizability of the findings. Future studies should include larger and more diverse samples to validate these results.

To enhance FYP programs, institutions can incorporate industry-driven projects and ensure regular interactions with industry professionals. Forming advisory boards with industry experts can provide ongoing curriculum input. Institutional policies should support and incentivize industry collaboration, facilitating formal partnerships that provide resources, expertise, and real-world problems for students. These collaborations can also open internship opportunities, offering valuable work experience.

Professional development for supervisors is crucial to address workload concerns and improve their guidance for students. Institutions should offer training sessions on project management, industry collaboration, and mentorship, equipping supervisors with the necessary tools and knowledge.

Future research could explore the long-term effects of FYP participation on graduates' career trajectories and employability. Comparative studies across institutions could identify variations in FYP effectiveness and best practices for program design and implementation. Strengthening digital infrastructure and support systems for online program delivery could also enhance virtual learning environments, improving student engagement and outcomes.

In summary, acknowledging limitations, this study highlights important implications for enhancing FYP programs. Implementing practical recommendations and pursuing further research can better prepare graduates for successful careers and foster stronger ties between academia and industry.

5. Conclusion

This study has demonstrated significant benefits of the Final Year Project (FYP) program for students, industry panels, and supervisors, contributing to both academic learning and professional development. Key findings and their practical implications for stakeholders are synthesized below to highlight the study's contributions to academia and industry.

The FYP program has been highly effective in enhancing students' project ideas and understanding of marketability. Students reported substantial improvements, emphasizing the program's role in bridging the gap between academic learning and practical industry perspectives. This alignment is crucial for improving students' employability post-graduation, making them better prepared for real-world challenges.

Feedback from industry panel members underscored the program's value in fostering industry-relevant skills and enhancing employability. The unanimous recognition of the need for industry collaboration highlights the importance of integrating industry insights into academic programs. This collaboration ensures that graduates possess the skills and knowledge required by the current job market, aligning academic outputs with industry needs.

Supervisors acknowledged the program's benefits in clarifying project ideas and expressed overall satisfaction. However, concerns about timing and workload suggest the need for tailored support mechanisms. Addressing these concerns through professional development opportunities and structured support can enhance supervisors' ability to effectively guide students, thereby improving the overall effectiveness of the FYP program.

The study also highlighted the suitability of online program delivery, although suggestions for optimizing virtual platforms were noted. Enhancing digital infrastructure and incorporating interactive and engaging online teaching methods can further improve the online learning experience. These improvements will ensure that the benefits of the FYP program are fully realized, even in a virtual environment.

In conclusion, the FYP program significantly benefits students, industry professionals, and supervisors, fostering collaboration between academia and industry. The study's findings underscore the importance of integrating industry feedback into academic programs and providing support for supervisors to enhance program effectiveness. Future research should explore the long-term impacts of FYP participation, investigate best practices in different contexts, and examine the role of FYPs in developing students' soft skills and workplace readiness. Addressing identified challenges and leveraging opportunities for improvement will ensure that FYP programs continue to prepare graduates for successful careers in their respective fields.

References

- Ahmed, F., Fattani, M. T., Ali, S. R., & Enam, R. N. (2022). Strengthening the Bridge between Academic and the Industry through the Academia-industry Collaboration Plan Design Model. *Frontiers in Psychology*, 13, 875940.
- Morales-Botello, María Luz, & Carlos Moreno Martínez. (2023). "Semi-guided learning tool as framework for STEM students learning: A case study for final year projects." *Education and Information Technologies* 28.2: 1535-1557.
- Mardis, M. A., Ma, J., Jones, F. R., Ambavarapu, C. R., Kelleher, H. M., Spears, L. I., & McClure, C. R. (2018). Assessing alignment between information technology educational opportunities, professional requirements, and industry demands. *Education and Information Technologies*, 23(4), 1547–1584. <https://doi.org/10.1007/S10639-017-9678-Y/TABLES/13>
- Mavri, Aekaterini, Andri Ioannou, and Fernando Loizides. (2023). A Model for Enhancing Creativity, Collaboration and Pre-professional Identities in Technology-supported Cross-organizational Communities of Practice. *Education and Information Technologies*: 1-42.
- Monteiro, S., Almeida, L., & Garcia-Aracil, A. (2021). It's a very Different World: Work Transition and Employability of Higher Education Graduates. *Higher Education, Skills and Work-Based Learning*, 11(1), 164-181.
- Ngonda, T., Shaw, C., & Kloot, B. (2022). The Pitfalls of Work Placement Learning: Perceptions of Mechanical Engineering Students from a South African University. *Australasian Journal of Engineering Education*, 27(1), 38-46.
- Razali, R. (2020). Supervision of Undergraduate Research in a Malaysian University: How Supervisors and Students Understand and Experience Supervision and Feedback during the Final Year Project (FYP) (Doctoral dissertation, ResearchSpace@ Auckland).
- Succi, C., & Canovi, M. (2020). Soft skills to Enhance Graduate Employability: Comparing students and employers' perceptions. *Studies in Higher Education*, 45(9), 1834–1847. <https://doi.org/10.1080/03075079.2019.1585420>
- Taş, E. (2024). Data Literacy Education through University-industry Collaboration. *Information and Learning Sciences*, 125(5/6), 389-405.
- Xu, X., & Zhang, S. (2024). Refining The Student Experience in Industry-University Collaborations: Strategies for Satisfaction, Engagement, and Effective Learning. In *INTED2024 Proceedings* (pp. 256-259). IATED

Analysis of Malaysian Polytechnic Students that Successful Commissioned RELASIS Brigade Credit Co-Curriculum Course towards Producing Quality TVET Graduates

Mohammad Fahmy Ibrahim^{1*}, Kamarul Ariffin Abd Rashid² & Norfazila Ahmad³

¹Politeknik Sultan Salahuddin Abdul Aziz Shah, Persiaran Usahawan, 40150 Shah Alam, Selangor, Malaysia

²Politeknik Seberang Perai, Jalan Permatang Pauh, 13500 Permatang Pauh, Pulau Pinang, Malaysia

³Politeknik Nilai, Negeri Sembilan, Kompleks Pendidikan Bandar Enstek, 71760 Bandar Enstek, Negeri Sembilan, Malaysia

^amfahmy@psa.edu.my, ^bkariffin@psp.edu.my, ^cnorfazilaahmad@polinilai.edu.my

Abstract

Credit co-curriculum is one of the requirements that all polytechnic students must take in order to qualify a student to be awarded a polytechnic diploma. This credit co-curriculum is divided into two parts, namely the Uniformed Body credit co-curriculum and the Sports, Club and Association credit co-curriculum. This study was conducted to analyse Malaysian polytechnic students that successfully commissioned RELASIS Brigade credit co-curriculum courses. The Objectives is to Identify the number of Polytechnic students enrol for the RELASIS Brigade course from year 2021 until 2023 and to analyse the trend of students that successful commissioned for the RELASIS Brigade. The methodology used in this study is a quantitative survey data obtained from the student Information Management System (SPMP) developed under the item 'i-KOKO'. The findings obtained from the study found that the percentage of students who chose the RELASIS Brigade co-curriculum was very low when compared to students who registered for the first semester. There are only 39% of the 23 Malaysian Polytechnics that offer the RELASIS Brigade have first semester students who choose the RELASIS Brigade curriculum compared to 61% of the number of polytechnics that enrol in the RELASIS Brigade. The number of students who successfully completed the RELASIS Brigade co-curriculum up to the certification level was reduced compared to 75% of the number who registered for the co-curriculum in the first semester. The results of this study can help the Department of Polytechnic Education and the Community College and Volunteer Department of Malaysia (RELA) formulate a strategy to increase the number of RELASIS Brigade credit co-curriculum membership and attract polytechnic students to join the RELASIS Brigade. The RELASIS Brigade credit co-curriculum syllabus also needs to be improved by applying elements that are a favorite of today's students

Keywords: Co-curriculum, Credit, RELASIS Brigade Students

1. Introduction

The National Education Philosophy has outlined the government's efforts to provide a workforce that has balanced knowledge and skills in terms of physical, emotional, spiritual and intellectual. The Malaysian Education Development Plan (2013 – 2035) through 10 leaps The Malaysian Education Development Plan for Higher Education has outlined the first leap to be achieved which is "Holistic graduates with entrepreneurial and balanced characteristics".

In this context, the role of co-curriculum is as a complement to the curriculum to produce balanced individuals. The importance of co-curriculum in the self-development of a student. To produce balanced individuals has been commented by Teng, Bon Tong (1982) and Vasudevan T. Arosoo (1988) who stated that among the uniqueness of the co-curriculum is that it contains

psychomotor (physical), cognitive (intellectual) and affective (emotional and spiritual) development. According to Zulkiflee and Aimi (2010), co-curriculum is complementary to the needs and importance of the curriculum. The combination of curriculum and co-curriculum can produce world-class human capital.

According to Kamus Dewan (2000), co-curriculum is part of the basic curriculum that involves activity or activities. In addition to the subjects taught in the classroom, extracurricular activities are also considered as part of the education course. Kreps (2002) summarizes that there are many activities related to co-curricular activities, including external research, community service projects, organization formation, being involved as an athlete, attending a program or competition. Mr. Alim Abdul Rahim (1999) defines co-curriculum as activities in the form of education that are carried out outside the classroom and provide teaching experiences. Co-curricular components include uniformed bodies, associations and clubs, sports and games.

Willson (2009), stated that co-curriculum is a necessity in providing various opportunities for students to improve their skills and knowledge. Co-curricular empowerment in the education system in Higher Education Institutions needs to be given due emphasis. Credit co-curriculum courses have been implemented from the June 2000 session and are compulsory for Semester one and two students at all Malaysian Polytechnics. Co-curriculum is a complementary container to learning in the lecture room. Co-curricular activities at the polytechnic are self-driven to hone talents and produce skills in a flexible, fun learning environment, adding to existing knowledge and students' skills in certain fields. Co-curriculum can also shape character and improve soft skills so that graduates born from Polytechnic Malaysia have potential and are able to be competitive and meet the requirements of graduate marketability. Accordingly, the co-curriculum provides a platform for students to cultivate the search for new knowledge, therefore several new courses have been proposed in the implementation of the co-curriculum in polytechnics throughout Malaysia starting from the June 2014 session for the Diploma Program and September 2013 for the Degree Program.

The learning scenario of the credit curriculum at the polytechnic starts from the first semester until the fourth semester and is divided into two paths, namely the first path is Sports, Clubs and Associations while the second path is the Uniformed Body. For students who choose route one, co-curriculum classes will start in the first semester which is the Sports Co-curriculum followed by the Club and Association Co-curriculum in the second semester. The second path is the Uniformed Body which starts from the first semester until the fourth semester. From the point of view of credit distribution, Sports conducted in the first semester was given one credit and Clubs and Associations in the second semester were given one credit. For the Uniformed Body, in the first semester, one credit is given and the second semester is given 1 credit. While for the third and fourth semesters no credit is given because in those semesters, students are given exposure with additional knowledge for certification. All polytechnic students are required to take one of the routes to enable the student to be awarded a Diploma.

2. Statement of the Problem

This study is based on the Malaysian Education Development Plan (2015 – 2025) (Higher Education) which has outlined 10 main pillars and two of them are to produce quality holistic TVET graduates where the Ministry of Education will increase programs to build the character and intellect of students in addition to having excellent academics. According to Ibrahim et al (2010), stated that co-curriculum activities can train students from the perspective of perfection and balance in terms of physical, emotional, spiritual and intellectual co-curriculum activities.

Following that, the polytechnic has drawn up a curriculum that includes a combination of academic curriculum and co-curriculum. Polytechnic Malaysia covering 23 Polytechnics has offered the RELASIS Brigade Course.

First semester students are given a briefing session regarding this Uniformed Body Credit Co-Curriculum at the beginning of the semester and students are given the option to choose which credit co-curriculum they want to choose. An issue that often occurs is the imbalance in the selection of the RELASIS Brigade co-curriculum compared to other creditable co-curriculum such as the Uniformed Bodies other than the RELASIS Brigade, Sports and Associations. The second problem that occurs is that the number of students who have registered with the RELASIS Brigade curriculum is reduced from the number who registered in the first semester compared to the students who were commissioned in the fourth semester. Therefore, this study was conducted to identify the acceptance of students in the RELASIS Brigade co-curriculum at Polytechnic Malaysia.

3. Study Objectives

The objectives of the study are as follows:

1. To Identify the number of Polytechnic students, enrol for the RELASIS Brigade course from year 2021 until 2023
2. To Analyse the trend of students that successful commissioned for the RELASIS Brigade course from year 2021 until 2023

4. Scope of The Study

This study is focused on the following aspects:

1. Malaysian Polytechnic Students taking the RELASIS Brigade course for the years 2023, 2022 and 2021.
2. Student data is taken starting from the first semester until the student is commissioned in the fourth semester.

5. Significance of The Study

Co-curriculum is a medium capable of developing students' soft skills apart from the knowledge acquired in the classroom. The findings of this study can help the Department of Polytechnic Education and Community College and the Department of Malaysian Volunteers formulate a strategy to increase the membership of the RELASIS Brigade and attract the interest of polytechnic students to join the RELASIS Brigade as well as formulate a suitable syllabus for the age level of polytechnic students.

6. Methodology

The methodology used in this study is a literature review and data obtained from the student Information Management System (SPMP) developed under the item 'i-KOKO'. This literature review was developed to obtain information related to student tendencies in the selection process of the RELASIS Brigade co-curriculum at Polytechnic Malaysia. In addition, data techniques obtained from the Student Information Management System (SPMP) are used to identify the number of students who have successfully completed the RELASIS Brigade co-curricular course up to the certification level. The study consists of students from four departments, namely the Civil Engineering Department, the Electrical Engineering Department, the Mechanical Engineering Department and the Trade Department.

7. Research Results

This chapter explains the analysis that has been carried out on the data obtained. The results of the data analysis done have been translated in the form of a table more clearly. The description of the data analysis is based on the research findings obtained.

Number of Polytechnic Student Enrol for The RELASIS Brigade Course from Year 2021 Until 2023

Data taken from the Student Information Management System (SPMP) shows that a total of 241 students have registered for semester one session I: 2021/2022, while in session II: 2021/2022 a total of 232 students for semester two have registered. Next, a total of 93 third semester students have registered in session I: 2022/2023 and 61 students have registered in session II: 2022/2023.

Table 1: Number of Students in the Malaysian Polytechnic RELASIS Brigade

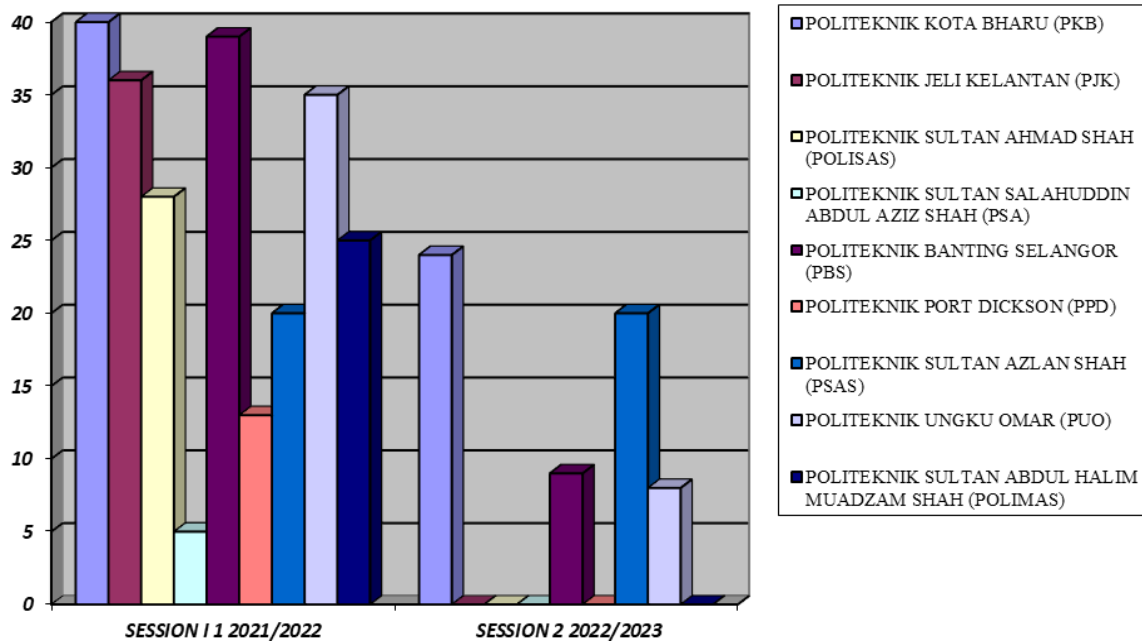
POLITEKNIK	SESSION			
	1	2	1	2
	2021/2022	2021/2022	2022/2023	2022/2023
Politeknik Kota Bharu (PKB)	40	39	29	24
Politeknik Jeli Kelantan (PJK)	36	36	0	0
Politeknik Sultan Ahmad Shah (POLISAS)	28	28	0	0
Politeknik Sultan Salahuddin Abdul Aziz Shah (PSA)	5	5	0	0
Politeknik Banting Selangor (PBS)	39	39	9	9
Politeknik Port Dickson (PPD)	13	5	0	0
Politeknik Sultan Azlan Shah (PSAS)	20	20	20	20
Politeknik Ungku Omar (PUO)	35	35	35	8
Politeknik Sultan Abdul Halim Muadzam Shah (POLIMAS)	25	25	0	0
Total	241	232	93	61

Trend of Students That Successful Commissioned for The Relasis Brigade Course from Year 2021 Until 2023

Table 2 shows the number of students who registered in the first semester and the number of students who were successfully accredited in the fourth semester. A very drastic drop in numbers during commissioning compared to registration in semester one. Only four polytechnics were successfully accredited, namely PKB, PBS, PSAS and PUO. A decrease of 75% in the number of members remaining until commissioning.

Table 2: Number of Students Successfully Completing Credited Co-Curriculum (Accreditation) RELASIS Briged Session I: 2021/2022 – Session II: 2022/2023

Politeknik	SESSION	
	1 2021/2022	2 2022/2023
Politeknik Kota Bharu (PKB)	40	24
Politeknik Jeli Kelantan (PJK)	36	0
Politeknik Sultan Ahmad Shah (POLISAS)	28	0
Politeknik Sultan Salahuddin Abdul Aziz Shah (PSA)	5	0
Politeknik Banting Selangor (PBS)	39	9
Politeknik Port Dickson (PPD)	13	0
Politeknik Sultan Azlan Shah (PSAS)	20	20
Politeknik Ungku Omar (PUO)	35	8
Politeknik Sultan Abdul Halim Muadzam Shah (POLIMAS)	25	0
TOTAL	241	61



The findings obtained from the study found that the percentage of students who chose the RELASIS Brigade co-curriculum enrollment was very low when compared to students who registered for the first semester. There are only 39% of the 23 Malaysian Polytechnics that offer the RELASIS Brigade have first semester students who choose the RELASIS Brigade curriculum compared to 61% of the number of polytechnics that enroll in the RELASIS Brigade. The number of students who successfully completed the RELASIS Brigade co-curriculum up to the certification level was reduced compared to 75% of the number who registered for the co-curriculum in the first semester. From the research data, it has been shown that almost all Malaysian Polytechnics experienced a drastic decrease in the number of RELASIS Brigade members who were successfully commissioned compared to members who registered in the first semester.

Based on table 2, most polytechnics show that the majority of students do not continue RELASIS courses in semesters 3 and 4 that do not have credit. This finding supports the statement of Fadzil and Ahmad, 2010 that interest plays an important role for students to join the uniform body. If these students have a high interest in uniformed bodies, of course they will be actively involved in activities such as camping, marching drills, etc. By engaging in physical activities this can have a positive impact on the personal formation, discipline and personality of students. This statement is supported by Tze et. Al (2021) who stated that the potential of students can be highlighted through involvement in favorite co-curricular activities such as uniformed units and even participation in such units will give more meaningful effects and self-satisfaction to students.

Management factors also need to be paid attention to increase the percentage of students continuing the RELASIS Course in semesters 3 and 4. The intended management aspect is that polytechnic RELASIS course lecturers need to diversify teaching and learning sessions such as interactive theoretical learning guided by multimedia using mobile devices and not only focused on physical activities. According to Michael and Ambotang (2019), well-managed activities will attract students' interest to get involved in extracurricular activities because usually these activities become more systematic and effective. Other than that, institutions must also provide sufficient

facilities in line with the current syllabus to attract students' interest in joining the RELASIS Brigade. This is supported by the statement of Mohamed and Mohamed (2017) who explained the importance of co-curricular facilities that should satisfy the demands and needs of students in making extra-curricular activities a success.

According to a study conducted by Michael (2023) concluded that parental support is one of the factors that influence student involvement in extracurricular activities. In addition, the role of the teacher is also very important in ensuring the involvement of students more comprehensively in all co-curricular activities carried out (Wamin, 2015). When students get encouragement and recognition from other individuals, they tend to be more actively involved. Esa and Jamaluddin (2009) explained that lecturers play an important role as mentors to students in the formation of self-skills after engaging in extracurricular activities. Support from the students' community can also give them additional motivation to continue to get involved in joining the RELASIS Brigade and share their success with others who can also attract other students to participate in activities that suit the students' abilities.

5. Conclusion

The findings of this study can help the Department of Polytechnic Education and Community College and the Department of Malaysian Volunteers formulate a strategy to increase the membership of the RELASIS Brigade and attract the interest of polytechnic students to join the RELASIS Brigade as well as formulate a suitable syllabus for the age level of polytechnic students. Students who have interest and confidence in the activities to be carried out tend to be actively involved in uniformed units. A variety of co-curriculum activities should be provided to ensure students participate in the co-curriculum activities they are interested in (Fadzil and Ahmad, 2010). Support from family, peers and lecturers can also influence student involvement in the RELASIS Brigade. The Uniformed Body credit co-curriculum has been designed with a very good plan that every student who follows the Uniformed Body credit co-curriculum is finally accredited in the fourth semester. This certification is an added value for a student to face the world of work later towards producing quality TVET graduates.

Reference

- Ab. Alim Abdul Rahim (1999). *Pengurusan Kokurikulum*. Fajar Bakti Sdn Bhd.
- Ahmad Esa, Mohd Khir Mohd Nor, Nawawi Jusoh, Norashidah Abd Rahman & Zalinah Salehan (2015). *Citra Kokurikulum*. Universiti Tun Hussein Onn.
- Ahmad Esa, Jailani Md Yunos & Noraini Kaprawi (2004). *Peranan Kokurikulum Dalam Pembangunan Kemahiran Generik*. Kolej Universiti Tun Hussein Onn.
- Esa, A. & Jamaludin, H (2009). *Peranan Kokurikulum di Universiti dalam Membentuk Ketrampilan Mahasiswa*. Universiti Tun Hussein Onn
- Fadzil, N. S. & Ahmad, J. (2010). Kepentingan Kokurikulum dalam Pendidikan di Sekolah Menengah. *Proceedings of the 4th International Conference on Teacher Education*; Bandung, Indonesia
- Ibrahim, B., Mastor, S., Mohd Salleh, K. & Sulaiman, N.L. (2010). *Kemahiran Berpasukan Menerusi Penyertaan di Dalam Kokurikulum di Universiti Tun Hussein Onn Malaysia*. Universiti Tun Hussien Onn Malaysia.
- Jamaluddin Hj Badusah, Rosna Awan Hashim, Mohd Majid Konting, Turiman Suandi, Maria Salih & Norhafezah Yusof. (2009). *Pembangunan Pelajar: Memperkasakan Kokurikulum Institusi Pengajian Tinggi*. UPM.

- Micheal, S. & Ambotang, A. S. (2019). Hubungan Pengurusan Kokurikulum dengan Penglibatan Pelajar dalam Aktiviti Kokurikulum Sekolah Menengah. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 4(7), 202-207
- Mohd Majid Konting (1990). *Kaedah Penyelidikan Pendidikan*. Kuala Lumpur Dewan Bahasa dan Pustaka
- Mohamed, N.A.S., Mohamed, N.A., & Mohamed, N.H. (2017). Proses Pelaksanaan Pengurusan Kokurikulum yang Diamalkan oleh Kumpulan Pengurusan Kokurikulum (Kpp Koku) di Sekolah Menengah Harian, Lembah Klang, *Jurnal Kurikulum & Pengajaran Asia Pasifik*, 5(1), 32-54.
- Micheal, S. (2023). Pengaruh Minat Murid, Sokongan Ibu Bapa dan Kompetensi Guru Terhadap Penglibatan Murid dalam Aktiviti Kokurikulum. *Jurnal Pemikir Pendidikan*, 11(1), 36-49.
- Ong, T. C., Nazili, T. M. A. T. M., & Lai, C. S. (2021). Faktor-Faktor Yang Mempengaruhi Keterlibatan Pelajar Bidang Teknologi Kimpalan Dalam Ko-Kurikulum di Kolej Vokasional: Factors that Influence Welding Technology Students Involvement in Co-Curriculum at Vocational College. *Online Journal for TVET Practitioners*, 6(2), 80-90.
- Harrington, A. (2005). *Modern Social Theory*. 1-13.
- Teng Bon Teng (1984). *Pendidikan Jasmani di Sekolah Rendah (Edisi ke 2)*. Longman Malaysia Sdn Bhd.
- Vasudevan T. Arosoo (1988). *Kegiatan KoiKurikulum: Penyeliaan dan Pentadbiran*. Penerbit Fajar Bakti Sdn. Bhd.
- Wardatul Aishah Musa & Nooraini Othman (2014). Kesedaran Kendiri terhadap Aktiviti Kokurikulum dan Keberkesanannya kepada Remaja. *Proceeding of the Social Science Research, June 2014*.
- Wilson, N. L. (2009). *Impact of extracurricular Activities on Students*. Dicapai pada Februari 2012: <http://www2.uwstout.edu/content/lib/thesis/2009/2009wilsonn.pdf>.
- Wamin, A. (2015). *Hubungan antara Sikap Guru terhadap Aktiviti Kokurikulum dengan Pengurusan Kokurikulum Sekolah Berasrama Penuh di Negeri Selangor*. Tesis: Universiti Sultan Idris.
- Zulkiflee Haron & Aimi Ayuni Idris (2010). *Persepsi Pelajar terhadap Penerapan Kemahiran Generik dalam Aktiviti Kokurikulum di Kalangan Pelajar Tahun Dua Fakulti Pendidikan*. Universiti Teknologi Malaysia.
- Zulkifli Mansor (2008). *Pelaksanaan dan Penilaian Kemahiran Insaniah Dalam Mata Pelajaran kokurikulum Di UTHM*. Universiti Tun Hussein Onn.

Tiktok Addiction and Its Impact on Academic Performance Among Teenagers"

Amirah Othman^{1a*}, Mohamad Hafizul Mohd Zaid^{2b}

^aCommerce Department, Politeknik Sultan Abdul Halim Mu'adzam Shah

^bCommerce Department Politeknik Muadzam Shah

amirahothman@polimas.edu.my

Abstract

This study aimed to investigate the impact of using the Tiktok app on the academic performance of Polytechnic Sultan Abdul Halim Mu'adzam Shah (POLIMAS). A set of questionnaires was employed as quantitative approach in this study. A total of 164 respondent from the Commerce Department at POLIMAS. Data gathering was carried out using a survey on the use of social media and academic achievement. The data indicates that Tiktok is the most preferred social media platform, with a 70.3% favorability rating. Instagram, at 24.4%, was closely followed by YouTube, which had a mere 4.8% representation. On average, users dedicate 34 hours each month to the app. 124 participants, accounting for 75.2%, utilize the app for social purposes, while 12.1% use it for gaming and 8 individuals, representing 4.8%, use social media for academic reasons. Most survey participants believe that Tiktok moderately affects academics, with an average score of 3.36. Social media was demonstrated to improve students' communication abilities.

Keywords: Tiktok, Academic Performance

1. Introduction

The expansion of communication technologies in many ways, expanded the reach of communication, relationships, and information dissemination through the use of information and communication technology (ICT). People can now use the internet to quickly obtain desired information through both interpersonal and mass communication from other parts of the world.

The existence of social media is due to the development of digital technology in the cyber world. Social media can also be categorized as 'New Media' which refers to interactive or multimedia media and does not face any restrictions on transmission that goes beyond distance and time. According to Ruzian et al., (2019), new media is a unique and flexible educational platform in delivering knowledge effectively.

According to Global Digital Report 2024 it show the most substantial engagement is seen among younger demographics, particularly those aged 25 to 34, with 17.9% of users being male and 15% being female. Some of the social media platforms used by people in their daily lives include Facebook, Instagram, Whatsapp, Twitter, Tiktok, YouTube, Blogs and so on. The existence of this new media makes it easier for the community to engage with one another without needing to meet in person or online. In Malaysia, the usage of social media is not new; the number of social media users is growing and becoming more popular within the community. According to data given by DataReportal: Global Digital Insight (2023), 26.8 million Malaysians utilize social media in January 2023, accounting for 78.5% of the total population.

Based on these statistics, among the social media that recorded the highest amount of usage were Whatsapp, Facebook and Instagram. These data from social media platforms offer insights into how Malaysians allocate their time online, revealing a preference for sites that blend interesting, informative, and engaging content. Platforms like Tiktok have experienced rapid

growth, attracting a substantial user base, especially from certain demographics. Tiktok has the highest monthly audience engagement in terms of time spent, with the number of users spending an average of thirty eight hours and forty nine minutes on the platform each month followed by Youtube and Facebook with the average 36 hours per month and 17 hours per month . As reported by Berita Harian (2023), the average internet user in Malaysia is between the ages of 16 and 64, and spends two hours and 47 minutes per day on social media, which is more than the worldwide average of two hours and thirty-one minutes, based to the Digital 2023 report.

Educational institutions' principal purpose is to improve academic performance as evaluated by assessment outcomes. Schools and education institutions are always challenged to develop techniques and methods for enhancing their teaching approaches in order to meet the growing needs of students, sponsors, and society as a whole. Academic performance is the importance of education, representing the degree to which students, teachers, or educational institutions meet their educational goals. It is typically examined through exams or continual assessments. Mensah and Nizam (2016) examined the impact of social media on the academic performance of students at Malaysian tertiary institutions. Their findings indicated that social media platforms had a considerable impact on these pupils' academic achievement. Due to social platforms, today's younger generation has become heavily reliant on technology, hence researchers investigate the impact of Tiktok on student's academic performance. A limited study has been conducted in Malaysia focusing on polytechnic students to examine the impact of use of Tik Tok on academic performance of Politeknik Sultan Abdul Halim Mu'adzam Shah.

1.2 Objective of Study

The main objective of the research was to investigate the impact of tik tok on students' academic performance. The specific research objectives were:

- i. To examine the usage of Tiktok for academic related purposes
- ii To assess the impact use of Tiktok on students' academic performance.

1.4 Research Question

- i How is Tiktok used in learning?
- ii Does the use of Tiktok affect students' academic performance?

2. Literature Review

Kaplan (2015) describes social media as an internet-based program that aims to create and exchange of user-generated content based on Web 2.0 ideology and technology. Social media has been considered a catalyst for change for companies and individuals (Hennig-Thurau et. al, 2010). Hazim (2023) stated that social media, which is considered as a new medium, is a technological facility available to all walks of life aimed at facilitating daily affairs by being supported by improved internet networking. The existence of social media such as Facebook, Instagram, Whatsapp, Twitter, Tiktok, YouTube, Blog and so on helps users interact virtually (Hazim, 2023) as well as being a flexible and effective knowledge delivery platform (Ruzian et.al, 2019).

Despite the advantages created by social media, it also leads to negative effects if not controlled by its use such as impaired academic performance, anti-social, and inhibiting the psychological and social achievements of adolescents are frequently related with active usage of social media.(Samin, 2012). Samin (2012) also mentioned that when the use of social media is not properly controlled, it will also cause social media addiction. According to Aziz & Jamaludin

(2013) the problem of social media addiction causes disciplinary problems, failure of efficient time management, aloof.

According to Nurul Solehah and Zakiyah (2019) trust that teens are willingly influenced by the issue on social media and are probable to be more prone to attempt out content they get on social media. The negative influence of social media also involves browsing unhealthy content and this situation makes it difficult to contain it (Muhammad & Hadi, 2020).

Herlisya and Wiratno (2022) describe Tiktok as a social media application available for download in the Apps Store and Google Play. Tiktok originated in China, emerged as a Chinese social media and music video platform in September 2016. The app enables users may make short music videos. While known as Dou Yin in China, it was renamed Tiktok to appeal to a broader international audience, as the former name was less familiar outside of China.

Abigail & Caitlin (2022) explore the integration of Tiktok into higher education to enhance science communication skills. The study highlights that Tiktok activities encourage students to communicate research to wider, non-scientific audiences using contemporary information systems. It also emphasizes the necessity for creativity and understanding of science communication principles within the context of social media platforms like Tiktok.

Tabassum and Ahmed (2018) investigated the impact of Facebook addiction on undergraduate students' academic performance and discovered that students who were heavily addicted to Facebook had lower grade point average. The authors employed descriptive statistics analysis and hypothesis testing to conclude that Facebook addiction has a negative effect on students' academic performance. Fatimah & Lisa (2022) said social media has a positive impact on students being able to complete tasks through easily accessible information as well as adding new knowledge through social media searches. The negative impact involves the students' reliance on solving any problems only through social media other than the addiction to social media use which affects the student's focus while in the classroom which directly affects the student's academic performance. An increasing number of studies show that excessive use of social media, such as TikTok, can have a negative impact on academic achievement. An example is a research conducted in 2024 by Johnson and Lee which examined how using social media impacts academic results. They discovered that spending too much time on apps such as TikTok is connected to poorer academic performance in high school students (Johnson, T., & Lee, R., 2024).

The findings of a study by Arwansyah et.al (2022) stated that excessive exposure to social media will have an impact on students' thinking which in turn will have a direct impact on academic performance. Wan et. al (2017) states that social media does not negatively impact students' academic performance but poor time management contributes to the deterioration of students' academic achievement. The findings of the study by Ida & Ratna (2021) also in line with Wan et.al (2017) which states that the usage of social media has no direct effect on students' academic achievement but the existent of social media can be a relief for students from fatigue after struggling to complete assignments and revision. Past studies on social media and academic performance yielded mixed results, driving this study to investigate the impact of using the Tiktok app on the academic performance of Polytechnic Sultan Abdul Halim Mu'adzam Shah students.

3. Methodology

This study employs a quantitative research design to systematically investigate Tiktok addiction and its impact on academic performance among teenagers. Data collection technique have been

used in this study was direct questionnaire. This study surveyed 164 undergraduate students from the Commerce Department at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). Data collection was conducted using a questionnaire on social media use and academic performance, adapted from Sutarno (2019).

The questionnaire has been divided into two parts, A and B. Part A consisted of seven questions that collected personal information such as gender, year of study, study program, favorite forms of social media, and time spent on social media per week. Part B comprised 22 Likert-scale questions that investigated the use of social media and its impact on academic performance. Respondents could choose from five options: strongly agree (SA), agree (A), neutral (N), disagree (D), and strongly disagree (SD).

4. Result and Discussion

A total of 200 questionnaires were randomly distributed to undergraduate students from the Commerce Department at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS), with 164 (82%) being returned to the researcher.

Table 1: Preferred Social Media Platforms

Sites	Frequency	Percent
Facebook	0	0
Twitter	0	0
Instagram	40	24.4
Tiktok	116	70.3
Youtube	8	4.8
Total	164	100

From Table 1 respondents gave the following as their favourite social media sites. The analysis shows that Tiktok is the most favourite social media site with 70.3%. While followed by Instagram representing 24.4% and Youtube only 4.8% . This confirm by Digital Report (2023) show that Tiktok has the highest average time spent on the application with the 34 hours per month.

Table 2: Daily Time Spent on Social Media Platforms

Response	Frequency	Percent
0-1 hours	12	7.3
2-3 hours	56	33.9
4-5 hours	60	36.4
5-6 hours	20	12.1
More than 6 hours	16	9.7
Total	164	100

From 164 of the respondents representing 36.4 % indicated that they spent four to five hour, 60 respondents. While, respondent spent between two to three hours representing 33.9%. The last group is spent less than one hour with the 7.3%

Table 3: Why Students Engage with Social Media

Response	Frequency	Percent
Social	124	75.2
Games	20	12.1
Professional	12	7.3
Academic	8	4.8
Total	164	100

Based on Table 3, 124 respondents representing 75.2% said they use the social media for social reason, representing 12.1% use it to games purposes and 8 respondents representing 4.8% use social media for academic. According to finding above, analysis shows the majority of the respondents 95.2% do not use the social media platform for academic work.

Data Reliability Analysis

According to Hair et al. (2010), the reliability of a data is assessed by looking at the value of the Cronbach-alpha coefficient (in terms of consistency). Based on the Cronbach-alpha coefficient benchmark of 0.60 as suggested by Hair et al. (2010), all variables in this study have reached coefficient values that exceed 0.6. This means that all constructs have a high level of reliability. The test results are shown in Table 4 below.

Table 4: Data Reliability Test

Variable	Item	Cronbach Alpha
Usage of Tiktok	13	0.719
Impact of Tiktok	10	0.888

The percentage method was used to analyze the respondent's profile data. For the other study variables, the analysis was conducted using (a) Score Range Interpretation and (b) Mean Value Interpretation, as recommended by Mohd Najib Abd Ghafar (2003). Table 5 displays the mean range used to interpret the obtained mean score values.

Table 5: Interpretation Range Mean

Mean score	Interpretation	Level
1.00-2.33	Low	Weak
2.34-3.66	Medium	Medium
3.67-5.00	High	Good

Table 6: Students Feedback on the Usage of Social Media for Academic Related Purposes

Statements	Mean	Interpretation
I engage in academic discussion on social media platforms	3.71	Good
I make use of social media to share information with my classmates	4.20	Good
I follow the latest development in my field through social media	4.00	Good
I solely rely on information gotten from social media to do my assignment without consulting any other sources	2.83	Medium
Engaging in academic forums on social media confuses me	3.05	Medium
The time I spend online on social media is more than the time I spend reading academically by polytechnic	3.56	Medium
My unrestricted access to social media via cell phone distracts me in class	3.20	Medium
I won't do well academically if I stop using social media	2.90	Medium
Sometimes I use social media to understand what I have been taught in class	3.90	Good
Social media is encouraged by lecturer as part of assignment	3.93	Good
We have a social media group for some of my courses	4.10	Good
I have to use social media extensively because most of my course assignment/project are in the forms of blogs/online presentation	4.00	Good
I communicate with the lecturer through social media	3.83	Good
Average Mean	3.63	Medium

The first objective of the study is to evaluate the level of use of Tiktok on the for academics purposes. Table 6 shows the mean of Tiktok usage with an overall mean of 4.88. As many as 13 items were presented in this section, 8 items scored between 3.67 to 6 (questions 1-3,6-10). Two items questions 4 until 8 are at a moderate level with scores ranging from 2.34 to 3.66. The

majority of respondents agree that the use of Tiktok for academic related purposes at moderate level which is 3.63.

Table 7: Students feedback on the impact of Tiktok on academic performance

Statements	Mean	Interpretation
The time I spent online on social media takes away from my studying	3.29	Medium
Online social networks distract me from my studies	3.39	Medium
Social media have impacted my GPA positively	3.44	Medium
Social media have impacted my GPA negatively	3.02	Medium
Engaging in academic forums on social media confuses me	3.05	Medium
Sometimes I use social media to understand what I have been taught in class	3.90	Good
The usage of social media for class related research has helped improve my grades	3.76	Good
Social media has negatively impacted my writing skills courses	2.56	Medium
Social media has improved my communication skill	3.80	Good
Once I interrupt my study time with social media, I lose concentration	3.39	Medium
Average Mean	3.36	Medium

In order to answer the objective 2 of the study to identify the impact of the of Tiktok on academic's performance, there are 10 items presented. From the analysis conducted, the majority of respondents agree that tiktok has an impact on academics at a moderate level with an average mean of 3.36. It was found that 3 questions were at a good mean level with a mean range between 3.67 and 5.00. Item on question 6 which is the highest score with a value of 3.90. This means that Tiktok helps students in academic purposes. the item in question 7 got the lowest score with the mean value 2.56. Based on the overall average result as shown in table 6 above, it was found that the overall effect of using Tiktok for academic purposes is at moderate level with a mean value 3.36.

Table 8 : Correlation usage of social and impact on academic performance

		PDPSUM	Impact Academic Performance
Usage of Tiktok	Pearson Correlation	1	.376**
	Sig. (2-tailed)		.000
	N	164	164

****.** Correlation is significant at the 0.01 level (2-tailed).

From Table 8, there is a positive relationship between the usage of Tiktok and impact academic performance with the value 0.375 at a significant of 0.01 level. This indicates that more usage on Tiktok affects excellent academic performance. Therefore, spending much on Tiktok to low academic performance

5. Discussion and Conclusion

This study looked into the use of social media and how it affected students' academic performance. The result showed that Tiktok and Instagram are the mostly social media use by the student everyday live. The result of the study conducted by the statista research department (2019) was not the same study which found that youtube is becoming the most accessed social media in Indonesia following by whatsapp, facebook, instagram, and line. The study also discovered that the majority of respondents used social media for 2-3 hours per day, which is like to Nguyen (2017), who stated that Indonesians spend an average of 3 hours and 16 minutes on social media daily.

The results of the study on how social media use affects students' academic performance showed that social media positively influenced students' GPA. Then, using social media for class

study has helped students boost their grades. The statements imply that social media has a favorable impact on pupils' academic achievement. Furthermore, it was shown that social media helped student to enhance their communication skills. The finding contradicts Acheaw and Larson's (2015) report that the use of social media sites had a negative impact on students' academic work, showing a pressing requirement to familiarize students with the accessibility of novels and other educational resources that can assist them academically.

The study found that respondents' use of Tiktok had an adverse impact on their academic performance, but there was also a positive correlation. The study found that Tiktok is primarily used for social, not for academic purposes.

In conclusion, the findings of the study show a significant relationship between the use of tiktok and its impact on academic performance, which does not exceed a 0.05 significant correlation level.

Social media is a technological invention that is integrally linked to students' daily routines. Students favor social networking platforms like WhatsApp as their primary communication channels. Meanwhile, media sharing platforms such as Tiktok are employed to promote intellectual progress. Students utilize social media for academic purposes, not only to communicate with peers, but also with their lecturers. In addition to communication purposes, they utilized social media for academic enhancement and better comprehension of classroom lessons.

This research is restricted to basic descriptive analysis and sample size due to its concentration on a single department. It is recommended that future studies incorporate more detailed analysis techniques to produce clearer results. Future studies should investigate how gender affects academic performance through social media use.

6. Recommendations

According to the results, the researchers provided the following recommendations:

1. Set clear goals.
 - a. Define your purpose. Determine why you're using social media (for work, networking, or relaxation), and set clear goals for each.
 - b. Limit Time Utilized: Determine how long you would like to spend on social media each day or week.
2. Establish a schedule. Identify specific times.
 - a. Set aside particular times during the day for social media use, such as breaks or after work hours. Use timers.
 - b. Set timers to limit each session and ensure you don't go over your allotted time.
3. Prioritize tasks on to-do lists.
 - a. Create a daily to-do list, prioritizing critical things. Complete these tasks before using social media.
 - b. Time Blocking: Use time blocking to devote specific amounts of time to various pursuits, including social networking.
4. Minimize the notifications.
 - a. Turn Off Notifications: Disable unnecessary notifications to reduce distractions and the desire to continuously check your phone.
 - b. Batch Notifications: You can set your phone to receive notifications at certain periods rather than continuously.

5. Stay connected and educated.

- a. Learn and adapt: Stay up to date on the newest trends and tactics for efficient social media management.
- b. Educate yourself. Understanding the psychological effects of social media might help you better regulate its influence on your behaviours.

References

- Acheaw, M. Owusu., & Larson, Agatha, Gifty. (2015). Use of Social Media and its Impact on Academic Performance of Tertiary Institution Students: a Study of Students of Koforidua Polytechnic, Ghana. *Journal of Education and Practice*. Vol. 6. No.6. Pp. 94-101
- Arwansyah, K., Ahmad, S.M., Mohd, H., Abdul R., Faisal H. I., Shakila, A., & Sharifah, K. (2022). Impak Negatif Media Sosial Terhadap Akademik Pelajar: Kajian Kes Pelajar UTHM. *Human Sustainability Procedia*, 2(1), 16-25.
- Aziz & Jamaludin, R. (2013). Strategi Menangani Penggunaan Facebook dalam Kalangan Pelajar Sekolah Menengah: Satu Kajian Kes. *Jurnal Personalia Pelajar*, 16, 93-103.
- Datereportal Digital Global Insight. (2023). *Digital 2023: Malaysia*. <https://datereportal.com/reports/digital-2023-malaysia?rq=%20Malaysia>
- Fathimah, A. Z. N., & Lisa, G. R. (2022). Dampak Media Sosial Terhadap Prestasi Belajar Mahasiswa. *EDUSTUDENT: Jurnal Ilmiah Pendidikan Dan Pengembangan Pembelajaran*, 1(3), 188-193.
- Harian, W. B. (2023, February 11). Rakyat malaysia habiskan hampir tiga jam sehari guna media sosial. *Berita Harian*.
- Hamizi, M. A. F. M. (2023). Penggunaan Media Sosial Sebagai Media Baharu dan Impaknya Terhadap Masyarakat Malaysia. *Perspektif Jurnal Sains Sosial dan Kemanusiaan*, 15, 24-37.
- Herlisya, Destia, dan Purna Wiratno. 2022. "Having Good Speaking English through Tik Tok Application". *Journal Corner of Education, Linguistics, and Literature* 1 (3):191-98. <https://doi.org/10.54012/jcell.v1i3.35>.
- Hennig-Thurau, T., Malthouse, E. C., Friege, C., Gensler, S., Lobschat, L., Rangaswamy, A., & Skiera, B. (2010). The impact of new media on customer relationships. *Journal of service research*, 13(3), 311-330.
- Howe, S. (2024, May 6). Social Media statistics for Malaysia [Updated 2024]. *Meltwater*. <https://www.meltwater.com/en/blog/social-media-statistics-malaysia>
- Ida, N. N., & Ratna, R. A. R. (2021). Hubungan antara ketagihan media sosial dengan pencapaian akademik: Kajian di Fakulti Ekologi Manusia, Universiti Putra Malaysia (UPM). *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 6(7), 54-62.
- Johnson, T., & Lee, R. (2024). "Impact of Social Media Usage on Academic Performance Among High School Students." *Journal of Educational Psychology*, 116(1), 85-95.
- Kaplan, A. M. (2015). Social media, the digital revolution, and the business of media. *International Journal on Media Management*, 17(4), 197-199.
- Khan, N. T., & Ahmed, S. (2018). Impact of Facebook addiction on students' academic performance. *Research Medical and Engineering Sciences*, 5(2), 424-426.
- Mohd. Najib Abdul Ghafar. (2003). Reka bentuk tinjauan soal selidik Pendidikan. Johor:Penerbit Universiti Teknologi Malaysia.
- Markom, R., Zainol, Z. A., & Fuad, N. A. (2019). Literasi perundangan media baharu dalam kalangan belia. *Jurnal Komunikasi; Malaysian Journal of Communication*, 35(3), 372-389.
- Muhammad, F., & Hadi, M. (2020). Penggunaan Media Sosial di Kalangan Siswa Sekolah Dasar. *Diniyah: Jurnal Pendidikan Dasar*, 1(1), 46-52.
- Mensah, Sandra Okyeadie., & Nizam, Ismail. (2016). The Impact of Social Media on Students' Academic Performance-A Case of Malaysia Tertiary Institution. *International Journal of Education, Learning and Training*. Vol.1. No.1. Pp.14-21.

- Nguyen, Han. (2017). Indonesia is Fastest Growing Country for Internet use. [Online]. Available: <https://www.google.com/amp/s/amp.rappler.com/world/regions/asia-pacific/indonesia/bahasa/englishedition/159593-internet-social-media-statistics>. [20-05-2019].
- Nurul Solehah, C. R., & Zakiyah J. (2019). Kesan penggunaan media sosial terhadap tingkah laku pelajar. e-Prosiding SMTComm'19 (e-ISBN 978-967-16435-5-6)
- Radin, A. G., & Light, C. J. (2022). TikTok: An emergent opportunity for teaching and learning science communication online. *Journal of microbiology & biology education*, 23(1), e00236-00221.
- Ruzian, M., Zainatul Ashiqin, Z., & Nurhidayah, A. F. (2019). Literasi perundangan media baharu dalam kalangan belia. *Jurnal Komunikasi: Malaysian Journal of Communication* 35(3), 372-389.
- Samin, Z. (2012). Pengaruh Ketagihan Internet Terhadap Kecerdasan Emosi dalam Kalangan Pelajar Kolej Komuniti Bandar Penawar. *Bandar Penawar. Johor*.
- Statista Research Department. (2019). Indonesia: social network penetration Q3 2018. [online]. Available: <https://www.statista.com/statistics/284437/Indonesia-social-network-penetration/>. [20-05-2019]
- Sutarno, S. (2019). The Impact of Social Media Usage On Students' Academic Performance (SAP). Wan R. W. O., Ziti F. M. A., & Nurul, H. N. (2017). Impact of social media usage on students' Academic performance in Terengganu, Malaysia. *Journal of Applied Environmental and Biological Sciences*, 7(5), 140-144.

HEALTH AND LIFE SCIENCES

"HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY"

Preliminary Investigation on the Use of Organic Waste as a Medium for Fast-Acting Biofiltration Systems

Mohamad Azlan Yusuff Abdul Rahim^{1*}, Mugilan Nalliannan², Darshini Sree Ahnathan³ & Azizah Alias⁴

¹Politeknik Nilai, Malaysia

Abstract

Environmental disasters and water crises can make access to clean water a critical challenge for many communities, often leading to severe health risks. The high costs and complexities of rapid filtration systems exacerbate this problem. This study aims to address these challenges by developing a biofilter that uses various fruit waste materials—specifically orange peels, sugarcane bagasse, and watermelon rinds—as filtration media. Turning fruit waste, which typically contributes to environmental pollution, into a resource for water treatment offers a sustainable approach, especially during times of crisis. To assess the effectiveness of these biofilters, we evaluated their performance using multiple criteria, including chemical oxygen demand (COD), biochemical oxygen demand (BOD), total coliform count, total ammoniacal nitrogen, pH, total dissolved solids (TDS), total suspended solids (TSS), and filtration rate. We compared the results to the Class IIB National Water Quality Standards (DOE, 2023) to determine whether the fruit waste biofilters meet required water quality levels. The analysis revealed that sugarcane bagasse was the most effective filtration medium, followed by orange peels, with watermelon rinds being the least effective of the three. These findings offer important insights into using fruit waste for biofiltration and suggest a cost-effective, sustainable solution for emergency water treatment. This research contributes to innovative methods of fruit waste utilisation, addressing the pressing need for accessible clean water in the wake of environmental disasters and water crises.

Keywords: Environment, Wastewater Treatment, Biofilters, Waste Management

1. Introduction

Access to clean and safe drinking water is crucial for human health and well-being, particularly during environmental disasters such as floods and water crises, which can compromise traditional water treatment infrastructure (Singh & Sirinivasan, 2019). These crises often result in high raw water turbidity, halting operations at Water Treatment Plants (WTP) and necessitating rapid, innovative water treatment solutions. While rapid filtration systems exist, their high costs and limited accessibility highlight the need for affordable, sustainable alternatives.

This preliminary study aims to evaluate the effectiveness of fruit waste in the form of orange peel (OP), sugarcane bagasse (SB), and watermelon rind (WR) as biofilter media for water treatment in environmental disasters. By examining their porosity, surface area, adsorption capacity, and filtration efficiency (Alvarado et al., 2020), the study assesses their suitability against key water quality parameters such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), total coliform count, total ammoniacal nitrogen, pH, total dissolved solids (TDS), and total suspended solids (TSS). The effectiveness of these fruit waste biofilters is compared to the Class IIB National Water Quality Standard (DOE, 2023) to determine their potential in providing safe and clean water during crises.

2. Method

Preparation of FPW

Fruit waste was washed with distilled water, cut into pieces, and sun-dried for 48 hours. Further drying was done in an oven at 65°C. The dried waste was ground into fine powder and sieved to 0.25mm. The powder was treated with 5% sulfuric acid (H₂SO₄) and washed with distilled water until neutral pH was achieved, then dried again at 65°C then stored in airtight containers.

Preparation of Biofilters

Fifteen centrifuge tubes were cleaned and filled with 2 cm of coarse gravel at the bottom. The tubes were then filled with 2 cm of fruit waste (three tubes), 1 cm of fine gravel and 1 cm of fine sand (positive control, three tubes) and no media (negative control, three tubes). The tubes were secured on a retort stand, and universal bottles were placed underneath to collect filtered water.

Filtration Process

Filtration was performed using pond water from Kompleks Pendidikan Bandar Enstek. For each set (orange peel, watermelon rind, sugarcane bagasse, positive control, negative control), 30 ml of water was poured into the centrifuge tubes sequentially. The time taken for filtration was recorded for each tube.

Pre- and Post-Water Quality Analysis

Pre-treatment samples (unfiltered) were analysed for filtration rate, include Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Coliform Count, pH, and Total Ammoniacal Nitrogen. Post-treatment samples (filtered through triplicate media) underwent the same analyses. The removal efficiency and percentage for each parameter were calculated by comparing pre- and post-treatment results.

Results & Discussion

Pre-Test Results

The results for the pre-test are depicted in *Table 1*. The pre-test COD value is 46 mg/L, indicating a substantial presence of organic pollutants in the water. The BOD value is 3.9 mg/L. Although this value is relatively moderate, it still indicates the presence of biodegradable organic pollutants. The TSS value is 17.3 mg/L, reflecting the concentration of particulate matter suspended in the water. The TDS value is 625 mg/L, indicating a high concentration of dissolved substances, including salts and minerals. The total coliform count is 1.25 CFU, indicating microbial contamination. The pH value of the pre-test water is 6.43, which is slightly acidic but within the acceptable range for most water uses. The total ammoniacal nitrogen value is 0.245 mg/L, indicating the presence of nitrogen compounds, which can contribute to nutrient pollution and eutrophication.

Table 1: Pre-Test Results of Water Sample

Parameters	Results (mg/L)
Chemical Oxygen Demand (COD)	46 mg/l
Biochemical Oxygen Demand (BOD)	3.9mg/l
Total Suspended Solid (TSS)	17.3mg/l
Total Dissolved Solid (TDS)	625mg/l
Total Coliform Count (TCC)	1.25 CFU
pH Value	6.43pH
Total Ammoniacal Nitrogen (TAN)	0.245mg/l

Post-Test Results

The T-Test results in *Table 2* portrayed that the non-significant T values across comparisons indicate that all three biofilter media (OP, SB, WR) perform similarly to the positive controls in this study. This underscores their potential as effective alternatives in water treatment applications, particularly during environmental crises where traditional methods may be compromised or insufficient.

Table 2: Comparison of Control

Comparison	T value	Alpha value
Positive Control & Orange Peel	0.017	0.05
Negative Control & Orange Peel	0.158	0.05
Positive Control & Sugarcane Bagasse	0.007	0.05
Negative Control & Sugarcane Bagasse	0.002	0.05
Positive Control & Watermelon Rind	0.091	0.05
Negative Control & Watermelon Rind	0.061	0.05

The data in *Table 3* portrays filtration results of fruit waste along with positive and negative control. COD is a crucial indicator of organic pollution in water. The OP medium demonstrated the lowest COD at 5 mg/L, indicating superior removal of organic compounds compared to WR (150 mg/L) and SB (57.7 mg/L). The positive and negative controls had COD values of 33.7 mg/L and 35 mg/L, respectively. These results suggest that OP is significantly more effective in reducing organic pollutants than WR and SB. BOD measures the amount of oxygen required by microorganisms to decompose organic matter. OP had a BOD of 24 mg/L, which was comparable to WR (25 mg/L) but much higher than SB (6.3 mg/L). The positive control registered a BOD of 4 mg/L, and the negative control had 4.9 mg/L. This indicates that while OP and WR are similar in performance, SB excels in reducing biodegradable organic matter.

Table 3: Filtration Results

Parameter	OP	WR	SB	Positive Control	Negative Control
Chemical Oxygen Demand (COD)	5mg/l	150mg/l	57.7mg/l	33.7mg/l	35mg/l
Biochemical Oxygen Demand (BOD)	24mg/l	25mg/l	6.3mg/l	4mg/l	4.9mg/l
Total Suspended Solid (TSS)	12.5mg/l	14.7mg/l	8.1mg/l	8.8mg/l	10.5mg/l
Total Dissolved Solid (TDS)	502.3mg/l	502.8mg/l	416.3mg/l	476.17mg/l	550mg/l
Total Ammoniacal Nitrogen (TAN)	0.027mg/l	0.628mg/l	0.079mg/l	0.235mg/l	0.343mg/l
pH	4.61	3.77	4.75	6.21	6.17
Total Coliform Count (TCC)	0 CFU	0 CFU	0 CFU	0.5CFU	0.67CFU
Filtration Rate	1.22ml/s	0.87ml/s	0.788ml/s	1.123ml/s	1.373ml/s

TSS is a measure of the particulate matter in water. OP had a TSS of 12.5 mg/L, WR had 14.7 mg/L, and SB had 8.1 mg/L. The positive control showed 8.8 mg/L, and the negative control had 10.5 mg/L. SB was the most effective in reducing suspended solids, followed by OP and WR. TDS indicates the concentration of dissolved substances in water. OP had a TDS of 502.3 mg/L, WR had 502.8 mg/L, and SB had 416.3 mg/L. The positive control had a TDS of 476.17 mg/L, while the negative control showed 550 mg/L. SB was again the most effective medium for reducing dissolved solids.

Ammoniacal nitrogen is a key indicator of nitrogen pollution. OP showed the lowest value at 0.027 mg/L, significantly outperforming WR (0.628 mg/L) and SB (0.079 mg/L). The positive and negative controls had values of 0.235 mg/L and 0.343 mg/L, respectively, underscoring OP's superior performance in removing ammoniacal nitrogen. The pH of water is a critical parameter for assessing its suitability for various uses. OP had a pH of 4.61, WR had 3.77, and SB had 4.75.

The positive control registered 6.21, and the negative control had 6.17. All three media showed acidic pH levels, with WR being the most acidic.

Total coliform count is an indicator of microbial contamination. OP, WR, and SB all registered 0 CFU, indicating no coliform presence. The positive control had 0.5 CFU, and the negative control had 0.67 CFU, confirming the effectiveness of all three media in eliminating coliform bacteria. The filtration rate is crucial for evaluating the efficiency of the filtration process. OP had a rate of 1.22 ml/s, WR had 0.87 ml/s, and SB had 0.788 ml/s. The positive control showed 1.123 ml/s, while the negative control had 1.373 ml/s. OP had the highest filtration rate, suggesting it is the most efficient in terms of throughput.

Table 4: Comparison of Filter Performance with Class IIB National Water Quality Standard

Post	Orange Peel	Watermelon Rind	Sugarcane Bagasse	National Water Quality Standard (Class IIB)
Chemical Oxygen Demand (COD)	5mg/l	150mg/l	57.7mg/l	25mg/l
Biochemical Oxygen Demand (BOD)	24mg/l	25mg/l	6.3mg/l	3mg/l
Total Suspended Solid (TSS)	12.5mg/l	14.7mg/l	8.1mg/l	50mg/l
Total Dissolved Solid (TDS)	502.3mg/l	502.8mg/l	416.3mg/l	-
Total Ammoniacal Nitrogen (TAN)	0.027mg/l	0.628mg/l	0.079mg/l	0.3mg/l
pH	4.61pH	3.77pH	4.75pH	6-9pH
Total Coliform Count (TCC)	0 CFU	0 CFU	0 CFU	5000CFU
Filtration Rate	1.22ml/s	0.87ml/s	0.788ml/s	-

While SB has certain advantages in BOD, TSS, and TDS reduction, OP demonstrates superior overall performance across multiple parameters, including the critical COD, total ammoniacal nitrogen, and filtration rate. OP's efficiency in removing a broad spectrum of pollutants, combined with its high filtration rate, makes it the best choice among the three-filter media.

The higher filtration rate of OP ensures that larger volumes of water can be treated in less time, which is an essential factor for scalability and practicality in real-world applications. Additionally, its superior performance in reducing harmful compounds such as organic pollutants and ammoniacal nitrogen highlights its effectiveness in enhancing water quality. The results in *Table 4* depicts OP as the best filter media when compared to the Class IIB water quality standard due to its exceptional performance in reducing COD, total ammoniacal nitrogen, and total suspended solids. Despite challenges in meeting the BOD and pH standards, OP's overall effectiveness in multiple parameters makes it a promising choice for biofiltration applications, especially where high organic pollutant removal and efficient filtration rates are crucial.

This physical characteristic of OP allows for increased contact between the contaminants in the water and the biofilter material, enhancing the adsorption and filtration processes (Sun et al., 2014). Orange peels contain various organic compounds, including pectin, cellulose, hemicellulose, and lignin, which have been found to possess adsorptive properties (Li et al., 2012). These components can bind with heavy metals, dyes, and other pollutants through various mechanisms such as ion exchange, complexation, and hydrogen bonding. Orange peel has a fibrous structure that provides a high surface area and significant porosity. Furthermore, the essential oils present in OP, such as limonene and other terpenes, have natural antimicrobial properties. These compounds can inhibit the growth of harmful bacteria and other microorganisms, making the biofilter more effective in reducing microbial contamination in water (Kim & Marshall, 2021).

3. Implications and Direction for Future Research

The study reveals that each filtration medium has its strengths and weaknesses. OP excels in reducing COD, ammoniacal nitrogen, and has the highest filtration rate. SB is most effective in reducing BOD, TSS, and TDS. WR, while less effective overall, still performs adequately in some parameters. These findings highlight the importance of selecting the appropriate filtration medium based on specific water quality needs. Future research should explore the long-term performance and cost-effectiveness of these media in real-world applications. Additionally, combining different media could potentially optimise overall water quality treatment.

Acknowledgement

We would like to extend our sincere gratitude to all individuals and institutions who contributed to this research. Special thanks to Politeknik Nilai, who's financial and facility support made this study possible. We appreciate the efforts of the reviewers and editors for their constructive feedback, which greatly improved the quality of this paper.

References

- Alvarado-Gutiérrez, M. L., Castañeda-Sandoval, L. M., & Ibarra-Junquera, V. (2020). Use of Fruit Waste as a Low-cost Adsorbent for Wastewater Treatment: A review. *Journal of Environmental Management*, 260, 110095. DOI: 10.1016/j.jenvman.2020.110095
- American Water Works Association. (2019). Standard Methods. Retrieved July 3, 2024, from <https://www.awwa.org/>
- Department of Environment Malaysia. (n.d.). National River Water Quality Standards and River Water Quality Index. Retrieved July 3, 2024, from <https://www.doe.gov.my/en/national-river-water-quality-standards-and-river-water-quality-index/>
- Kim, J., & Marshall, M. R. (2021). Antibacterial Activity of Limonene Against Gram-positive and Gram-negative Bacteria. *Letters in Applied Microbiology*, 73(5), 570-577. DOI: 10.1111/lam.13690
- Singh, N., & Srinivasan, V. (2019). Water Crisis through the Analytic of Urban Transformation: An Analysis of Bangalore's hydrosocial regimes. *Development Southern Africa*, 36(4), 504-518. DOI: 10.1080/02508060.2019.1578078
- Li, Y., & Li, Y. (2012). Adsorption of Metal Ions on Lignin. *Journal of Hazardous Materials*, 243, 168-177. DOI: 10.1016/j.jhazmat.2012.10.024
- Sun, X., Wang, C., Li, Y., & Wang, L. (2014). Adsorption of Reactive Dyes on Activated Carbon Developed from *Enteromorpha Prolifera*. *American Journal of Analytical Chemistry*, 5(17), 1164-1174. Available at: <https://www.scirp.org/journal/ajac/>

The Effectiveness of Tannic Acid from Tea Waste as a Coagulant for Reducing Solids & Cod in Wastewater Treatment

Mohamad Azlan Yusuff Abdul Rahim^{1*}, Is Aizat Samsuri², Nurul Syafika Zulkifli³, Siti Nurafiqah Nasir⁴ & Muhammad Hariz Hazwan Hamidi⁵

¹Politeknik Nilai, Malaysia

Abstract

Tea is one of the most popular beverages globally, second only to water. The worldwide demand for tea is growing rapidly, a trend expected to continue for the next decade. While this surge in production meets market demand, it also generates substantial tea waste, contributing to environmental issues. This study explores the sustainable use of tea waste by extracting tannic acid and investigates its potential as a solid coagulant, which could function similarly to aluminium sulphate. Municipal wastewater typically contains a mix of suspended particles, organic matter, and pathogens, with organic materials ranging in size from under 0.001 μm to over 100 μm . Untreated wastewater can introduce organic and solid waste into water bodies, causing undesirable changes in colour, turbidity, and dissolved oxygen levels. To avoid these environmental impacts, regulations set limits on total suspended solids (TSS) and biochemical oxygen demand (BOD) in municipal wastewater discharges. Given the need for effective wastewater treatment, this study aims to test tannic acid extracted from tea waste as a coagulant in comparison to aluminium sulphate. The research involves four key tests to assess coagulant efficiency in wastewater treatment: total dissolved solids (TDS), total suspended solids (TSS), and chemical oxygen demand (COD). By evaluating these parameters, the study seeks to determine if tea waste-derived tannic acid can be a sustainable and effective alternative for treating municipal wastewater, reducing environmental impact, and providing a beneficial use for tea industry by products.

Keywords: Environment, Wastewater Treatment, Coagulant, Tannic Acid

1. Introduction

Coagulation is a fundamental process in wastewater treatment, essential for removing suspended solids and reducing chemical oxygen demand (COD). Traditional coagulants, such as alum and ferric chloride, have been widely used for their effectiveness (Koul et al., 2022). However, these chemical coagulants often present environmental and economic challenges, including the production of hazardous sludge and high operational costs. As the demand for sustainable and eco-friendly treatment methods grows, the search for natural alternatives becomes increasingly important. This study investigates the use of tannic acid derived from tea waste as a natural coagulant (Debnath et al., 2021).

Tannic acid, a polyphenolic compound, is abundant in tea waste and offers several advantages over conventional coagulants. It is biodegradable, renewable, and cost-effective, making it an environmentally friendly option. Additionally, tannic acid has shown promising coagulation properties, capable of effectively reducing suspended solids and COD in wastewater. The research aims to evaluate the coagulation performance of tannic acid, comparing it to alum under various conditions. By optimising the application of tannic acid, this study seeks to enhance the efficiency of wastewater treatment processes while minimising environmental impact. The results could pave the way for more sustainable and economically viable wastewater management practices, leveraging the potential of agricultural waste products.

2. Method

Extraction of Tea Waste

Tea waste, sourced from local plantations and discarded tea bags, underwent washing with distilled water to remove impurities and decolorization using hot water, followed by drying at 110°C for 20 minutes. The dried tea waste was then crushed and prepared for further experimentation. In order to extract tannic acid, 300g of crushed tea leaves were soaked in 600ml of an 80% acetone solution and left to stand for 24 hours. The resulting mixture was filtered through filter paper to separate the acetone extract containing tannic acid from the residual solids. The acetone was evaporated using a rotary evaporator to concentrate the solution, yielding water and tannic acid.

Jar Test

The extracted tannic acid was then evaluated in a jar test, which simulated coagulation and flocculation processes in water treatment. Five glass beakers were filled with 1000ml of wastewater samples, and varying concentrations of tannic acid (55ml, 75ml, 95ml, 115ml, and 135ml) and aluminium sulphate (160ml, 180ml, 200ml, 220ml, and 240ml) were added to each beaker. The solutions were agitated at 200 rpm for 20 minutes to form microfloc particles, followed by a reduced speed of 20-30 rpm for an additional 5 minutes to encourage macro floc formation. The clarity of the treated water and the settling rate of solids were observed to determine the optimal coagulant dosage.

Water Quality Test

Concurrently, the treated water samples underwent chemical analysis. The Chemical Oxygen Demand (COD) was determined using a Tintometer method, where samples were mixed with reagents and heated to 110°C for two hours, followed by spectrophotometric measurement. Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) were measured using filtration and drying techniques. TDS involved filtering and drying a known volume of sample to determine the residue weight, while TSS required filtration through a pre-weighed glass fibre filter and subsequent drying. Total Solids (TS) were determined by evaporating a known volume of sample and measuring the residual weight after drying. Each step ensured precise quantification of solids present in the samples.

Results and Discussion

The performance of tannic acid and alum as coagulants in wastewater treatment was evaluated by measuring the reduction in Total Dissolved Solids (TDS), Total Suspended Solids (TSS), and Chemical Oxygen Demand (COD) before and after coagulation. Based on the jar test conducted, the optimum concentration for tannic acid was 95 ml/L and alum was 240ml/L. The results are summarised in Table 1 and Table 2.

Table 1: Optimum Concentration of Tannic Acid Coagulation

Parameters	Tannic Acid Concentration (ml/l)	Before Coagulation (mg/L)	After Coagulation (mg/L)
TDS	95	1001.65	1.693
TSS	95	2.7	1.054
COD	95	1.01	6.01

Both tannic acid and alum demonstrated high efficiency in reducing TDS, which is indicative of their strong capability to remove dissolved ions and small particles from wastewater. Tannic acid achieved a reduction of 99.83%, slightly outperforming alum, which showed a reduction of 99.33%. The marginally better performance of tannic acid may be attributed to its

higher affinity for binding with dissolved ions, facilitating more efficient removal (Liu & Lan, 2018).

Table 2: Optimum Concentration of Tannic Acid Coagulation

Parameters	Alum concentration (ml/l)	Before coagulation (mg/L)	After coagulation (mg/L)
TDS	1001.65	1001.65	6.7
TSS	2.7	2.7	6.3
COD	1.01	1.01	0.64

For TSS reduction, which measures the effectiveness of the coagulants in removing larger particulate matter from the wastewater, tannic acid and alum showed reductions of 61.11% and 57.14%, respectively. Tannic acid's slightly higher reduction percentage suggests that it may form larger or more stable flocs, which can be more readily settled out of suspension (Butler & Ford, 2018). The effectiveness of tannic acid in reducing TSS is significant as it directly impacts the clarity and quality of the treated water.

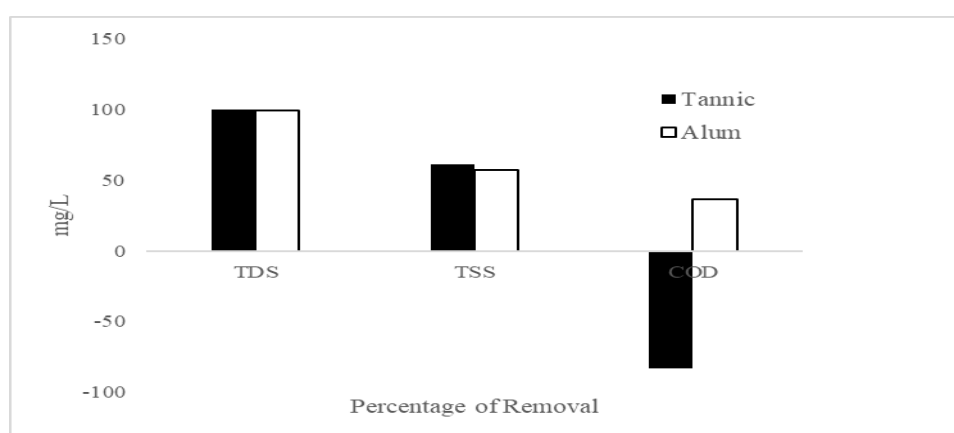


Figure 1: Percentage of Removal Using Optimum Concentration

The reduction in COD is a crucial parameter as it indicates the effectiveness of the coagulant in removing organic pollutants from wastewater. However, in this study, tannic acid resulted in a significant increase in COD by 83.19%, indicating that it introduced more organic matter into the wastewater rather than removing it. This unexpected outcome could be due to the release of organic compounds from the tannic acid itself (Wang et al., 2019), suggesting that while tannic acid may be effective in removing certain types of pollutants, it may simultaneously contribute to an increase in COD. receiving water bodies.

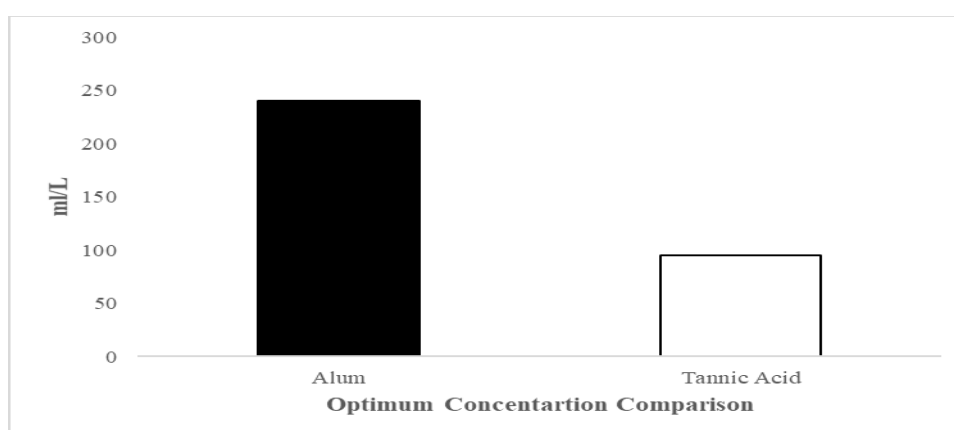


Figure 2: Comparison of Optimum Concentration of Coagulant

The concentration of the coagulants used is a critical factor in assessing their performance and cost-effectiveness (*Figure 2*). In this study, alum was used at a concentration of 240 ml/L, whereas tannic acid was used at a much lower concentration of 95 ml/L. Despite the significantly lower dosage, tannic acid achieved higher reductions in TDS and TSS compared to alum. This indicates that tannic acid is more potent as a coagulant, requiring less material to achieve similar or better results. The lower dosage requirement for tannic acid can lead to reduced operational costs and lower environmental impact due to less chemical usage and residue generation.

3. Implications and Direction for Future Research

Tannic acid achieved higher reductions in TDS and TSS, indicating its greater efficacy in removing both dissolved and suspended solids. In this study, alum was used at a concentration of 240 mg/L, whereas tannic acid was used at a much lower concentration of 95 mg/L. Despite the significantly lower dosage, tannic acid achieved higher reductions in TDS and TSS compared to alum. This indicates that tannic acid is more potent as a coagulant, requiring less material to achieve similar or better results. The lower dosage requirement for tannic acid can lead to reduced operational costs and lower environmental impact due to less chemical usage and residue generation.

However, the higher COD observed with tannic acid suggests a trade-off between its efficiency in removing solids and its impact on organic load. The lower concentration of tannic acid may also reflect its higher reactivity and ability to form more effective flocs at lower dosages. Further optimization of tannic acid concentration could potentially mitigate the increase in COD, enhancing its overall performance.

Acknowledgment

We would like to extend our sincere gratitude to all individuals and institutions who contributed to this research. Special thanks to Politeknik Nilai, who financial and facility support made this study possible. We appreciate the efforts of the reviewers and editors for their constructive feedback, which greatly improved the quality of this paper.

References

- American Water Works Association. (2019). *Standard Methods*. Retrieved July 3, 2024, from <https://www.awwa.org/>
- Butler, B. A., & Ford, R. G. (2018). Examining the Impact of Total Suspended Solids on Water Quality. *Environmental Science & Technology*, 52(10), 5848-5856. <https://doi.org/10.1021/acs.est.7b06476>
- Debnath, B., Halder, D., & Purkait, M. K. (2021). Potential and Sustainable Utilisation of Tea Waste: A Review on Present Status and Future Trends. *Journal of Environmental Chemical Engineering*, 9(5), 106179. <https://doi.org/10.1016/j.jece.2021.106179>
- Koul, B., Bhat, N., Abubakar, M., Mishra, M., Arukha, A. P., & Yadav, D. (2022). Application of Natural Coagulants in Water Treatment: A Sustainable Alternative to Chemicals. *Water*, 14(22), 3751. <https://doi.org/10.3390/w14223751>
- Liu, J., & Lan, Y. (2018). Efficiency of Tannic Acid in Coagulation and Flocculation for Drinking Water Treatment. *Journal of Water Process Engineering*, 25, 145-151. <https://doi.org/10.1016/j.jwpe.2018.07.002>
- Wang, L., Wang, L., & Wang, H. (2019). Tannic Acid as a Natural Coagulant for Water Purification: Mechanisms and Performance. *Science of the Total Environment*, 646, 1296-1303. <https://doi.org/10.1016/j.scitotenv.2018.07.002>

Study of Malay Traditional Architecture Approach in Landscape Architecture Design

Mohamad Hafiz Sulaiman¹

¹Department of Agrotechnology & Bio-Industry Polytechnic Nilai, Malaysia

Abstract

The landscape design principles in Malay traditional architecture are guided by philosophical and cultural values, such as the balance between built and natural environments, the use of indigenous plants, and the strategic placement of water features. These elements not only create visually pleasing and serene surroundings but also support local biodiversity and sustainable living. The study also delves into the symbolic meanings of various landscape elements, such as the placement of gardens, trees, and courtyards, which reflect societal hierarchies, spiritual beliefs, and community practices. Through a comprehensive analysis of literature review, and interviews with practice architects, this research highlights the importance of preserving and adapting traditional landscape design practices in contemporary urban planning and development. By drawing lessons from Malay traditional architecture, modern landscape design can achieve a harmonious balance between cultural heritage and ecological sustainability, offering valuable insights for creating resilient and culturally enriched environments. Findings shown that several elements in landscape architecture that should be focus on Malay traditional approach such softscape, hardscape, types of material used, functionality, and arrangement. Based on analysis, findings shown that all the informants agreed several selections of Malay traditional approaches in architecture such plants selection, wooding with carving elements, functionality and arrangement are the most importance parts as representing Malay traditional approach in landscape architecture. Based on the findings from interviews session, this research can conclude that Malay traditional architecture also can be blend into landscape architecture design which is some importance elements such softscape and functionality the most importance part as to consider to put on landscape design as to representing Malay traditional approach plants selection on planting design by using edible and fruits plants, functionality approach such seating design looked like decking for cross-legged type, and lastly combination materials selection between brick and wood materials. Material selection such as solid wood application on structure or carving method on wood also should be put on consideration and lastly hardscape and arrangement element on design such decking, compound areas usually shown Malay house has very wide areas because most of Malay community live in suburban areas especially on north, east coast, and west coast of peninsular Malaysia.

Keywords: Landscape Architecture, Malay Traditional Architecture Design, Landscape Elements.

1. Introduction

Landscape architecture is defined as an activity of the arrangements of open spaces, in aiming to add natural elements that improve urbanized landscapes. Malaysia is known for its diversity in cultures which has high impact on landscape architecture design. The studies by Nor Zalina Harun, Noor Aziah Mohd Ariffin, Fadiah Abdullah (2017) regarded that cultural landscape or adding cultural elements into designing landscape is the most complex, since it involves the interactions between man, nature, cultural values, and the associated built environment. The traditional Malay Landscape involves a balanced interaction between these aspects which contains unique and interesting features for each state in Malaysia.

The characteristics of landscape design for each state in Malaysia has unique features that slightly differentiates them from each other. Ahmad Zamil Zakaria, Ismail Hafiz Salleh, Mohd

Sabrizaa Abd. Rashid (2013) on their research stated that the landscape design that incorporated Malay culture is a complex blend of culture and artistic values, originating from ancient Malays' palaces and houses. Despite not having strong landscape design components, the old Malay gardens' furniture and hard elements are significant. Malay cosmologies are influenced by art, design composition, and symbolism, reflecting beliefs, culture, and function. The unique Malay Garden symbolizes the civilized Malays and serves as a reference for landscape architects promoting Malay culture.

This study will collect information on components that being incorporate in Malay landscape design that differentiate it from other cultural landscape design. In Malaysia, there are 13 states which has their own unique landscape architecture that symbolize their own unique customs and culture. For example, Negeri Sembilan is also famous for its Minangkabau and cultural landscape, which one of it is the popular landscape in Istana Seri Menanti. Chieh (2020), an author stated in his writing that the traditional architecture in Malaysia is often associated with the creative Malay's nature and their close relationship with the environment and the impact of globalization. Traditional architectural design was used as the symbol of culture, which referred to the social status of individuals within a society. Some aspect in the traditional design that are considered in the study typology of the height, shape, layout, and structure. Clement (1997), wrote that cultural or landscape architecture is importance in enriching people's identity, developing a sense of place or belonging and protecting the original culture of certain community or place as it is the main key to human legacy.

The Concept of Malay Landscape Design

According to Ismail Hafiz Salleh, Mohd Sabrizaa Abd. Rashidb, Siti Rasidah Md Sakip (2015) the Malay Garden design concept is an endeavour to establish the identity of Malay Garden design and to reassert this design concept as distinct to Malaysia's original community, the Malays. The Malay Garden design is meticulously planned through harmonious interactions between man, nature, and culture, which are reflected in the home design and surrounding environment. Malays are well-known for their ideology of producing or building something as a sign of symbolism, which implies that it is either implicitly or overtly based on their relationship with God, their environment, and human beings. The Malay Garden design's strength is its use of plants (soft landscape) and landscape furniture (hard landscape), as well as its composition and interaction with internal and external spaces. It is remarkable because it clearly represents the Malays' historical culture and demonstrates that the Malays have extensive understanding of plant functions in the garden or their environment.

Components in Traditional Malay Landscape Garden

Ismail Hafiz Salleh, Mohd Sabrizaa Abd. Rashidb, Siti Rasidah Md Sakip (2015) stated in their research that the composition in traditional Malay Garden is like any other landscape designs which is consist of the design concept and two main components, softscapes and hardscape elements. Nur Huzeima Hussain (2010) stated that in Malay traditional landscape architectural design, softscapes refer to the living elements in the landscape area, such as plants, trees, and shrubs that are incorporated into the overall design. These softscapes are carefully selected and arranged to create a balance and harmonious environment that reflects the natural beauty of the surroundings.

Softscape element is one of crucial role in Malay traditional landscape architectural design. Traditional Malay people believed that softscape element can enhance the overall aesthetics of the space and create a peaceful and calming atmosphere. Additionally, softscape elements are chosen

based on their cultural significance and symbolic meanings, adding layers of meaning and depth to the design. Meanwhile hardscape element refers to the non-living, man-made elements in the landscape, which includes structures such as pathways, pavilion or also known as “gazebo” or “pondok” in Malay language, bridges, walls, and other built features.

In Malay traditional landscape architecture, hardscape elements are often crafted from natural materials such as wood, stone, and bamboo, which help reflecting the traditional Malay architectural style. Hardscape elements that integrated into the landscape provide functional spaces for activities and gathering, as well as to instil a sense of order and organization in the natural surroundings. Hardscape design in Malay traditional landscapes is frequently distinguished by its simplicity, beauty, and seamless integration with the surrounding natural components.

2. Method and Results

This study employs a qualitative research approach, specifically utilizing semi-structured interviews with subject matter experts. The rationale for choosing interviews lies in their ability to provide deep insights and nuanced understanding of complex phenomena from the perspectives of those directly involved in or knowledgeable about the subject matter especially in traditional Malay architecture. The discussion should interpret the findings in view of the results obtained in this and past studies on the topic and findings during interview data has been analyse using N-vivo software. The process of qualitative data including of transcription, data organizing, data familiarizations, coding, theme, data validity, and reporting.

Participants in this study were selected based on their extensive experience and expertise in traditional Malay architecture. Structure, unstructured, and semi-structured interviews were conducted to gather rich, detailed information. This approach allowed for flexibility in questioning, enabling exploration of emergent themes while ensuring consistency in covering core topics and interviews were conducted face-to-face with informants. Informants was selected with architecture background in Malay traditional understanding especially in educational background, experience, and project involvement and informants background has been selected as below.

Table 1: Informants Details and Background

Informants	Name & Background
1	Datuk Mazlan bin Sabli Kinetic Builder Group as Project Manager West Oxfordshire College, Oxon, London 27 years of experince in construction industry
2	Interception of Rainfall & windbreaks Sahrul Mizal bin Samsuddin Dracaena Landscape Sdn Bhd as Managing Director Universiti Teknologi Mara (UiTM) 23 years of experince in Landscape project

Finding has been shown that all the informants agreed several selections of Malay traditional approaches in architecture such plants selection, wooding with carving elements, functionality and arrangement are the most importance parts as representing Malay traditional approach in landscape architecture.

Based on the interviews, all the informants agreed that Malay traditional approach also has several elements especially allied with landscape element such softscape, hardscape, types of material used, functionality, and arrangement.

Landscape element should blend with softscape, hardscape, material used, functionality, and arrangement even the theme or approach in design focus on whatever such Japanese garden, Zen Garden, Islamic Garden, or etc

Informant 1

The compulsory element in landscape design should have softscape, hardscape, material used, functionality, and arrangement.

Informant 2

Based on the interviews, all the informants agreed that Malay traditional approach also has several elements especially allied with landscape element such softscape, hardscape, material used, functionality, and arrangement. This statement also can be contributed to collaborative design methodology to search for the identifying references of the landscape and the belonging of the territory to the reference community and the different meanings that can emerge from the local dimension of the identity". The process maps practices, arts, episodes, stories, crafts, representations and material and immaterial expressions. Additionally, integrating local identity mapping into cultural landscape projects can help preserve and enhance the unique characteristics of a region, supporting community engagement and pride (Amoruso, G., Battista, V, 2020).

Regarding to fundamental analysis from the beginning data analysis, this research has been developed several coding numbers based on several landscape elements that can be put on interview findings such as:

Table 2: Coding Determinations

Code	Explanation
1	Softscape element <ul style="list-style-type: none"> Plants selections Types of plants
2	Hardscape element <ul style="list-style-type: none"> Water element Installation techniques Coloring selection
3	Types of materials <ul style="list-style-type: none"> Local materials Recycle materials
4	Functionality <ul style="list-style-type: none"> Hardscape function Softscape function
5	Arrangement <ul style="list-style-type: none"> Coumpound areas

Research findings has been concluded based on landscape element such softscape, hardscape, material selection, functionality, and arrangement as below:

Table 3: Softscape Elements

Question	Informants Response	Code
Informant 1	What is softscape elements that representing for Malay traditional culture in landscape architecture? <i>"for the selection of plants, I believe that the types of plants that have characteristics that can be eaten or used in daily cooking. For example, lemongrass, pandan, ginger, turmeric, or others. as we understand that Malay cuisine needs some types of local herbs, and it is synonymous with traditional Malay cuisine"</i>	1

Informant 2	What is softscape elements that representing for Malay traditional culture in landscape architecture? <i>"plants for the traditional Malay community are synonymous with edible types. This is due to most of the Malay community originally being or living in the suburbs and most of the villages. Therefore, the Malay community is more interested in vegetable crops, or edible ones. Other than that, Malay traditional plants also prefer for fruits trees like lemon, lime, and local fruits plants"</i>	1
-------------	--	---

Table 4: Hardscape Elements

Question	Informants Response	Code
Informant 1	What is hardscape elements that representing for Malay traditional culture in landscape architecture? <i>"the selection of hardscape for the traditional Malay community is more about the use of wooden elements. As we understand that Malaysia is one of the countries that has a source of hard wood in the world. Most traditional Malay houses have wooden elements or constructions. To apply elements of wood use in the landscape, we can apply elements of wood use in the construction of decking and seating. In addition, most Malay houses also have an element of water for washing the feet where the Malay community will take off their shoes before entering the house. Malay traditional design also popular with carving elements especially for east coast peninsular Malaysia"</i>	2 3 4
Informant 2	What is hardscape elements that representing for Malay traditional culture in landscape architecture? <i>"it is certain that in traditional Malay architecture the use of wooden elements is very important because our country is rich in the best wood resources in the world such as Jati, Meranti, Merbau, Cengal and many more. The use of wood can be applied in the construction of seating or gazebo in local landscape design in addition to in walkways approach"</i>	2 3 4

Table 5: Materials Selection

Question	Informants Response	Code
Informant 1	What is materials selection elements that representing for Malay traditional culture in landscape architecture? <i>"for sure solid wood and certain used of concrete elements selection to support the construction phases"</i>	3
Informant 2	What is materials selection elements that representing for Malay traditional culture in landscape architecture? <i>"Malay traditional architecture prefer for wood materials and it was very synonyms in Malaysia. They also build some hardscape from certain materials such brick an examples of moderate Malay house bottom from bricks and top wall from woods"</i>	3

Table 6: Functionality

Question	Informants Response	Code
Informant 1	What is functionality elements that representing for Malay traditional culture in landscape architecture? <i>"in terms of functionality in traditional Malay architecture, they are more inclined to areas with cross-legged seating. In addition, they also tend to edible plants as I have explained just now"</i>	4 1

Informant 2	What is functionality elements that representing for Malay traditional culture in landscape architecture? <i>“in terms of functionality in traditional Malay architecture, they are more inclined to areas with cross-legged seating. In addition, they also tend to edible plants as I have explained just now”</i>	4 1
-------------	---	--------

Table 7: Arrangement

Question	Informants Response	Code
Informant 1	What is arrangement design that representing for Malay traditional culture in landscape architecture? <i>“most traditional Malay houses plant flowering plants in the yard such Hibiscus, Alamanda and many more while edible plants are planted at the back of the house. This situation seems to give a welcome impression to the guests who will come to their home. They also tend to have a large yard, and this will make it easier if they are going to hold events such as weddings and so on”</i>	1 5
Informant 2	What is arrangement design that representing for Malay traditional culture in landscape architecture? <i>“some practices in the Malay community in house architecture where the functionality of each corner of the house area will give details of functionality. For example, in front and side of the house they will plant hedge trees and flowering plants. While in the back of the house they will plant trees that can be eaten. The yard will also be planted with some large fruit trees as a shade element and under the shade they will place a cross-legged type of seat and there they will sit with the neighbors who are present while enjoying the food of the guests. Don't forget it's also customary for a traditional Malay house yard to have a wide yard, probably because most of them have a large land size”</i>	4 1 4 5

Based on the findings from interviews session, this research can conclude that Malay traditional architecture also can be blend into landscape architecture design which is some importance elements such softscape and functionality the most importance part as to consider to put on landscape design as to representing Malay traditional approach plants selection on planting design by using edible and fruits plants, functionality approach such seating design looked like decking for cross-legged type, and lastly combination materials selection between brick and wood materials.

Material selection such as solid wood application on structure or carving method on wood also should be put on consideration and lastly hardscape and arrangement element on design such decking, compound areas usually shown Malay house has very wide areas because most of Malay community live in suburban areas especially on north, east coast, and west coast of peninsular Malaysia. Analysis table for interview session as below.

Table 8: Arrangement

Code	Explanation	Numbers
1	Softscape element <ul style="list-style-type: none"> Plants selections Types of plants 	6
2	Hardscape element <ul style="list-style-type: none"> Water element Installation techniques Coloring selection 	2

3	Types of materials	
	▪ Local materials	4
	▪ Recycle materials	
4	Functionality	
	▪ Hardscape function	6
	▪ Softscape function	
5	Arrangement	
	▪ Coumpound areas	2

By drawing lessons from Malay traditional architecture, modern landscape design can achieve a harmonious balance between cultural heritage and ecological sustainability, offering valuable insights for creating resilient and culturally enriched environments. It is also by practising local elements in design would be bringing most valuable and sensory elements amongst visitors and Amoruso, G., Battista, V, (2020) also stated that integrating local identity mapping into cultural landscape projects can help preserve and enhance the unique characteristics of a region, supporting community engagement and pride. By drawing lessons from Malay traditional architecture, modern landscape design can achieve a harmonious balance between cultural heritage and ecological sustainability, offering valuable insights for creating resilient and culturally enriched environments.

Acknowledgment

This paper is an output of the social science project, and I would like to express my sincere gratitude to everyone who has contributed to the completion of this research paper. First and foremost, I am deeply thankful to all staff Programme in Diploma Landscape Horticulture, for their invaluable guidance, support, and encouragement throughout this research endeavour. Their expertise and insights have been instrumental in shaping this work. Furthermore, I extend my appreciation to Muhammad Hasif, Nurul Sabrina and Nur Amira Irdina for their assistance in data collection and analysis, which greatly facilitated the progress of this study. Finally, I wish to thank my colleague for their unwavering encouragement and understanding throughout this academic journey. Thank you all for your contributions and support.

References

- Harun, N. Z., Mohd Ariffin, N. A., & Abdullah, F. (2017). Changes and Threats in the Preservation of the Traditional Malay Landscape. *Planning Malaysia*, 15(4).
- Ahmad Zamil Zakaria, Ismail Hafiz Salleh, Mohd Sabrizaa Abd. Rashid (2013). Landscape Furniture Present in The Ancient Malay Garden According to Old Manuscripts and Their Effects on The Formation of Malay Garden Design Concept Model in Malaysia. *Procedia-Social and Behavioral Science* 91 (2013) Page 28-35
- Tengku Anis Qariah bt Raja Abdul Kadir, Puteri Shireen Jahn Kassim2, Nurul Syala Abdul Latif, Harlina Md. Shariff (2020). Identifying the Parameters of The Malay Classical Architecture. *Journal of the Malaysian Institute of Planners*, Volume 18 Issue 2 (2020), Page 59 – 72
- Nur Huzeima, M. H., & Suriati, A. (2010). Malay landscape: Typical design for contemporary house at Desa Wawasan. cE-Bs, FAPS, UiTM - *Asian Journal of Environment-Behaviour Studies*, 1(3)38 – 47.
- Noor Aimran Samsudin (2014). *The Physical Design Attributes of Traditional Malay Kampong in Kampung Tanjung Bunut, Kuala Terengganu*. Universiti Teknologi Malaysia, Johor Bahru, Malaysia 19-21.
- Amoruso, G., Battista, V. (2020). Landscape. Bottom-Up Approach for Cultural Landscape and Local Identity Mapping. In: *Anzani, A. (eds) Mind and Places. Springer Series in Design and Innovation*, vol 4. Springer, Cham. https://doi.org/10.1007/978-3-030-45566-8_16

The Potential of Shrub Plants as Soil Erosion Control

Mohamad Hafiz Sulaiman^{1*}

¹Department of Agrotechnology & Bio-Industry Polytechnic Nilai, Malaysia

Abstract

This study aims to identify the suitable and sustainable plant in sloped areas to prevent soil erosion and also as a vegetation approach for soil erosion control. This study was also conducted on two types of shrubs plants namely *Duranta Gold* and *Excoecaria chocinchinesis*. The test also has been compared with current vegetation control method by using *Axonopus Compressus* turf. This study has been carried out through a plotting system where an artificial slope has been built with nine-metre square feet. All the selected plants have been planted in the plot area and data was collected after two months in consideration of these shrubs and turf has been well grown. The criteria of selected plants comprise of plant growth, maximum height, root type and depth, water preference, and sunlight need. This study also looked at the growth rate of shrubs where all these shrubs were to make sure the growth rate is very suitable for controlling soil erosion on slope area. The growth rate of shrubs criteria such as plant height, root depth, and number of leaves was taken for one week after all plants had well established growth around one month with artificial rain. Data collection for soil erosion was picked with two main parameters which are volume of soil runoff and the volume of water runoff. Findings shown that the percentage of differentiate between using shrubs and turfing for soil erosion control has low significant where *Excoecaria chocinchinesis* has been recorded the lowest volume with 225.5grams/minutes, followed by *Axonopus Compressus* turf with 226 grams and the highest volume recorded is *Duranta Gold* with 227 grams. This finding showed that all these types of plants have good root density and root length density as to holding soil structure and has potential to prevent soil erosion. For water runoff, there have significant findings between current soil erosion control using vegetation method by using *Axonopus Compressus* as compared with *Excoecaria chocinchinesis* and *Duranta Gold*. Based on this finding, the ability of shrubs, especially *Duranta Gold*, is able to compete with the ability of *Axonopus Compressus* turf where the difference in the amount of water accumulated for a period of one minute between these two plants is only in the range of 0.12 litres. *Axonopus Compressus* turf was recorded 0.53 litres per-minutes while *Duranta Gold* recorded 0.65 litres per-minutes and regarding this finding showed that shrubs plants also have potential for soil-erosion control. Based on the results, this study can conclude that these two shrubs *Duranta Gold* and *Excoecaria chocinchinesis* has almost similar ability with current method on soil erosion control by using *Axonopus Compressus* turf in slope area. Other than that, by using shrubs also has an advantage where it can give an aesthetic value for slope with shrubs plants. The main factor that contributes for soil strength that can be holding soil structure are plant root system which is root density and root length density. For growth rate data, findings shown that all plants have similar growth rate and the differentiate each of them has shown in a small number. All these sample of plants growth such of plants height, root depth, and number of leaves in average rate shown that shrubs also have a potential for soil erosion control. The use of vegetation, such as grasses, shrubs, trees, and ground cover plants, is a cost-effective and environmentally friendly approach to reducing soil erosion by forming a vegetative cover in areas. The roots of these plants help bind soil particles together, preventing them from being washed away by wind or water and the benefits of using plants go beyond erosion control.

Keywords: Soil Erosion, Shrubs Trees, Vegetation Control

1. Introduction

Ecological restoration programs frequently utilise vegetation to mitigate the severe impact of soil erosion processes on various landscapes, including agricultural fields, steep slopes, road embankments, and levees. Vegetation cover serves multiple functions in erosion control, including protection against raindrop impact and surface runoff, reduction of runoff volume and velocity through increased infiltration and surface roughness, and sediment trapping. While the effectiveness of above-ground vegetation in erosion control has been extensively studied, the role of below-ground vegetation, particularly plant roots, has received less attention. Plant roots play a significant yet often overlooked role in reducing soil detachment rates, particularly in controlling rill and gully erosion. These erosion types are crucial contributors to catchment sediment yield and offsite impacts like flooding and reservoir sedimentation.

Understanding the erosion-reducing potential of plant roots requires considering complex interactions within the root-soil matrix, which alter mechanical and hydrological soil properties. Factors influencing this potential include root density, architecture, soil texture, moisture, and dry bulk density. Selecting appropriate plant species for erosion control programs requires knowledge of these root-soil interactions. Despite numerous individual case studies, there is a lack of meta-analyses synthesising data on the erosion-reducing potential of root systems during concentrated flow erosion. Such an analysis would contribute to developing a general model for estimating root effectiveness in erosion control, accounting for site-specific differences.

This research aims to fill this gap by providing a comprehensive overview of studies quantifying root effectiveness in reducing concentrated flow erosion rates and exploring trends in erosion reduction based on root density, architecture, and soil texture. By integrating published data, this study advances understanding of how plant root characteristics influence concentrated flow erosion rates across various environments. Research over the past twenty years shows that plant roots are really good at preventing soil from being washed away by strong water flows. This means they can help stop erosion in areas where there are small channels or bigger ditches in the soil (Gyssels et al., 2005, De Baets & Poesen, 2010).

Slope Stabilization Approach

The use of shotcrete covers together with soil nails installed into the slope, gabion, reinforcement concrete wall was the most common slope stabilisation measure in Malaysia. The rationale behind these methods is to reduce rainwater infiltration and surface erosion. However, the use of shotcrete can no longer satisfy the public's urge to have a green and sustainable environment. Unfortunately, by these methods it is not promoting greenery and low ecological values especially in the urban areas. Several reasons for the importance of vegetation as soil stabilisation approaches such as live plants induce soil suction by evapotranspiration. The shear strength of soil is thus increased (Indraratna et al., 2006, Pollen, 2007, Preti et al., 2010, Rees & Ali, 2012, Simon & Collison, 2002). Other than that, vegetation approach also promoting plant roots reinforce the soils by transferring the soil's shear stress into root tensile resistance through the soil-root friction (Abdi et al., 2010, Gray & Sotir, 1996, Greenway, 1987, Operstein & Frydman, 2000, Reubens et al., 2007, Schiechl, 1980, Schmidt et al., 2001, Stokes et al., 2009, Xu et al., 2011).

Greening and vegetation approach has been developed several years ago where a guideline has been published by Department of Town and Country Planning of Malaysia (myTOWNnet) where the local government has been endorsed *Garis Panduan Pengurusan Cerun di Kawasan Pihak Berkuasa Tempatan* on August 2021.

2. Methodology, Results and Discussion

This study has been carried out by organising several testings on three types of selected plant: *Loropetalum chinensis*, *Excoecaria chocinchinesis* and *Axonopus Compressus* turf. The selections of plants have been identified through suitable plants for slope areas which have several selection parameters. The parameter comprises plant growth, maximum height, root depth, water preference, root type, and sunlight need. Plants selection criteria and parameter has been identified based on each criterion as shown below:

Table 1: Plants Selection Criteria

Plant selection	Criteria				
	Max Height	Root Depth	Water Preference	Root Type	Sunlight Need
<i>Excoecaria chocinchinesis</i>	1 metre	5 metres	Moderate water	Fibre root	Full sunlight
<i>Duranta Gold</i>	3.7 metres	6 metres	Moderate water	Fibre root	Full sunlight

Source: 1001 Garden Plants in Singapore

Table 2: Plants Parameter Criteria

Parameter	Criteria
Plant growth	Plants growth rate
Maximum height	Interception of Rainfall & windbreaks
Root type & depth	Soil Stabilization, Resistance to water erosion, & soil structure
Water preference	Volume of water demand for plants
Sunlight need	Volume of sunlight needed for plants

Source: 1001 Garden Plants in Singapore

Table 3: Plants Growth Rate

Parameter	Criteria
Plant height	Plants height rate
Root depth	Prone to concentrated flow erosion
Number of leaves growth	Plants leaves growth

Source: 1001 Garden Plants in Singapore

The testing of plants has been conducted after one month after plants have been well grown on a plot slope area which has been set around nine-metre square feet and experiment has been conducted on one week with artificial rain. The criteria of slope stabilisation after shrubs planting on site such volume of soil runoff, volume of water runoff, and slope shape changes. Low frequency simulated rainfall was created to measure under natural rainfall conditions the effects of three vegetation samples of *Excoecaria Chocinchinesis*, *Duranta Gold*, and *Axonopus Compressus* turf.

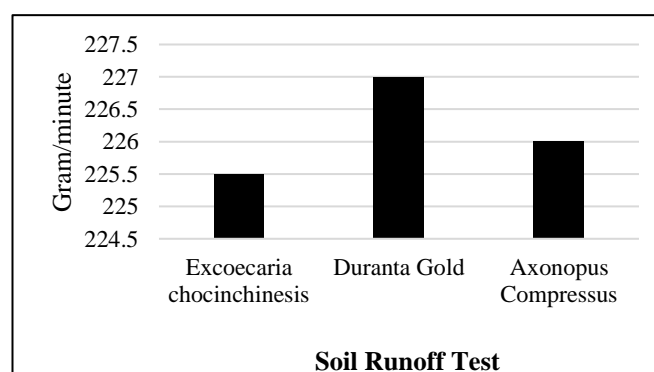


Figure 1: Soil Runoff Grams/Minutes

Based on figure 1, there are significant findings between three types of plants where all these plants shown a nearest volume of soil erosion during heavy rain. Soil has been collected on the bottom of slope and shown that *Excoecaria Chocinchinesis* has been recorded the lowest volume with 225.5grams/minutes, followed by *Axonopus Compressus* turf with 226 grams and the highest volume recorded is *Duranta Gold* with 227 grams. This finding shown that all these types of plants have good root density and root length density as to holding soil structure and has potential to prevent soil erosion. The erosion-reducing potential of plant roots are the result of complex interactions within the root-soil matrix changing the mechanical and hydrological properties of the soil (e.g. V.T Eviner & Chapin, 2003, Gregory, 2006). As a result, the effectiveness of plant roots in reducing concentrated of flow erosion rates is influenced by several root and soil characteristics such root length and density, root architecture, soil texture, soil moisture and dry soil bulk density (e.g. De Baets et al., 2007a, Burylo et al., 2012). Based on this finding, we can conclude that shrubs plants also have a potential as soil erosion-reducing approach on slope areas.

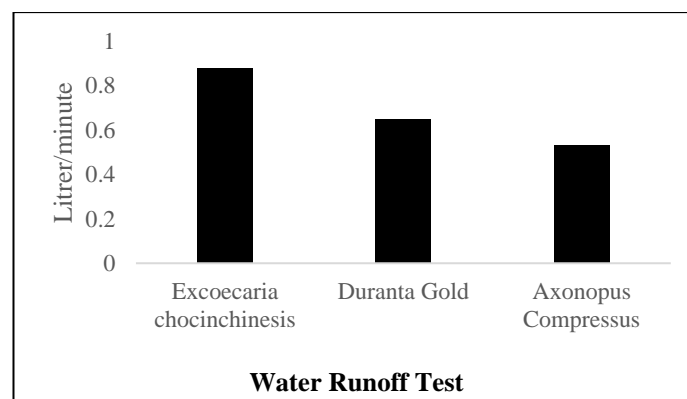


Figure 2: Water Runoff Litre/Minutes

Figure 2 explained the findings of total volume of water runoff on sampling plot per-minutes. Based on the graph above, there are significant findings between current soil erosion control using vegetation methods by using *Axonopus Compressus* as compared with *Excoecaria chocinchinesis* and *Duranta Gold*. Based on this finding, it can be seen that the ability of shrubs, especially *Duranta Gold*, is able to compete with the ability of *Axonopus Compressus* turf where the difference in the amount of water accumulated for a period of one minute between these two plants is only in the range of 0.12 litres. *Axonopus Compressus* turf was recorded 0.53 litres per-minutes while *Duranta Gold* recorded 0.65 litres per-minutes and with regard to this finding showed that shrubs plants also have potential for soil-erosion control. Alegre et al., (2004) stated that shrubs give leaves and other plant material to the soil, making it richer in organic matter, also their tangled root systems make the soil better by creating bigger holes, which helps water soak in and reduces soil washing away (Garcia-Estringana et al., 2010). Runoff and soil erosion processes were strongly influenced by soil surface conditions because of the formation of erosion pits and rills, so by applying vegetation with fibre roots, it can hold the soil surface strength and indirectly will decrease soil erosion from heavy rain falls.

3. Implications and Direction for Future Research

The roots of two pioneer shrubs *Excoecaria Chocinchinesis* and *Duranta Gold* have high tensile strengths and also have a similar strength like *Axonopus Compressus* as soil erosion control through vegetation approach. They can increase soil shear strength considerably without having the negative effects often attributed to the dynamic and static surcharges of large trees. At the same

time, this approach also promoting greeneries as compared to structured approach like retaining wall or others.

This research also can be expanding on others testing such modelling of mechanical root on slope area where this approach also has potential for green approach for soil erosion control. This approach looks for other attributes on vegetation niche such as the rooting system and this approach is called a biomechanical approach. Other than that, future research also can focus on soil moisture that can be affected by soil stabilisation. There are lots of vegetation types and planting methods for controlling soil moistures, from their findings can be determined suitable types of vegetation and planting methods that can be applied on slope areas.

Acknowledgment

I would like to express my sincere gratitude to everyone who has contributed to the completion of this research paper. First and foremost, I am deeply thankful to all staff Programme in Diploma Landscape Horticulture, for their invaluable guidance, support, and encouragement throughout this research endeavour. Their expertise and insights have been instrumental in shaping this work. Furthermore, I extend my appreciation to Muhammad Azim, Nursyaza Amani and Muhammad Amin for their assistance in data collection and analysis, which greatly facilitated the progress of this study. Last but not least, I wish to thank my family and friends for their unwavering encouragement and understanding throughout this academic journey. Thank you all for your contributions and support.

References

- R. Gopinath, G.P. Ganapathy, S.P. Saravanan, V. Vijayan, S. Muthukumar, M. Muthuseenivasan, V. Muthuraj & V. Prabu (2015), Experimental Studies on Soil Stabilization Using Vetiver Root as Reinforcement. *International Journal of Applied Engineering Research*, ISSN 0973-4562 Vol. 10 No.53
- F. Abdullaha, Aimrun W.a, N. M. Nasidia, K. Hazari S. A. F. b, L Mohd. Sidekc & Zalilah Selamatc. (2019). Modelling Erosion and Landslide Induced by Farming Activities at Hilly Areas, Cameron Highlands Malaysia-Aimrun W. et al. *Jurnal Teknologi (Sciences & Engineering)* 81:6, 195–204.
- Md Shofiquil Islam & Atikur Rahman, (2019), *Slope Stability Problem and Bio-engineering Approach on Slope Protection: Case Study of Cox's Bazar Area, Bangladesh den Plants in Singapore*, A New Compendium, NParks' Publication
- Gyssels et al., De Baets & Poesen, (2005) Impact of Plant Roots on the Resistance of Soils to Erosion by Water, *Progress in Physical Geography Earth and Environment* 29 (2):189-217
- Flora T.Y. Leung, W.M. Yan, Billy C.H. Hau & L.G. Tham. (2015). Root Systems of Native Shrubs and Trees in Hong Kong and Their Effects on Enhancing Slope Stability. *CATENA*, Volume 125, P 102-110
- Achyut R. Adhikari, Mahesh R. Gautam, Zhongbo Yu, Shogo Imada & Kumud Acharya. (2013). Estimation of Root Cohesion for Desert Shrub Species in the Lower Colorado Riparian Ecosystem and its Potential for Streambank Stabilisation. *Ecological Engineering*, Volume 51, P 33-44
- Ehsan Abdi, Baris Majnounian, Maria Genet & Hassan Rahimi. (2010). Quantifying the Effects of Root Reinforcement of Persian Ironwood (*Parrotia Persica*) on Slope Stability; a Case Study: Hillslope of Hyrcanian Forests, Northern Iran. *Ecological Engineering*, Volume 36, Issue 10, P 1409-1416
- V. T Eviner & Chapin, (2003), Gregory. (2006). Functional Matrix: A Conceptual Framework for Predicting Multiple Plant Effects on Ecosystem Processes, *Annual Review of Ecology Evolution and Systematics* 13(34):455-85

- S. De Baets, J. Poesen, G. Gyssels & A. Knapen. (2006). Effects of Grass Roots on the Erodibility of Topsoils during Concentrated Flow. *Geomorphology*, Volume 76, Issues 1–2, P 54-67
- Garcia-Estringana, Pablo & Alonso-Blázquez, Nieves & Alegre, Jesus. (2010). Water Storage Capacity, Stemflow and Water Funnelling in Mediterranean Shrubs. *Journal of Hydrology*. 389. 363-372. 10.1016/j.jhydrol.2010.06.017. Department of Town and Country Planning of Malaysia (myTOWNnet).

Climate Change Increases the Risk of Infectious Diseases and Solutions to Address the Issues

Rabiatul Adawiyah Mohd Radzuan¹ & Nur Adibah Mohidem^{1*}

Public Health Unit, Department of Primary Health Care, Faculty of Medicine and Health Sciences, Universiti Sains Islam Malaysia, Bandar Baru Nilai, 71800 Nilai, Negeri Sembilan, Malaysia.

^{1*}nuradibahmohidem@usim.edu.my

Abstract

Earth's climate has been shifting since the middle of the 20th century due to human activity. Increase global temperature reported by Intergovernmental Panel on Climate Change (IPCC) projecting to increase. Changes in climatic factors result in epidemiological changes of infectious diseases. This review aims to identify the epidemiology of infectious diseases driven by climate change, its factor and solution to the issue of climate change and infectious diseases. The searches of this review were conducted in ScienceDirect, Google Scholar, PubMed and WILEY Online Library with a limited period of search, which is between the years 2018 and 2024. The incidence of mosquito-borne disease, tick-borne disease, food and water borne disease had been accelerated along the year globally, attributed by climatic factors such as temperature, precipitation and human behaviour. To address this issue, few solutions can be done, such as surveillance, adaptation, disease risk assessment, mitigation and health education can be done to protect public health.

Keywords: Climate Change, Risk, Infection Diseases, Solution

1. Introduction

According to NASA 2023, climate change is defined as a shift of typical weather patterns that characterize the local, regional and global climates of the Earth over a long-term duration. From the middle of the 20th century, the climate of the Earth had been changed due to human actions notably by burning of fossil fuel. This process elevates levels of heat-trapping greenhouse gasses in Earth's atmosphere, leading to an increase of the average surface temperature of the Earth (Chowdhury FR, et al., 2018). The Intergovernmental Panel on Climate Change (IPCC) which assessed the global temperature data concluded that the mean global temperature across land and ocean surfaces increased by 0.85°C between 1880 and 2012. They forecasted that by the end of the 21st century, there will be a further rise in global surface temperature by 1.5°C compared to the year 1850 (Chowdhury FR, et al., 2018). Particularly in Southeast Asia, surface air temperatures are predicted to rise by 2°C by 2060 and potentially by as much as 5°C by 2098 (Sophie Dennis & Dale Fisher, 2018).

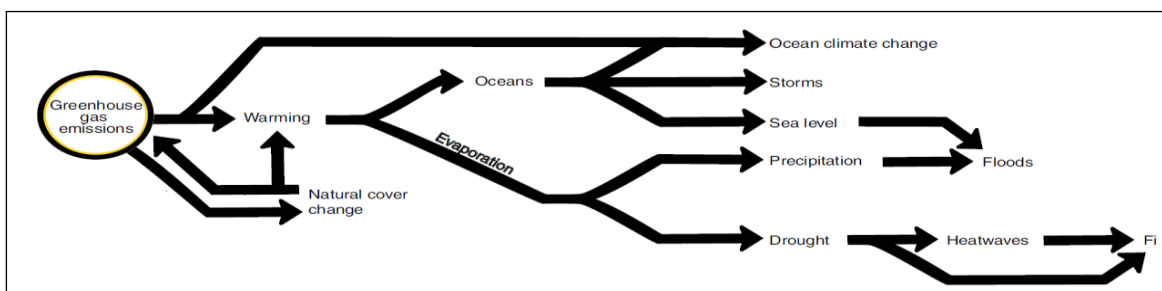


Figure 1: The Climatic Hazards of the Earth's System are Impacted by the Continuous Emission of Greenhouse Gasses (GHGs) (2).

Meanwhile, several indicators of climate change have been identified in Malaysia. Five areas in Malaysia, including Malacca, Setiawan, Bintulu, Kota Kinabalu, and Miri, have experienced a greater than 90% increase in the number of warm nights. Additionally, by the end of the 21st century, a notable temperature is expected to rise in Malaysia, ranging between 3 and 5 °C. During a 50-year span from 1951 to 2000, numerous regions in Malaysia experienced a temperature rise ranging from 1.75 to 2.69 °C, while the IPCC projected that temperatures in Malaysia will have risen between 0.6 and 4.5 °C by the year 2060 (Shaffril HAM et al, 2017). Since the 1980s, numerous meteorological stations have observed a surge in the number of days with extreme rainfall events surpassing the 90th percentile of total rainfall. Over the long term, there is a heightened risk of extreme wind speeds in areas such as Alor Setar, Mersing, Kuantan, and Kota Bharu. Furthermore, there has been a sea level rise in Malaysia, averaging 1.25 mm per year from 1988 to 2006. Three locations in Malaysia with sea level increases exceeding 3 mm per year from 1993 to 2008: Sandakan (3.45 mm/year), followed by Chendering (3.20 mm/year), and Kukup (3.02 mm/year) (Shaffril HAM et al, 2017).

The World Health Organization (WHO) regards climate change as one of the primary dangers to human health as the epidemiology of infectious diseases is significantly altered due to its impact against the geographic distribution of the microbes and the vectors (Casadevall A., 2020; Caminade C et al., 2019). Annually, 12.6 million deaths are attributed to adverse environments, specifically influenced by factors such as climate change and pollution revealed by WHO (1). The anticipated rise in yearly temperatures, precipitation and occurrence of severe weather events will directly and indirectly affect the environment where the pathogens, vectors and hosts interact. As the environment gets altered, the endurance of the infectious pathogen bolsters, thereby increasing the rate and intensity of diseases (Sophie Dennis & Dale Fisher, 2018). For instance, variations in the transmission of dengue in Malaysia are linked to changes in monsoon seasons due to climate change. Based on the model developed by the Institute for Medical Research (IMR), increased rainfall is associated with higher transmission rates of dengue (Jegasothy R et al., 2021).

Therefore, the aim of this paper is to review the impacts of climate change on infectious disease and the epidemiology of infectious disease due to the changes. Insights from this analysis offer various solutions that can protect the public from the disease threats.

2. Methodology

The early step in creating an adaptation strategy involved analysing relevant papers to identify the association of climate change and infectious disease. English searches of this literature review were conducted in ScienceDirect, Google Scholar, PubMed and WILEY Online Library using keywords such as 'climate change', 'factor ', and 'solution'. The search was limited to the years 2018 and 2024 and few materials had been found such as articles, book chapters and journals. Selected articles needed to fulfill the following criteria: explore the potential impacts of climatic factors on the emergence of infectious diseases.

3. Infectious Diseases that Caused by Climate Change

Vector Borne Diseases

In the past three decades, most of the disease outbreaks that have emerged are either zoonotic or vector-borne (Waits A et al., 2018). Vector-borne illnesses contribute to over 17% of total infectious diseases, resulting in upwards of 700,000 fatalities annually (Bartlow AW et al., 2019). Vector-borne infectious diseases (VBDS) are primarily spread by arthropod vectors, which are highly influenced by shifts in climate (Caminade C et al., 2019). Several of the vectors are bloodsucking insects. They acquire disease-causing microorganisms while feeding on an infected

host's blood and subsequently inject them into a new host during their next blood meal (Bartlow AW et al., 2019).

In North America, vector-borne infections are mainly caused by pathogens transported by mosquitoes and ticks (Edelson PJ et al., 2023). These two vectors had different biological characteristics, and it's probable that their responses to climate change will also vary (Waits A et al., 2018). However, both of them are arthropods which are ectothermic organisms in which their internal temperature is controlled by the conditions of the surrounding environment (Caminade C et al., 2019). Hence, any changes in the ecosystem or population of the animal or vector that are impacted by the climate factors can eventually result in the dynamic of the infections. For example, the ways in which a warming climate disrupts host-pathogen transmission include alterations in host density, heightened pathogen survivability, expansion of vector range, and modifications to host susceptibility (Waits A et al., 2018).

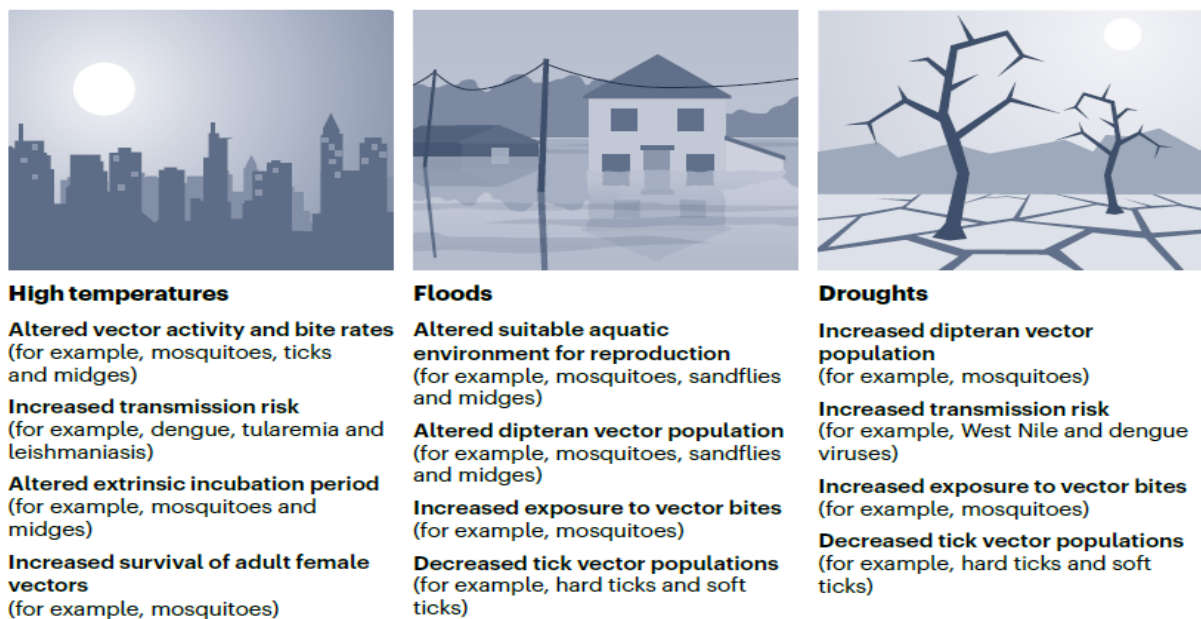


Figure 2: The Influence of severe weather events on vectors and vector-borne diseases (Baker RE, et al., 2022).

Plus, dissemination of vector-borne disease can facilitate by the way of global travel in which new vectors are introduced to areas with conducive environmental conditions or by introducing novel pathogens into both native and invasive vector populations. Throughout history, vectors have been introduced through trade routes, with ships believed to have played a pivotal role in the widespread distribution of *Ae. aegypti* and *Ae. albopictus*, subsequently establishing themselves in areas possessing suitable environmental conditions (Baker RE et al., 2022).

Mosquito Borne Diseases

In the last decade, cases of locally transmitted malaria, dengue and chikungunya have been reported in continental Europe (Semenza JC & Suk JE., 2018). Three genera of mosquitoes that act as vectors spreading mosquito-borne diseases are *Aedes*, *Anopheles* and *Culex* (Bartlow AW et al., 2019). Due to climate change, Zika, chikungunya, dengue and yellow fever which were absent in the last century, have re-emerged (Dal T et al., 2023). In the Americas, chikungunya and Zika virus have recently emerged, sparking significant outbreaks, while the annual dengue epidemics persist. These viruses rapidly spread across the continent upon introduction, resulting in long term effects such as Zika-related birth defects (Bartlow AW et al., 2019).

Dipteran vectors like mosquitoes typically undergo a short life cycle, with complete development from egg to adult ranging from one week to several months, and each stage of development occurring within days (Baker RE, et al., 2022). They are extremely climate sensitive vectors (Sophie Dennis & Dale Fisher, 2018). Thus, the disease dynamics can get affected when there are fluctuations in the temperature and the phenomenon of global warming has altered the epidemiology of endemic mosquito-borne diseases (Dal T et al., 2023). For instance, global climate suitability for the transmission of dengue has increased by 8.9% for *Aedes aegypti* and 15.0% for *Aedes albopictus* (Tong S. et al, 2021). In the United States, there are significant changes in the epidemiology of mosquito-borne disease due to climate change. This includes sustained localized transmission of Zika and chikungunya, the spread of dengue from localized areas in Texas and Florida, and the reintroduction of yellow fever, which has not been seen in the United States for more than a century (Edelson PJ et al., 2023).

Temperature influences the pace of pathogen development and reproduction within mosquitoes (Semenza JC & Suk JE., 2018). Increasing temperatures may accelerate the growth of both vectors and their pathogens, resulting in extended lifespans for the vectors and heightened human infection risks. (Edelson PJ et al., 2023). Elevated temperature also enables the species to overwinter and can broaden the geographical range of disease carrying vectors (Waits A et al., 2018). Overwinters could facilitate the northward spread of numerous species in which the rate of their development becomes faster especially in arctic environments (Bartlow AW et al., 2019). Likewise, it is probable that climate change will result in elevated temperatures along altitudinal clines. Consequently, regions at higher elevations (upslope) and those with temperate climates may become increasingly favourable environments for vectors and the transmission of pathogens (Baker RE, et al., 2022). Mosquito biting patterns are also affected by temperature, as higher average temperatures tend to correlate with increased biting rates in certain species (Edelson PJ et al., 2023).

Being aquatic insects, the life cycle and developmental duration of mosquitoes rely on the availability of water (Bartlow AW et al., 2019). Their biological and feeding behavior depends on the humidity (Chowdhury FR et al., 2018). Therefore, vector population dynamics enhanced when the air humidity was at high levels (Dal T, Ramli I, Garaizar J. (2023). In a condition where there is high humidity such as storms, heavy rainfall and floods, stagnant water collected, increasing the grounds for the mosquitoes to breed and grow (2). These conducive conditions for certain vectors can elevate the risk of malaria, dengue fever and chikungunya (Baker RE, et al., 2022).

However, apart from the effects of environmental changes that promote the rise in insect populations, human activities due to climate change may also precipitate changes in mosquito populations (Dal T, Ramli I, Garaizar J. (2023). To illustrate, after a hurricane or flood, people become more exposed to mosquito bites as people spend more time outdoors cleaning up. In the northern Gulf of Mexico, early season hurricanes can increase total annual West Nile Virus (WNV)-positive mosquito numbers by 7.8% and 94.3% of human neuro-invasive disease incidence across all areas due to hurricane damage (Baker RE, et al., 2022).

Climate change, swift urbanization and shifting land use patterns will heighten the likelihood of disease emergence in the forthcoming decades. Particularly, climate change leads to geographical redistribution of mosquito-borne infections (Baker RE et al., 2022). This happened when the previously uninhabitable areas transformed into favorable breeding grounds for them (Sophie Dennis & Dale Fisher, 2018). For example, the swift dissemination of the West Nile Virus across the United States and Europe coupled with the introduction of the Zika virus into the

Caribbean, Central, and South America, exemplifies the rapidity at which mosquito-borne viruses are establishing themselves in previously unaffected regions (Dal T et al., 2023). *Aedes Aegypti* is the primary vector for these infections.

While this species is commonly found in broad tropical and subtropical regions, it has also been detected in the Mediterranean Sea area. Meanwhile, *Aedes albopictus*, a vector for chikungunya, dengue fever, and Zika, had spread a much wider geographical distribution globally, including the Mediterranean region (Dal T et al., 2023). Adaptation of the introduced mosquito-borne pathogen to native mosquito species that are already present in that location also can expand the transmission. The best illustration for that is the chikungunya virus, typically transmitted by *Aedes albopictus*. After its appearance in Europe, the native European mosquito species like *Ae. geniculatus* were discovered to be remarkably susceptible to chikungunya virus infection, potentially taking over *Aedes albopictus* in disease epidemiology (El-Sayed A & Kamel M., 2020).

West Nile Virus

The transmission of West Nile Virus (WNV) occurs via mosquitoes of the *Culex* species. While infections can pose significant risks, particularly for the elderly, it's worth noting that more than 60% of cases are asymptomatic (Semenza JC & Suk JE., 2018). This mosquito-borne virus can lead to fatal encephalitis in mammals, humans and even birds (Dal T, Ramli I, Garaizar J. (2023). WNV has been circulating in Africa since the 1930s and made its initial appearance in New York City, United States, in 1999 (Caminade C et al., 2019). Increase in the prevalence of the disease is resulted from the rise in mosquito population due to increased rainfall, coupled with the extension of the mosquito activity season from rising temperatures (El-Sayed A & Kamel M., 2020). Considering that the extrinsic incubation period of WNV in *Culex* mosquitoes significantly shortens with temperature increases, it's certain that climate change will have a substantial impact on future WNV epidemics (Caminade C et al., 2019).

Similar to other mosquito-borne illnesses, this disease has extended its geographical reach, spreading to new countries due to climatic changes. It first appeared in South America in 2003 and caused a significant outbreak in Europe in 2010, affecting countries such as Greece, Romania, Hungary, Spain, Russia, Turkey, and Italy. Moreover, cases were reported in other European countries including France, Portugal, and Serbia. The origin of the invading viruses was confirmed to be from Israel, Morocco, and Turkey (El-Sayed A & Kamel M., 2020). Abnormal elevations in temperature above the monthly average were a key factor contributing to the 2010 WNV outbreak. In the following years, there have been yearly outbreaks of WNV in Eastern and Southern Europe, indicating ongoing transmission of the virus (Semenza JC & Suk JE., 2018).

The significant and widespread circulation of WNV in Southern and Central Europe in 2018, which saw 2083 cases, can be attributed to high temperatures during early spring. These temperatures consequently hastened virus amplification within both avian and mosquito populations (Semenza JC & Suk JE., 2018; Semenza JC et al., 2022). Warming, for instance, has had favourable impacts on the development and survival of mosquito populations, as well as on their biting rates and viral replication. Drought conditions also led to the congregation of mosquitoes and birds around remaining water sources, which promoted the spread of the West Nile virus (Mora C et al., 2022). There were 336 human cases of locally-acquired West Nile virus (WNV) infections in 2020 reported in the EU and European Economic Area (EEA) Member States, followed by 463 cases in 2019 and 2083 cases in 2019. This is due to the migratory avian traveling from sub-Saharan Africa, North Africa, or the Middle East introducing WNV into Europe, where the virus overwinters in mosquitoes (Semenza JC & Suk JE., 2018).

Chikungunya

Chikungunya virus (CHIKV) is spread by mosquitoes of the *Aedes* species (Waits A et al., 2018). It was initially detected in Tanzania in 1952, sparking a localized outbreak in Africa and various parts of Asia, before disseminating to nations surrounding the Indian Ocean (Semenza JC et al., 2022). The increase in disease prevalence was observed to have a linear relationship with the rise in temperature (El-Sayed A & Kamel M., 2020).

Travel and trade have played significant roles in the ongoing geographic expansion of the virus to temperate regions. Additionally, the virus has been repeatedly introduced into Europe, where favourable climatic conditions contributed to two major outbreaks in Italy, occurring in 2007 and 2017 (Semenza JC et al., 2022). In 2007, Europe experienced its first significant outbreak of chikungunya with 330 reported cases in Italy, sparking public health concerns. Additionally, two smaller outbreaks of native cases of chikungunya occurred in France in 2010 and 2014 (Semenza JC & Suk JE., 2018). The outbreak in 2014 may have resulted from heavy precipitation by causing a rapid rise in vector populations (Semenza JC & Suk JE., 2018).

Winds also play a substantial role in the dissemination of mosquitoes and the diseases they carry. In several regions of China, the wind has been implicated as the catalyst for the emergence of mosquitoes, particularly *Culex tritaeniorhynchus* (El-Sayed A, Kamel M., 2020). A decade after the first outbreak in Italy, a significant surge of 489 cases occurred during the season favourable for the virus due to climate conditions (Semenza JC & Suk JE., 2018). Projected models indicate a potential rise in the southern coastal regions, where more summers are expected to have climatic conditions conducive to the *Aedes albopictus* mosquito vector (Waits A et al., 2018). Meanwhile, another recent projection for chikungunya indicates a growing suitability of climatic conditions in temperate regions of Western Europe, encompassing countries such as France, the Benelux Union, and Germany, for the future (Caminade C et al., 2019).

Malaria

Chikungunya virus (CHIKV) is spread by mosquitoes of the *Aedes* species (Waits A et al., 2018). It was initially detected in Tanzania in 1952, sparking a localized outbreak in Africa and various parts of Asia, before disseminating to nations surrounding the Indian Ocean (Semenza JC et al., 2022). The increase in disease prevalence was observed to have a linear relationship with the rise in temperature (El-Sayed A, Kamel M., 2020). Travel and trade have played significant roles in the ongoing geographic expansion of the virus to temperate regions. Additionally, the virus has been repeatedly introduced into Europe, where favourable climatic conditions contributed to two major outbreaks in Italy, occurring in 2007 and 2017 (Semenza JC et al., 2022). In 2007, Europe experienced its first significant outbreak of chikungunya with 330 reported cases in Italy, sparking public health concerns.

Additionally, two smaller outbreaks of native cases of chikungunya occurred in France in 2010 and 2014 (Semenza JC & Suk JE., 2018). The outbreak in 2014 may have resulted from heavy precipitation by causing a rapid rise in vector populations (Semenza JC & Suk JE., 2018). Winds also play a substantial role in the dissemination of mosquitoes and the diseases they carry. In several regions of China, the wind has been implicated as the catalyst for the emergence of mosquitoes, particularly *Culex tritaeniorhynchus* (El-Sayed A, Kamel M., 2020). A decade after the first outbreak in Italy, a significant surge of 489 cases occurred during the season favourable for the virus due to climate conditions (Semenza JC & Suk JE., 2018).

Projected models indicate a potential rise in the southern coastal regions, where more summers are expected to have climatic conditions conducive to the *Aedes albopictus* mosquito vector (Waits A et al., 2018). Meanwhile, another recent projection for chikungunya indicates a growing suitability of climatic conditions in temperate regions of Western Europe, encompassing countries such as France, the Benelux Union, and Germany, for the future (Caminade C et al., 2019).

Dengue

Dengue stands out as the mosquito-borne disease experiencing the most rapid spread, witnessing a staggering 30-fold increase in global incidence over the past 50 years (Caminade C et al., 2019). Each year, 50 to 100 million of cases estimated occurred worldwide, affecting almost half of the world's population living in countries where the disease is endemic (Sophie Dennis & Dale Fisher, 2018). In Malaysia, a sum of 71, 590 dengue cases, resulting in 162 deaths between January 1 and August 20, 2016. The majority of these cases occurred in the states of Selangor, Kelantan, Johor and Kuala Lumpur (Jegasothy R et al., 2021). Dengue virus is transmitted by *Aedes* mosquitoes (Sophie Dennis & Dale Fisher, 2018). Dengue incidence shows a positive correlation with temperature, precipitation, and relative humidity in various locations worldwide, such as the Americas, India, and the Philippines (Semenza JC et al., 2022). In warmer and high humidity conditions, breeding and maturation of *Aedes* mosquitoes accelerated. Hence, they proliferate faster and contribute to higher rates of infection due to the changes in climate coincide with increasing urbanization, amplified density of human populations and the presence of abundant mosquito breeding sites such as household waste (Sophie Dennis & Dale Fisher, 2018).

Sea surface temperature, rainfall, and changes in wind patterns linked to the El Niño Southern Oscillation over the Pacific Ocean have also been utilized as predictors of dengue incidence. The disruption of vector control measures in Central American countries following Hurricane Mitch in 1998 resulted in almost 40,000 cases of dengue and dengue hemorrhagic fever (Semenza JC et al., 2022). A recent study emphasizes that forthcoming climate conditions may become more conducive to dengue transmission in Southern Europe (Caminade C et al., 2019). For instance, by 2050, climate change is anticipated to bring about more favorable temperatures and increased rainfall, potentially enhancing the suitability for dengue in various regions. These include southern and western Africa, southeastern USA, central Mexico, northern Argentina, and inland areas of Australia. Additionally, coastal cities in eastern China and Japan are forecasted to become more favorable environments for dengue transmission by 2050 (Semenza JC et al., 2022).

Zika

Zika Virus (ZKV) is primarily spread through the bites of infected *Aedes* mosquitoes. It can lead to severe neurological complications, including microcephaly in unborn children, and less commonly, a paralytic autoimmune disorder known as Guillain–Barré syndrome (Caminade C et al., 2019). The virus was probably introduced into northeastern Brazil by a traveler in 2014, with the first human case subsequently detected in May 2015 and causing an outbreak in the same year. It then spread to most countries in South and Central America and the Caribbean (Caminade C et al., 2019). The following year, ZKV started to spread extensively worldwide, resulting in massive outbreaks in South America and circulated in few countries in Africa and Southeast Asia (Caminade C et al., 2019; Semenza JC et al., 2022). This disease expansion is due to high temperatures and severe drought conditions in the previous year. The practice of storing drinking water in open containers at home, which became more common due to the drought, might have created optimal breeding and exposure conditions for vectors, thus contributing to the outbreak (Semenza JC et al., 2022). The epidemic of ZKV between 2015 to 2016 triggered serious public

health problems and is estimated to appear in Europe, given that both of its vectors, *Aedes aegypti* and *Ae. albopictus*, are native to the region (El-Sayed A, Kamel M., 2020). This evidenced by limited and localized transmission of ZKV in Texas and Florida, located in the southern United States during summer of 2017 (Caminade C et al., 2019).

Tick Borne Diseases

Ixodes ticks have the capability to transmit bacteria belonging to the *Borrelia* genus, leading to Lyme disease, the most common tick-borne infection in temperate regions of Europe. Additionally, these ticks are responsible for transmitting the virus accountable for numerous cases of tick-borne encephalitis (TBE) annually in European countries (Semenza JC & Suk JE., 2018). *Ixodes Ricinus* serves as the main carrier for both Lyme borreliosis and tick-borne encephalitis in Europe which are considered the most significant tick-borne disease (TBVD) in the region (Anderson M et al., 2021). Meanwhile, in North America, *Ixodes scapularis* serves as the primary vector (Waits A et al., 2018).

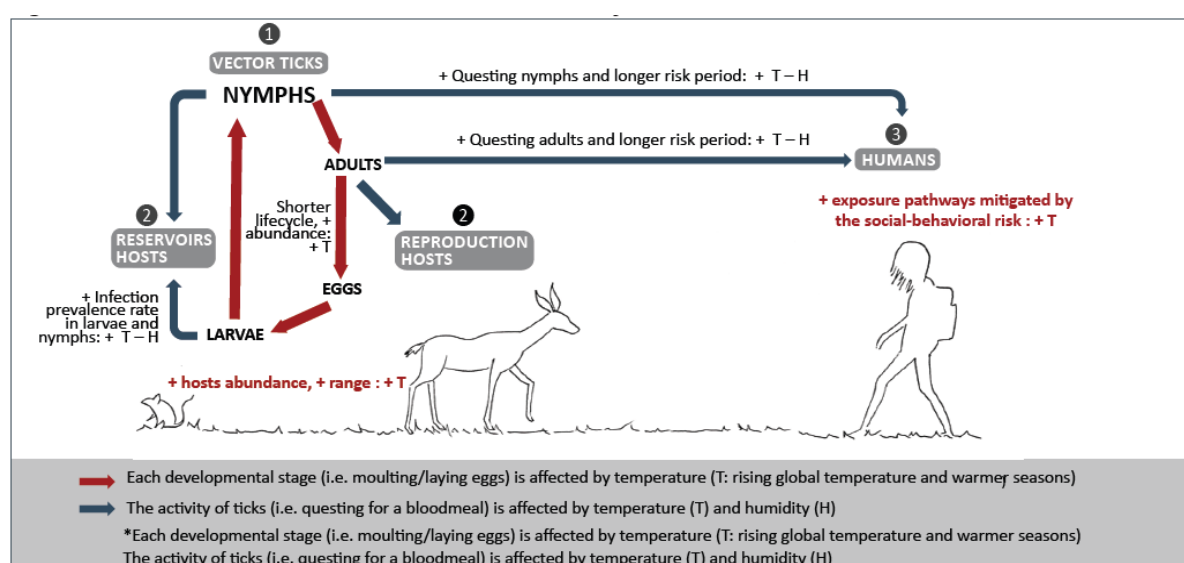


Figure 3: Meteorological and climatic factors that promote the life cycle of ticks and heighten the risk to humans (19).

It is known that ticks can endure for 2-3 years by seeking shelter from extreme surface temperatures, heavy rainfall, and extended lifespans by burrowing into the soil (Dal T et al., 2023). They are influenced by climatic factors, particularly humidity and temperature (Anderson M et al., 2021). To illustrate, based on epidemiological and climatic data for the Arkhangelsk, nearly a 60-fold rise of morbidity due to TBD between 1980 to 2015 attributed to the climate warming (Waits A et al., 2018). Increasing temperatures due to climate change have affected both the reproduction hosts and the reservoir hosts involved in the tick life cycle in which the condition becomes more favorable for the survival, reproduction, and accelerated development of ticks. For example, higher temperature the distribution range of both rodents and deer, as well as increasing their abundance and activity (Bouchard et al., 2019).

Warmer winter temperatures can also facilitate increased tick survival during the winter months, consequently leading to a further rise in tick populations (Edelson PJ et al. (2023). A high incidence of tick-borne disease has been reported to be associated with moderate winters and humid, warm summers in countries such as Sweden, Slovakia, and Hungary. However, it's worth noting that the incidence of these diseases may also be influenced by climate's impact on recreational activities (Anderson M et al., 2021).

For example, as a consequence of climate change, people may engage in outdoor activities earlier in the spring and continue them later into the fall. As a consequence of climate change, people may initiate outdoor activities earlier in the spring and prolong them until later in the fall. This aligns with the period when ticks are most active, from the melting of snow in the spring to the return of snow cover in the fall. The extended duration of exposure to tick habitats, along with the prolonged tick activity season, increases the probability of encountering ticks (Bouchard et al., 2019).

The geographic range of *Ixodes ricinus*, the predominant arthropod vector of human disease in Europe, is impacted by various climatic factors including humidity, soil moisture, and air temperature (Semenza JC & Suk JE., 2018). Studies have revealed expansion of tick populations to higher latitudes and altitudes, as evidenced by reports of northward movement in Sweden and upward movement to higher elevations in Austria and the Czech Republic. Similar range expansions have also been observed in Norway and Germany (Anderson M et al., 2021). The expansion is also influenced by changes in the tick's seasonal activity due to increase in temperature in which warmer winters and extended spring and autumn seasons experienced in the 1990s (Semenza JC & Suk JE., 2018). With the anticipated warming, it is expected that the geographic range of *Ixodes ricinus* will also expand towards the north and east (Waits A et al., 2018).

Tick-borne encephalitis (TBE) is a significant zoonotic infection, marked by a growing disease burden and a widening geographic distribution spanning across Europe, Russia, and various parts of Asia (Semenza JC et al., 2022). From 2005 to 2015, the annual incidence rates of TBE per 100,000 people were 2 to 5.4 times higher compared to the corresponding rates nationwide (Waits A et al., 2018). Meanwhile, in 2014, the EU reported 2,057 cases of tick-borne encephalitis (TBE).

Over the past 30 years, there has been an almost 400% rise in reported cases in European endemic areas, although this increase can also be attributed to improved surveillance and diagnosis (Anderson M. et al., 2021). A study examining epidemiological shifts in tick-borne encephalitis (TBE) incidence in the Russian Federation over two decades (1997–2006 and 2007–2016) discovered that the most significant changes are taking place in Siberia and the Far East (Waits A et al., 2018). Milder winters and warmer springs, attributed to climate change, have been implicated as one of the contributing factors to the range expansion of these tick-borne diseases (TBDs). In 2019, 3411 cases were reported in EU/EEA countries resulting in 20 deaths indicating that TBE is a potentially a serious disease (Semenza JC et al., 2022).

Lyme disease is the most prevalent tick-borne illness globally (Dal T et al., 2023). It is also known as Lyme borreliosis or tick-borne borreliosis which is also responsible for the highest disease burden among all vector-borne diseases in the European Union with an estimated 65,000 cases annually (Anderson M et al., 2021). It is caused by the bacteria *Borrelia burgdorferi*, *Borrelia afzelii*, or *Borrelia garinii* (Waits A et al., 2018). This disease commonly manifests with an erythema migrans rash and nonspecific symptoms including fatigue, fever, headache, and muscle and joint pains. If left untreated, it can progress to a multisystem disease. It is rarely fatal, however recent reports have linked deaths to Lyme carditis (Bouchard C, et al., 2019).

In recent years, it has been observed that *Ixodes scapularis*, the primary vector of *Borrelia burgdorferi*, the causative agent of Lyme disease, has gradually spread from the United States into Canada (Dal T et al., 2023, Anderson M et al., 2021). This expansion is correlated with higher temperatures, the emergence of tick populations, expansions in their geographical range, and

recent spread into new areas. In the coming decades, the season for Lyme disease is anticipated to expand in the USA under a 2°C warming scenario, with a projected 20% increase in cases. This expansion is expected to result in an earlier onset and a prolonged duration of the annual Lyme disease season (Anderson M et al., 2021).

3.3 Food & Water Borne Disease

Waterborne and foodborne illnesses are significant contributors to global mortality rates and represent a notable source of sickness in developed nations (Amy Greer et al, 2008). They indeed posed a significant public health threat on a global scale (El-Sayed A & Kamel M., 2020). In the United States, the primary waterborne diseases include bacterial diarrheal illnesses such as salmonellosis, shigellosis, Campylobacter disease, diarrheagenic Escherichia coli, and yersiniosis, along with viral infections caused by norovirus and rotavirus. These diseases typically spread through contaminated food and water, as well as person-to-person contact due to poor hygiene practices (Edelson PJ et al., 2023). Additionally, they are influenced by climate warming (Edelson PJ et al., 2023). Increased temperatures and extreme precipitation attributed by climate change can increase the incidence of food- and waterborne diseases (Waits A et al., 2018; Amy Greer et al, 2008).

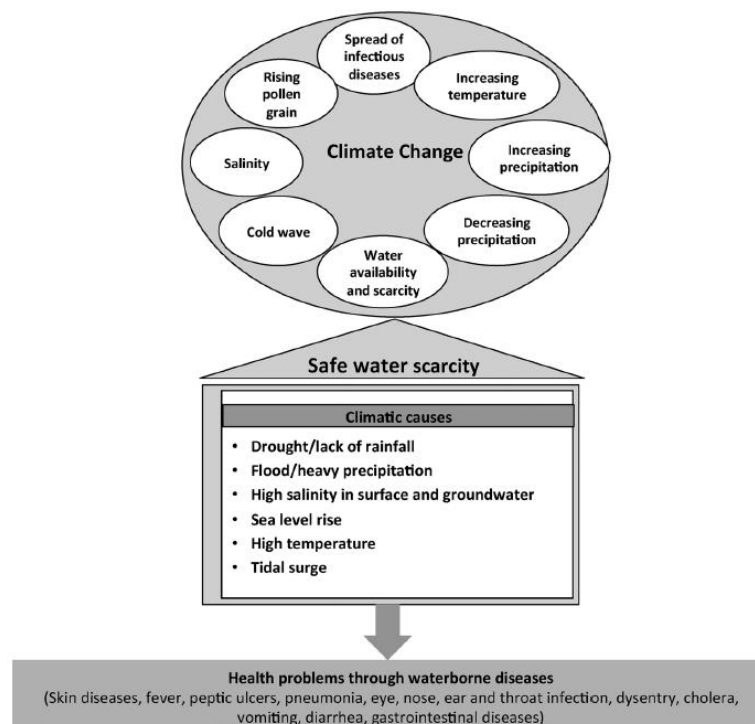


Figure 4: The sequence of climate change, the shortage of safe water, and health concerns (Abedin MA, et al,2019).

Extreme precipitation events have been connected to significant outbreaks of waterborne diseases, and these events are anticipated to become more frequent in the upcoming decades (Amy Greer et al, 2008). A study examined the relationship between heavy precipitation and waterborne outbreaks in Denmark, Norway, Finland, and Sweden spanning from 1992 to 2012. The study compared outbreaks reported to national surveillance system registries with daily precipitation data. It found that a rise in heavy precipitation in the preceding weeks correlated with an increase in waterborne outbreaks (Waits A et al., 2018).

As the frequency and intensity of precipitation-related weather events are projected to increase, it is expected that flooding will occur more frequently (Sophie Dennis & Dale Fisher, 2018). Consequently, water volume will rise and eventually lead to sewage drainage systems to become overwhelmed, leading to overflow and subsequently contaminating drinking water, producing waterborne outbreaks (El-Sayed A & Kamel M., 2020). Intense storms can also lead to the overflow of wastewater. This was demonstrated by an outbreak of *E. coli* gastroenteritis in Ontario in May 2000. Furthermore, heavy rainwater runoff has been linked to outbreaks of giardiasis in Montana and cryptosporidiosis in Milwaukee, Wisconsin (Edelson PJ et al., 2023). Similarly, a global systematic review revealed that *Vibrio* spp. and *Leptospira* spp. constituted 45% of the pathogens detected in water supplies following heavy rainfall (Sophie Dennis & Dale Fisher, 2018).

Campylobacter is the predominant bacterial cause of diarrheal disease in developed nations, with more than 220,000 cases annually and a notification rate of 60 cases per 100,000 population. It is consistently reported as the leading cause of bacterial gastroenteritis in humans across the EU/EEA (Semenza JC & Suk JE., 2018). The situation with *Campylobacter* differs because the pathogen cannot replicate outside the host. Therefore, warm weather conditions may not directly impact *Campylobacter* replication rates, but instead may reflect human behavioural factors such as riskier practices in food production and consumption, or other seasonal influences such as flies (Semenza JC et al., 2022). A study on *Campylobacter* infections in England and Wales revealed that the rise in infections during late spring was notably correlated with temperatures recorded two weeks earlier. Similarly, research conducted in the Nordic countries indicates that the temporal and geographical distribution of *Campylobacter* can be linked to rises in temperature and heavy rainfall, potentially leading to an increase in reported cases in the subsequent week. Conversely, heat waves and winter precipitation might result in a decrease in reported cases (Semenza JC & Suk JE., 2018).

Salmonellosis, with over 87,000 cases annually in the EU/EEA, stands as the second most frequently reported gastrointestinal infection in humans following campylobacteriosis. It represents a notable cause of foodborne outbreaks, with infections occurring more frequently during the summer months (Semenza JC & Suk JE., 2018). Indeed, *Salmonella* is sensitive to climate conditions and thrives within a narrow temperature range, displaying strong seasonality (17). For example, the occurrence of human *Salmonella* infections, with a rate of 20.0 cases per 100,000 population, is higher during the summer months compared to the winter months (Semenza JC & Suk JE., 2018).

The most well-known waterborne disease is cholera which is transmitted primarily through the consumption of contaminated water (El-Sayed A & Kamel M., 2020). It is a bacterial diarrheal disease that is caused by toxigenic strains of *Vibrio cholera* with high case-fatality rate and maintains as a major cause of death in the developing world (Amy Greer et al., 2008). Cholera has been linked to various climatic factors, especially in areas with inadequate water, sanitation, and hygiene (WASH) facilities and where the disease is already prevalent in the population. Elevated ambient temperatures, along with both lower and higher levels of precipitation, are significant parameters influencing cholera incidence (Semenza JC et al, 2022). Moreover, *Vibrio cholerae* is closely linked with zooplankton, and both *Vibrio cholerae* and zooplankton populations tend to flourish as water temperatures rise (El-Sayed A, Kamel M., 2020).

Due to climate change, water temperatures become warmer and the risk of cholera increases, indicating a potential sharp rise in global cholera activity. Such increases pose a risk not

only to developing nations but also to developed countries through the importation of the disease (20). In 1970, primary outbreaks of *Vibrio cholerae* emerged on the mainland, with epidemics documented in Africa, specifically in Guinea, and the Horn of Africa, encompassing Ethiopia, Somalia, and Sudan. The most severe cholera outbreak on the African mainland occurred in 1998, constituting more than 72% of the global total number of cholera cases (Darbandi A., 2023). The incidence of *Vibrio*-associated diseases has notably risen worldwide in recent decades and may potentially emerge in numerous Northern European countries due to global warming. Infections tend to spread during warm summers through activities like swimming in pools and in coastal areas. Thus, individuals with open wounds and consumers of shellfish are particularly susceptible to *Vibrio cholerae* infection (El-Sayed A, Kamel M., 2020).

Vibriosis is an illness caused by bacteria belonging to the *Vibrio* genus (Waits A et al., 2018). Nontoxigenic strains of *V. cholerae* and other noncholera *Vibrio* species, such as *Vibrio parahaemolyticus* and *Vibrio vulnificus*, could become more prevalent causes of disease due to rising ocean temperatures and the increased occurrence of extreme weather events. For instance, cases of illness caused by these microorganisms were observed in connection with Hurricane Katrina in 2005 (Amy Greer et al, 2008). Likewise, heat waves have been associated with an increase in outbreaks of vibriosis in the Arctic, especially when there is a rise in sea surface temperature.

In July 2014, heat waves experienced in Finland and Sweden coincided with abnormal sea surface temperatures and a higher number of reported cases of vibriosis. Meanwhile, similar findings were observed in Canada when examining the relationship between sea surface temperature and cases of *Vibrio parahaemolyticus* (Vp) infection. An elevated risk of Vp infection was noted when sea surface temperatures surpassed 14.3°C (Waits A et al., 2018). The primary explanation for vibriosis outbreaks in regions where this disease is not typically prevalent is the phenomenon of ocean warming and heavy precipitation, which decreases coastal water salinity, hence creating favourable conditions for the proliferation of *Vibrio vulnificus* and *Vibrio cholerae* (Mora Cet al., 2022). The similar phenomenon also facilitates the range of expansion of these pathogens and induce risk of *Vibrio* emergence at higher latitudes (Edelson PJ et al., 2023).

4. Solutions to Address the Effects of Climate Change on Infectious Disease

Surveillance serves a crucial role in promptly identifying and subsequently managing infectious disease outbreaks. It necessitates systematic gathering and analysis of data pertaining to infectious diseases. This approach aids in disease management and control by providing insights into frequency, trends, affected demographics, and geographic distribution (Okaka FO & Odhiambo BDO, 2018). Nevertheless, additional specialized approaches must be incorporated into existing efforts, including targeted and intensified surveillance for specific diseases in particular regions. For instance, expanding current mosquito surveillance could enable the detection of new pathogens within vector populations, possibly utilizing advanced techniques like next-generation sequencing.

Furthermore, adopting a One Health approach, which considers the epidemiology of animal and avian infections, will be essential for anticipating and effectively responding to outbreaks and spillover events. Heightened focus on vectors, intensified surveillance for specific pathogens, incorporation of comprehensive meteorological data into human and animal epidemiological studies, and identification of emerging pathogens will require a proportional rise in funding and the recruitment and training of proficient personnel. Moreover, clinicians must be equipped to confront infections that might not have previously been endemic to an area and could occur outside of typical seasonal patterns. Medical institutions, residency programs, fellowships, and continuing

medical education should provide clinicians with training to anticipate and address these evolving challenges (Edelson PJ et al., 2023). Additionally, it's crucial to allocate resources towards enhancing laboratory infrastructure to promptly, securely, and efficiently identify emerging pathogens (Ellwanger JH et al., 2020).

Adaptation can significantly decrease rural communities' susceptibility to climate change by enhancing their capacity to adjust to climate change and variability. This not only mitigates potential damages but also enables them to better manage and cope with adverse consequences. Ultimately, adaptation diminishes vulnerability and enhances resilience (Abedin MA et al., 2019). Climate services tailored for health represent one of the most effective adaptation strategies within the health sector. These services encompass various tools such as early warning systems and epidemic forecasting models, which utilize climate predictions to anticipate disease risks. By furnishing the health sector with targeted information, climate services facilitate informed decision-making, enabling timely interventions to mitigate or prevent disease outbreaks (Stewart-Ibarra AM, 2022).

Incorporating Early Warning Systems (EWSs) for infectious diseases enables individuals at risk to either evacuate or implement precautionary measures, while also enabling the public health sector to adequately prepare for potential outbreaks. A notable example can be found in Botswana, where EWS initiatives have effectively minimized malaria outbreaks during floods. This success is attributed to accurate predictions and timely anticipation, which facilitated the prompt implementation of mitigation measures (Okaka FO & Odhiambo BDO, 2018).

Meanwhile, in a recent comprehensive review of climate modeling tools for infectious diseases, only 37 tools were identified, with over half (53%) concentrating on malaria. Surprisingly, only a single tool was discovered for water-borne diseases, namely the ECDC Vibrio Map Viewer. Moreover, ENSO forecasts can also be integrated into disease prediction models, with studies showing the ability to predict El Niño events up to 2.12 years in advance. When an ENSO event occurs, seasonal climate forecasts tend to be more accurate, enhancing the potential for an early warning system to effectively predict extreme climate events and consequent disease outbreaks. For instance, researchers combined seasonal climate forecasts with ENSO forecasts to predict, months ahead of time, an increase in dengue cases following heavy rainfall and flooding in southern coastal Ecuador during the 2016 El Niño event (Stewart-Ibarra AM, 2022).

Disease risk assessment is another solution (Okaka FO & Odhiambo BDO, 2018). It involves strategies, policies, and actions to enhance understanding, reduce risk, and improve preparedness, response, and recovery practices (Ebi KL et al., 2021). Risk assessment should concentrate on hazards such as the disruption and pollution of safe water sources, sanitation and cooking facilities, uninhabitable shelter conditions, resulting population displacement leading to overcrowding, heightened exposure to disease vectors, and limited access to healthcare services. Such risk assessment guides decisions aimed at safeguarding health and well-being (Okaka FO & Odhiambo BDO, 2018). Specific disaster risk management measures, such as heat wave warning programs and infrastructure resilience, may concurrently foster climate change adaptation and overall disaster preparedness (Ebi KL et al., 2021).

Mitigations may include vaccination and vector control. Strategies of vaccination will require time to develop, including the duration needed for vaccine stockpiling in high-need areas. Enhanced understanding of future vaccine demands and the influence of animal trade and movement is crucial for optimizing limited resources to mitigate the global threat of infectious

diseases (Bartlow AW et al., 2019). According to the World Health Organization, a key strategy in reducing disease transmission within communities is vector control. This approach involves creating conditions that are unfavorable for the survival, development, and reproduction of disease-carrying vectors. For instance, in controlling mosquito-borne diseases like malaria, methods such as indoor residual spraying and the use of insecticide-treated nets have proven effective in minimizing outbreaks. Similarly, for rodent-borne diseases, proper waste disposal is necessary to discourage vector breeding, while clearing tall grasses around residential areas can further reduce breeding grounds (Okaka FO & Odhiambo BDO, 2018).

Another solution that can be suggested is health education. Health care practitioners carry a crucial role in relaying information to the public regarding exposure to infectious diseases and the association of climate change to infectious disease in current time. Health awareness campaigns are required to protect the public health by reducing the health vulnerability. The primary objective of the campaign is to prepare the community for the anticipated negative health risks during and after extreme weather events. They also need to be informed about the precautions that can be practiced to avoid the occurrence of disease outbreak and spread of infectious diseases.

5. Conclusion

As the world is warming at an extraordinary rate, it is crucial to prioritize research on the potential impacts of climate changes on infectious disease. Disease transmission can be influenced by climatic factors either directly or indirectly, yet most of the effects are indirect such as changes in human behavior, vector dynamic or pathogen survival. Vector borne diseases encompass mosquito borne diseases (West Nile virus, dengue, malaria, chikungunya and zika) and tick-borne disease (tick borne encephalitis and Lyme disease) primarily associated with temperature. Warmer temperature enhances their development and survival as well as the pathogens they brought along. Thus, spreading the disease worldwide and increasing the incidence of the cases. Furthermore, a warming climate can lead to disease expansion due to the survival ability of the vectors in warmer winters.

Outbreaks may occur in regions where no cases had been reported previously. Meanwhile, food and waterborne diseases are impacted by temperature and precipitation. Increased precipitation events lead to waterborne disease outbreaks, with flooding overwhelming sewage systems and contaminating drinking water. Warming temperatures also contribute to the proliferation of the pathogens which are *Vibrio* spp., *Campylobacter* and *Salmonella*. These diseases are projected to become more prevalent due to rising ocean temperatures and extreme weather events. There are few solutions in addressing climate change's impact on infectious disease. Surveillance plays a vital role in identifying and managing outbreaks, yet requires systematic data collection and analysis.

Furthermore, adaptation strategies are crucial for reducing vulnerability to climate change. It includes Early Warning Systems (EWS) and epidemic forecasting tools. Vaccination strategies and vector control are vital components of mitigation efforts. Meanwhile, Health education campaigns are also necessary to raise awareness and empower communities to mitigate risks associated with climate change and infectious diseases. Overall, comprehensive and collaborative approaches are essential to address this multifaceted challenge and protect public health in a changing climate.

It is crucial to compile the epidemiology of infectious disease due to climate change in order to monitor the rates and prevent the disease progression. Moreover, human activity such as

population mobility from endemic places adds additional risk. However, there have been many health interventions done to mitigate the effects of climate change on infectious disease. More research is required to address all the climatic factors and the trends of infectious disease globally due to climate change for a deeper understanding and opportunity to eradicate this health burden.

This review is constrained by language limitations, rigid inclusion criteria, and the selected search terms. The search terms employed might have constrained the articles identified for the review.

References

- Abedin MA, Collins AE, Habiba U, Shaw R. (2019). Climate Change, Water Scarcity, and Health Adaptation in Southwestern Coastal Bangladesh. *International Journal of Disaster Risk Science*. 2019 Mar 1;10(1):28–42.
- Amy Greer, Victoria Ng, David Fisman. (2008). Climate Change and Infectious Diseases in North America: The Road Ahead. *Can Med Assoc J*. 2008 Aug 21;
- Anderson M, Forman R, Mossialos E. (2021). Navigating the role of the EU Health Emergency Preparedness and Response Authority (HERA) in Europe and beyond. Vol. 9, *The Lancet Regional Health - Europe*. Elsevier Ltd
- Baker RE, Mahmud AS, Miller IF, Rajeev M, Rasambainarivo F, Rice BL, et al. (2022). Infectious Disease in an Era of Global Change. Vol. 20, *Nature Reviews Microbiology*. Nature Research; 2022. p. 193–205.
- Bartlow AW, Manore C, Xu C, Kaufeld KA, Valle S Del, Ziemann A, et al. (2019). Forecasting Zoonotic Infectious Disease Response to Climate Change: Mosquito Vectors and a Changing Environment. Vol. 6, *Veterinary Sciences*. MDPI Multidisciplinary Digital Publishing Institute; 2019.
- Bouchard C, Dibbernardo A, Koffi J, Wood H, Leighton P, Lindsay L. (2019). Increased Risk of Tick-borne Diseases with Climate and Environmental Changes. *Canada Communicable Disease Report*. 45(4):83–9.
- Caminade C, McIntyre KM, Jones AE. (2019). Impact of Recent and Future Climate Change on Vector-borne Diseases. Vol. 1436, *Annals of the New York Academy of Sciences*. Blackwell Publishing Inc. p. 157–73.
- Casadevall A. (2020). Climate Change brings the Specter of New Infectious Diseases. Vol. 130, *Journal of Clinical Investigation*. American Society for Clinical Investigation; p. 553–5.
- Chowdhury FR, Ibrahim QSU, Shafiqul Bari M, Jahangir Alam MM, Dunachie SJ, Rodriguez-Morales AJ, et al. (2018). The Association between Temperature, Rainfall and Humidity with Common Climate-sensitive Infectious Diseases in Bangladesh. *PLoS One*. Jun 1;13(6).
- Dal T, Ramli I, Garaizar J. (2023). Effect of Climate Change on Nature and Human Health with a Special Focus on Infectious Diseases in the Mediterranean Region. Vol. 17, *Journal of Infection in Developing Countries*. p. 1501–10.
- Darbandi A, Ohadi E, Nezamzadeh F, Jalalifar S, Bialvaei AZ. (2023). The Effect of Climate Changes on Human Bacterial Infectious Diseases. Vol. 17, *Iranian Journal of Medical Microbiology*. Farname Inc; 2023. p. 273–87.
- de Souza WM, Weaver SC. (2024). Effects of Climate Change and Human Activities on Vector-Borne Diseases. *Nature Reviews Microbiology*. Nature Research
- Ebi KL, Vanos J, Baldwin JW, Bell JE, Hondula DM, Errett NA, et al. (2021). *Extreme Weather and Climate Change: Population Health and Health System Implications*. Available from: <https://doi.org/10.1146/annurev-publhealth->

- Edelson PJ, Harold R, Ackelsberg J, Duchin JS, Lawrence SJ, Manabe YC, et al. (2023). Climate Change and the Epidemiology of Infectious Diseases in the United States. Vol. 76, *Clinical Infectious Diseases*. Oxford University Press; 2023. p. 950–6.
- Ellwanger JH, Kulmann-Leal B, Kaminski VL, Valverde-Villegas JM, Da Veiga Abg, Spilki FR, et al. (2020). Beyond Diversity Loss and Climate Change: Impacts of Amazon Deforestation on Infectious Diseases and Public Health. *An Acad Bras Cienc*. 2020;92(1).
- El-Sayed A, Kamel M. (2020). Climatic Changes and Their Role in Emergence and Re-emergence of Diseases. Vol. 27, *Environmental Science and Pollution Research*. Springer. p. 22336–52.
- Jegasothy R, Sengupta P, Dutta S, Jeganathan R. (2021). Climate Change and Declining Fertility Rate in Malaysia: The Possible Connections. Vol. 32, *Journal of Basic and Clinical Physiology and Pharmacology*. De Gruyter Open Ltd; 2021. p. 911–24.
- Mora C, McKenzie T, Gaw IM, Dean JM, Von Hammerstein H, Knudson TA, et al. (2022). *Over Half of Known Human Pathogenic Diseases can be Aggravated by Climate Change*. Nat Clim Chang. 2022;
- Okaka FO, Odhiambo BDO. (2018). Relationship between Flooding and Outbreak of Infectious Diseases in Kenya: A Review of the Literature. *J Environ Public Health*.
- Shaffril HAM, Abu Samah A, D'Silva JL. (2017). Adapting towards Climate Change Impacts: Strategies for Small-scale Fishermen in Malaysia. *Mar Policy*. Jul 1;81: 196–201.
- Semenza JC, Rocklöv J, Ebi KL. (2022). Climate Change and Cascading Risks from Infectious Disease. Vol. 11, *Infectious Diseases and Therapy*. p. 1371–90.
- Semenza JC, Suk JE. (2018). Vector-borne Diseases and Climate Change: A European Perspective. Vol. 365, *FEMS Microbiology Letters*. Oxford University Press
- Sophie Dennis, Dale Fisher. (2018). *Climate Change and Infectious Diseases: The Next 50 Years*. 2018;47(10).
- Stewart-Ibarra AM. (2022). Climate Change and Infectious Diseases: Research and Policy Actions Needed to Address an Inequitable Health Crisis. Vol. 5, *One Earth*. Cell Press; 2022. p. 333–5.
- Tong S, Ebi K, Olsen J. (2021). Infectious Disease, the Climate, and the Future. Vol. 5, *Environmental Epidemiology*. Wolters Kluwer Health, p. E133.
- Waits A, Emelyanova A, Oksanen A, Abass K, Rautio A. (2018). Human Infectious Diseases and the Changing Climate in the Arctic. Vol. 121, *Environment International*. Elsevier Ltd: p. 703–13.

Telang Flower: A Novel Approach to Pharmaceutical Innovation in Malaysia

Saiful Mohamed Shuib^{1*}, Elena Anwar² & Anwar Abdul Rahman³
^{1, 2 & 3}Politeknik Tuanku Syed Sirajuddin, Malaysia

Abstract

The COVID-19 pandemic has drastically reshaped the global economy, but it has also created new opportunities for the herbal medicine industry. Malaysia, with its rich biodiversity and over 2,000 plant species reported to have medicinal properties, has emerged as a hub for herbal product research and development. The Malaysian government has recognized the potential of this sector, designating herbs as a key economic area, and investing heavily in the research and development of high-value herbal products. One such plant that has garnered significant attention is the Telang Flower, also known as *Clitoria Ternatea*, which is explored for its potential as a pharmaceutical product. Malaysia's diverse flora, coupled with the government's commitment to the herbal industry, has fuelled a surge in scientific research aimed at validating the medicinal claims of various plant-based products. Researchers have shown an increased interest in developing commercialized herbal products, including Telang Flower which is listed as one of the 18 high-value herbs under the government's agriculture initiative. This research will show the ability of Telang Flowers innovated as a pharmaceutical product that is safe to use and provides optimal effects to its users.

Keyword: Covid 19 Pandemic, Pharmaceutical Product, Biodiversity, Telang Flower

1. Introduction

Malaysia, with its rich biodiversity, has been recognised as a promising hub for the development of plant-based pharmaceutical products. The country's natural wealth, comprising over 12% of the world's plant species, has attracted increasing attention from researchers and industry players alike. The Malaysian government has taken strategic steps to capitalize on this potential, establishing national plans and funding mechanisms to propel the growth of the biotechnology and herbal medicine sectors (Abuduxike, 2014). The COVID-19 pandemic has further fuelled the demand for medical supplies, including herbal remedies, highlighting the need for Malaysia to harness its natural resources to address both local and global health needs.

While the local herbal industry has experienced significant growth in recent years, majority of the products used by Malaysians are imported, primarily from countries like China, India, Indonesia, and the United States. This presents a prime opportunity for Malaysian researchers and pharmaceutical companies to develop innovative, plant-based therapies that can meet the growing domestic and international demand. One such plant species that has garnered attention is *Clitoria Ternatea*, a native Malaysian herb with reported medicinal properties. Researchers have been actively investigating the potential of *Clitoria Ternatea* and other local botanicals to develop new pharmaceutical products (Zaini & Mustafa, 2019).

Telang Flower (*Clitoria Ternatea*), Composition and Characteristic

Clitoria Ternatea, commonly known as Telang flower, is native to Tropical Asia and exhibits a wide distribution across numerous tropical and subtropical regions. Its natural habitat spans South and Central America, the East and West Indies, as well as China and India.



Figure 1: Mature Telang Flower (*Clitoria Ternatea*)

Source: *Open Access Journal of Medicinal and Aromatic Plants* 3(2):12-14

Also known as *Butterfly Pea*, this plant is a perennial herbaceous plant characterized by elliptic and obtuse leaves. This plant thrives in environments with moist and neutral soil conditions, achieving heights ranging from 90 to 162 cm. Its distinctive flowers are blue, appearing as linear and flat scabbards measuring 6-12 cm in length. The fruits of *Telang Flower* are flat pods, 5-7 cm long, each containing 6-10 seeds. These pods are edible when tender, offering potential nutritional benefits. The comprehensive botanical description of the plant underscores its suitability for various ecological and agricultural studies, focusing on its growth patterns, reproductive characteristics, and potential applications in both traditional and modern agricultural practices.

The chemical composition of *Telang Flower* reveals significant nutritional and biochemical characteristics across its various parts. The total protein content of the plant ranges from 14% to 20%, with leaves containing 21.5% crude protein and fibre ranging from 21.5% to 29%. The seeds are notably high in protein, ranging from 15% to 25%, and contain 25-38% carbohydrates, 5% total sugars, and 10% oil. The nitrogen concentration in the whole plant varies from 1.7% to 4%. Amino acid composition in the seed, as a percentage of crude protein, further underscores its nutritional profile.

Biochemical analysis of flower extracts using petroleum ether (60-80°C) has identified the presence of Taraxerol, a pentacyclic triterpenoid (Shyamkumar & Bhat Ishwar, 2012). The flowers also contain steroids, triterpenoids, saponins, resins, tannins, and starch when extracted with petroleum ether (60-80°C). These findings highlight the diverse array of bioactive compounds present in various parts of *Telang Flower*, suggesting potential applications in pharmaceuticals, nutraceuticals, and other industries where these compounds are valued for their medicinal and functional properties.

Traditional Uses

Telang Flower holds a significant place in traditional Indian medicine, where it is used as a brain tonic believed to enhance memory and intelligence. The therapeutic applications of this plant are diverse: the juice extracted from its flowers is applied to treat insect bites and various skin diseases, while a paste made from the flowers serves to alleviate eye infections. Additionally, the entire plant is employed as an antidote for snake bites (Nadkarni K.M., 1954). In Ayurvedic medicine, *Telang Flower* finds extensive use across different plant parts. The roots, noted for their bitterness and cooling properties, are recognized as laxative, intellect-promoting, diuretic, and tonic.

They are traditionally prescribed for conditions including dementia, hemicrania (migraine), inflammation, leprosy, bronchitis, asthma, pulmonary tuberculosis, ascites, and fever. The seeds

of butterfly pea function as cathartics, aiding in digestive ailments, while the leaves specifically apply in the management of earaches (otalgia) and liver disorders (hepatopathy). These traditional uses underscore the plant's versatility and its potential therapeutic benefits in treating a wide array of ailments, reflecting its longstanding cultural and medicinal significance in traditional Indian herbal medicine practices.

Medical Value

Research also reveals a plethora of bioactive properties across various extracts and parts of the plant. The petroleum ether (60-80°C) extract from the flowers has shown significant anti-inflammatory effects at doses of 200 and 400 mg/kg body weight, indicating its potential therapeutic utility in inflammation related disorders (Shyamkumar & Bhat Ishwar, 2012). Furthermore, the same extract exhibited analgesic activity at a dose of 400 mg/kg body weight, highlighting its potential as a pain-relieving agent. Studies on the root extracts of *Telang* Flower have demonstrated an increase in acetylcholine content in rat brains, akin to the effects of the standard cerebra drug pyritinol, suggesting possible cognitive enhancement properties (Taranalli & Cheeramkuzhy, 2000).

Moreover, the hydroalcoholic extracts of both roots and seeds of *Telang* Flower have shown promising antihyperlipidemic effects in diet-induced hyperlipidaemic rats, significantly reducing serum cholesterol and triglyceride levels, and improving the HDL/LDL ratio, akin to the effects of standard drugs like atorvastatin and gemfibrozil (Solanki YB & SM Jain, 2010). Additionally, ethanol extracts from *Telang* Flower roots exhibited antiasthmatic activity in animal models, inhibiting allergic reactions such as leucocytosis, eosinophilia, and mast cell degranulation (Taur D.J. & R.Y. Patil, 2011). The plant also shows potential in various neurological and psychiatric conditions, as methanolic extracts have demonstrated nootropic, anxiolytic, antidepressant, anticonvulsant, and antistress activities in animal studies (Jain N., 2003).

2. Research Objectives

- i. Evaluate the effectiveness and safety of compounds derived from the *Telang* Flower for specific pharmaceutical uses.
- ii. Examine consumers adoption towards natural and herbal pharmaceutical products.

3. Application

This research introduces the application of the *Telang* Flower in pharmaceutical products designed for skincare, including facial soap, sunblock, toner, and day cream. It explores the potential effectiveness and advantages of incorporating *Telang* flower extracts into these formulations, aiming to uncover their therapeutic qualities and appeal to consumers in the skincare industry.

Telang Flower Sunblock

In formulating sunblock cream based on *Telang* flower, various additional ingredients are utilised including Distilled Water, Glycerine, Sunflower Oil, Propylene Glycol, Titanium Dioxide, Zinc Oxide, Olive Oil, *Telang* extract, Aloe Vera Extract, Phenoxyethanol, Viscositymax, and Fragrance. Laboratory tests for the detection of dangerous chemicals such as arsenic, cadmium, lead and mercury have shown negative findings; ND (<0.01) (not detected).

CERTIFICATE OF ANALYSIS

RECEIVED DATE : 28 FEBRUARY 2024
 TEST PERFORMANCE DATE : 28 FEBRUARY 2024
 SAMPLE DESCRIPTION : ONE (1) BOTTLE OF SAMPLE WAS RECEIVED
 SAMPLE MARKING : SUNBLOCK

CHEMICAL / PHYSICAL TEST

TEST PARAMETER	UNIT	METHOD USED	RESULTS
Arsenic	mg/kg	BP 2019, Vol. V, Appendix VII & IID (AAS)	ND(<0.01)
Cadmium	mg/kg	BP 2019, Vol. V, Appendix VII & IID (AAS)	ND(<0.01)
Lead	mg/kg	BP 2019, Vol. V, Appendix VII & IID (AAS)	ND(<0.01)
Mercury	mg/kg	BP 2019, Vol. V, Appendix VII & IID (FIMS)	ND(<0.01)

Figure 2: Telang Flower Sunblock Laboratory Test Report
 Source: Bio Synergy Laboratories Sdn. Bhd



Figure 3: Telang Flower Sunblock (15g / 0.5 fl. oz.)
 Source: Authentic Product Photography

Telang Flower Serum

Distilled Water, Glycerine, Telang Extract, Aloe Vera Extract, Hyaluronic Acid, Phenoxyethanol, Carbopol, Triethanolamine and Fragrance are mixed ingredients in the production of *Telang Flower Serum*. Laboratory report consistently demonstrate the absence of harmful substances in the product and at the same time prove the safety of this product for use as facial soap.

CERTIFICATE OF ANALYSIS

RECEIVED DATE : 28 FEBRUARY 2024
 TEST PERFORMANCE DATE : 28 FEBRUARY 2024
 SAMPLE DESCRIPTION : ONE (1) BOTTLE OF SAMPLE WAS RECEIVED
 SAMPLE MARKING : SERUM

CHEMICAL / PHYSICAL TEST

TEST PARAMETER	UNIT	METHOD USED	RESULTS
Arsenic	mg/kg	BP 2019, Vol. V, Appendix VII & IID (AAS)	ND(<0.01)
Cadmium	mg/kg	BP 2019, Vol. V, Appendix VII & IID (AAS)	ND(<0.01)
Lead	mg/kg	BP 2019, Vol. V, Appendix VII & IID (AAS)	ND(<0.01)
Mercury	mg/kg	BP 2019, Vol. V, Appendix VII & IID (FIMS)	ND(<0.01)

Figure 4: Telang Flower Serum Laboratory Test Report
 Source: Bio Synergy Laboratories Sdn. Bhd



Figure 5: Telang Flower Serum Actual Product (20ml / 0.7fl. oz.)
Source: Authentic Product Photography

4. Market Potential

Choosing the right focus area is a critical factor in determining the success of pharmaceutical product being sold. Researchers have found that key variables such as product and service quality, customer satisfaction and trust play a significant role in shaping consumer behaviour and retention in the tourism industry. Destinations that can offer a delightful experience to tourists are more likely to attract repeat visitation and positive word of mouth recommendations (R & Goel, 2017). In ascertaining the market viability of this innovative *Telang Flower* product, a selection of rated spa centres on Langkawi Island registered under the Ministry of Tourism, Arts and Culture (MOTAC) is chosen as research sites.

Langkawi Island Rated Spa Centre

There are thirteen spa facilities accredited by MOTAC on Langkawi Island, each rated between one and five stars. The findings derived from semi structure interviews gathered from seven accredited spa centres personnel, and their validity ensured as data saturation reached.

#	Spa Name	Validity	Rating
1.	IRIDIUM SPA THE ST REGIS LANGKAWI, 23-27 JALAN PANTAI BERINGIN, PEKAN KUAH, MUKIM KUAH, 07000 LANGKAWI, Kedah ☎ 04-960666 📠 04-9606777	23/05/22 - 23/05/25	★★★★★
2.	THE GEO SPA BY FOUR SEASONS RESORT LANGKAWI JALAN TANJUNG RHU, MUKIM AYER HANGAT, 07000 LANGKAWI, Kedah ☎ 04 950 8603 📠 04 950 8899	07/06/22 - 07/06/25	★★★★★
3.	THE HEAVENLY SPA BY WESTIN Jalan Pantai Dato' Syed Omar, 07000 Langkawi, Kedah ☎ 04-9608888 📠 04-9608800	19/11/21 - 19/11/24	★★★★★
4.	THE RITZ CARLTON SPA LANGKAWI PO BOX 199, PT 313 JALAN PANTAI KOK, KAMPUNG TELUK NIBONG, 07000 LANGKAWI, Kedah ☎ 04-9524888	23/05/22 - 23/05/25	★★★★★
5.	ALUN ALUN SPA PANTAI CENANG LOT 716 PANTAI CENANG, MUKIM KEDAWANG 07000 LANGKAWI, Kedah ☎ 04-953 3838	13/01/23 - 13/01/26	★★★★★
6.	ALUN-ALUN SPA BAYVIEW LANGKAWI HOTEL, LEVEL 3, KUAH, 07000 LANGKAWI, Kedah ☎ 04-9661818	13/01/23 - 13/01/26	★★★★★
7.	ALUN ALUN SPA PANTAI TENGAH TROPICAL RESORT, JALAN TELUK BARU, PANTAI TENGAH, MUKIM KEDAWANG, 07000 LANGKAWI, Kedah ☎ 04-9555570	13/01/23 - 13/01/26	★★★★

Figure 6: Rated Spa Centre as Sampling Respondents
Source: Ministry of Tourism, Arts and Culture

User Response to Products Based on *Telang* Flowers

Research findings indicated that respondent of a rated spa centre involved experienced notable improvements after using *Telang* Flower sunblock for at least one week. However, there were also individuals among them who expressed scepticism regarding the product's efficacy. Respondent in answering the question stated that.

“Ever since I started using Telang flower-based sunblock, my skin has been better under the sun. It does not burn or get red as much, even after being out for a long time. Plus, it keeps my skin tone even and fades those sunspots”. (Respondent 1)

“Since switching to Telang sunblock, I have seen significant improvements compared to other brands I have used. My skin is noticeably less prone to sunburn and redness, even after prolonged sun exposure, which was not the case with previous”. (Respondent 3)

“The Telang Flower Sunblock has completely outperformed my previous brand. It offers fantastic sun protection while being lightweight and non-greasy. My skin feels moisturized and looks healthier, with no irritation or clogged pores. The natural formula has truly made a difference. I highly recommend this sunblock to anyone looking for superior protection and skincare benefits”. (Respondent 4)

Serum is among the products that demonstrate noticeable effects upon initial use. Respondents in interview responses favourable outcomes while using *Telang* Flower based products. Among the recorded comments are:

“After switching to the Telang Flower Serum from my previous brand, I have noticed remarkable improvements in my skin. Unlike the other brand, this serum absorbs quickly and leaves my skin feeling hydrated and radiant without any greasy residue. My complexion is now brighter and more even, and the natural ingredients have significantly reduced redness and fine lines. I highly recommend the Telang Flower Serum for anyone seeking a more effective and natural skincare solution”. (Respondent 3)

“Using the Telang Flower Serum showed immediate results on my skin. Right after the first application, my skin felt incredibly hydrated and looked noticeably brighter. The lightweight formula absorbed quickly without any greasiness. I was amazed at how quickly it reduced redness and improved my overall complexion. I highly recommend this serum for instant skin rejuvenation”. (Respondent 7)

“The first time I used the Telang Flower Serum, I saw instant results. My skin felt smoother and looked more radiant immediately after application. The serum absorbed quickly, leaving no residue, and significantly reduced redness within minutes. I was impressed by how fast it worked and how fresh my skin looked. This serum is now a must-have in my skincare routine”. (Respondent 6)

5. Conclusion

As the demand for sustainable and eco-friendly products continues to rise, the potential for innovative plant-based products has never been more promising. Emerging trends suggest that the policy and market context is favourable for the growth of plant-based alternatives, with consumers

becoming increasingly aware of the need for input-reduced production to address issues of climate change and population growth (Aschemann-Witzel et al., 2020). Overall, there were evidence proved that the plant-based products can give satisfactory results like existing commercial products in the market. Therefore, a drastic movement in spreading the goodness of any product based on natural ingredients is necessary and can indirectly provide a positive effect in controlling pollution in the form of harmful chemicals to consumers. Through this writing, it can be concluded that the *Telang* Flower is very suitable to be innovated as a pharmaceutical product and can be used safely and effectively.

Acknowledgment

The researchers thank the respondent involved in the interview session as their cooperation and insightful responses towards the innovation products were crucial to the success of this study.

References

- Abuduxike, G. (2014, January 1). Health Biotechnology Development in Malaysia: Targeting Local and Global Health Needs Through Health Technology. *BioMed Central*. 14(S1). <https://doi.org/10.1186/1471-2458-14-s1-o23>
- Amutha, D. (2013, January 1). Booming Medical Tourism in India. *RELX Group (Netherlands)*. <https://doi.org/10.2139/ssrn.2234028>
- Aschemann-Witzel, J., Gantriis, R. F., Fraga, P., & Perez-Cueto, F. J. A. (2021). Plant Based Food and Protein Trend from A Business Perspective: Markets, Consumers, And the Challenges and Opportunities in The Future. *Critical Reviews in Food Science and Nutrition*, 61(18), 3119–3128. <https://doi.org/10.1080/10408398.2020.1793730>
- Jain, N., C.C. Ohal, S.K. Shroff, R.H. Bhutada, R.S. Somani, V.S. Kasture, S.B. Kasture (2003). *Clitoria Ternatea and CNS' Pharmacology Biochemistry and Behavior* 75 (3): 529.
- Nadkarni K.M 1954 in Shyamkumar & Bhat Ishwar (2012).
- R, P P., & Goel, M. (2017, January 1). *Enhancing the Effectiveness of Marketing A Tourist Destination Using Satisfaction Analysis*. Inderscience Publishers, 11(1/2), 163-163. <https://doi.org/10.1504/ijbsr.2017.080850>
- Rated Spa Centre - Ministry of Tourism, Arts and Culture Official Portal. (n.d.). www.motac.gov.my. <https://www.motac.gov.my/en/check/spa>
- Shyamkumar & Bhat Ishwar (2012) Anti Inflammatory, Analgesic and Phytochemical Studies of *Clitoria ternatea* Linn Flower Extract. *International Research Journal of Pharmacy*; 3(3), Pg 208-210. www.irjponline.com
- Solanki YB, Jain SM. (2010). *Antihyperlipidemic Activity of Clitoria Ternatea And Vigna Mungo in Rats. Pharm Biol.*
- Taranalli, A.D. and T.C. Cheeramkuzhy, 2000. Influence of Clitroia Ternatea Extracts On Memory and Cerebro Cholinergic Activity in Rats. *Pharmaceutical Biology*, 38(1): 51-56.
- Taur D.J. & R.Y. Patil (2011). Evaluation of Antiasthmatic Activity of *Clitoria Ternatea* L. Roots. *Journal of Ethnopharmacology* 136, Pg 374-376.
- Zaini, N.A., & Mustaffa, F. (2019, October 21). *Health Benefits of Commercialized Herbal Product in Malaysia-A Review*. MedCrave Group, 7(5), 254-256. <https://doi.org/10.15406/ppij.2019.07.00260>

Development of Bio-Board from Reutilization of Spent *Pleurotus Cajor-Saju* Substrate

Muhammad Naim Razali^{1*} & Shaveena Devi Venilen²

^{1&2}Politeknik Nilai, Negeri Sembilan, Malaysia

Abstract

Spent *Pleurotus Cajor-Saju* mushroom substrate is considered residual biomass after mushroom cultivation. It is produced in large quantities and often disposed of without consideration for the environment. This project aims to reduce environmental pollution and manage solid wastes by reutilizing the substrates into eco-friendly bio boards. Various formulations of bio boards were produced, and several tests were conducted to determine the most sustainable and durable formulation. After the heat compression process, the density and weight reduction of the bio boards were recorded. Water resistance and strength tests were also performed. The results indicated that formulation E showed the best performance compared to other formulations. It had the highest density, the best water resistibility, and did not exhibit any cracks during the strength test. This suggests that formulation E can serve as the control variable in future efforts to produce high-performance bio boards. In conclusion, the reutilization of *Pleurotus Cajor-Saju* mushroom substrate can help manage the large amount of spent mushroom substrate generated and recycle it into useful materials, supporting a sustainable circular economy in the mushroom industry. Additionally, bio boards made from mushroom waste can help reduce the need for cutting trees for board production and decrease environmental pollution.

Keywords: Mushroom, Substrate, Pollution, Waste, Bio-board

1. Introduction

Spent *Pleurotus Cajor-Saju* mushroom substrate is defined as the residual biomass after mushroom cultivation, and has been known to cause serious pollution, especially river pollution, due to its large-scale production and improper disposal. Mushroom production is currently the largest solid-state fermentation industry in the world (Soccol & Vandenberghe, 2008). The commercial production of edible and medicinal mushrooms is conducted on substrates formulated with lignocellulose materials from various sources, either alone or mixed with supplements, to overcome nutritional limitations and provide suitable substrate structure and pH (Zhang *et al.*, 2002). High levels of residual nutrients remain in spent mushroom substrate (Fidanza *et al.*, 2010), which can result in environmental pollution if dumped as waste (Rajput *et al.*, 2009).

With the increasing global demand for mushrooms, the volume of spent mushroom substrate generated also rises, presenting significant challenges in waste management and disposal. The global mushroom market's consumption increases annually and is projected to reach 20.84 billion tons by 2026. Approximately 5 kg of spent mushroom waste is generated per kilogram of mushroom production (Lou *et al.*, 2017), which means 104.2 billion tons of waste will be generated annually by 2026. Therefore, the reutilization of SMS is essential to mitigate its environmental impact.

In the meantime, industries also produce wood waste, such as plywood waste, which contributes to environmental pollution. If left untreated, these wastes are hazardous to humans because they contain synthetic chemical adhesives that release formaldehyde into the atmosphere. Formaldehyde is a highly poisonous substance that can be absorbed by humans through inhalation. Long-term exposure to formaldehyde gas, known as a probable human carcinogen, may induce irritation to the eyes and respiratory system (Deepalakshmi, 2014).

Furthermore, the construction industry is expanding at a rapid pace because of rising population and living standards. Wood and wood-based composite boards remain the preferred choice for construction due to their low cost, lightweight nature, and high strength. According to global statistics, between 3.5 billion and 7 billion trees are cut down each year. Furthermore, Malaysia has lost an average of 140,200 hectares of forest per year since 2000. At this rate, we may only have 10% of the world's rainforests left by 2030, and they could all be gone within a hundred years (Mongabay, 2013). This rapid expansion of the construction industry exacerbates deforestation and environmental degradation.

A bio board made from spent mushroom substrate will be less harmful to humans and the environment. To reduce environmental pollution and manage solid wastes, this project aims to redevelop spent mushroom substrate into an eco-friendly bio board. The mycelium coated on the spent *Pleurotus* substrate, which is the vegetative part of the mushroom, supports its growth and development. Mycelium has great potential to be used as a green adhesive material to replace synthetic adhesives in wood production. During the hot-compression process, the solid white mycelium melts and penetrates the SMS matrix, forming tight nets of cohesive and incoherent material. This enhances the adhesive and bonding properties, resulting in a strong bio-composite (Elsacker *et al.*, 2019).

2. Methodology

Synthesis of Spent *Pleurotus* Sajor-Caju Substrate

The spent mushroom substrate consists of growth substrates formulated from food waste, diaper waste and sawdust were used to grow different types of mushrooms. All substrates were collected from a mushroom farm at Jenderam, Putrajaya. The plastic that covered the spent substrate was cut open and dried to remove moisture content. Then, the mushroom substrate was put in a tray.

Preparation of Different Bio-board Formulation.

The mushroom substrates and water quantities were mixed for 5 minutes until it became homogenised. Different amounts of spent mushroom substrate were used to determine the optimal amount of spent mushroom substrate to produce an effective and solid bio board.

Table 1: Formulation for Bio-board preparation

Formulation	Mushroom Substrate (g)	Drying Oven Temperature (°C)
1	100	160
2	100	220
3	200	160
4	200	220
5	300	160
6	300	220

The mixture was poured into the mould and heat pressed by using a drying oven at 160 °C or 220 °C for 120 minutes respectively for each formulation. Then, the mould was removed from the drying oven and the dandified fibre was allowed to cool at room temperature overnight and the compressed bio-board was then removed.

Weight Reduction and Density Test

The density of the bio-board is calculated using Equation 1. Final weight is the weight of the bio-board after the heat compression process. Volume is the size of the mould (12 cm x 12 cm) times with thickness of board (cm).

$$\frac{\text{Final weight (g)}}{\text{Volume (cm}^3\text{)}} = \text{Density (g/cm}^3\text{)} \quad (1)$$

For each bio board the weight reduction is recorded after heat compressed. The weight of the bio-boards (final weight) after heat compression were recorded using weighing balance. To calculate the weight reduction, Equation 2 is used.

$$\text{Initial weight (g)} - \text{Final weight (g)} = \text{Weight reduction (g)} \quad (2)$$

Water Immersion test

A water immersion test was conducted to evaluate the water resistance characteristics of the bio-board and to assess the occurrence of bubbles or delamination on its surface. The bio-board underwent a cumulative immersion time of 60 minutes. Upon removal from the water immersion container, the bio-board surface was gently wiped with tissue paper. Dry and wet measurements were subsequently utilised to determine the percentage of water absorption as shown in Equation 3.

$$\frac{\text{Weight after immersion (g)} - \text{Weight before immersion (g)}}{\text{Initial weight (g)}} \times 100 = \% \text{ Immersion} \quad (3)$$

Strength Test

To analyse the strength of the bio-board, weights of 50g and 100g will be dropped onto a beam from a height of 100 cm. This test aims to evaluate the board's shock absorption capability, which is crucial for determining the most effective bio-board. Concurrently, the board's condition will be observed to assess its ability to withstand the applied loads. It is expected that bio-boards with different formulations will exhibit varying strengths, influenced significantly by their respective densities.

3. Results

Physical Analysis

Table 2 presents descriptions of the appearances, thicknesses, and densities of six formulations. The colour variation of the bio-board corresponds to the quantity of spent substrate used and the settings of the drying oven.

Table 2: Physical Analysis of Different Bio-board Formulation

Formulation	Appearance		Thickness (cm)
	Colour	Texture	
1	Dark Brown	Rough, Thin	1.6
2	Brown	Smooth, Thin	1.8
3	Light Brown	Smooth, Thick	1.7
4	Dark Brown	Rough, Thick	1.8
5	Light Brown	Rough, Thick	2.2
6	Brown	Smooth, Thick	1.9

Density and Weight Reduction of Bio-board

Table 3 displays the densities and weight reductions of the bio-board after heat compression at two distinct drying temperatures. The results illustrate varying densities and corresponding weight reductions across different formulations following the application of heat.

Table 3: Weight Reduction and Density of Different Bio-board Formulation

Formulation	Weight Reduction (g)	Final Weight (g)	Volume (cm ³)	Density (g/cm ³)
1	49.31	50.69	230.40	0.220
2	50.57	49.43	259.20	0.191

3	114.91	85.03	244.80	0.347
4	136.31	63.69	259.20	0.245
5	177.68	122.32	316.80	0.386
6	205.74	94.26	273.60	0.346

Water Resistibility of Bio-board

Table 4 presents the results of the water resistance test conducted after immersing the bio-board in water for approximately 60 minutes.

Table 4: Water Resistibility of Different Bio-board Formulation

Formulation	Time taken for board to sink (minutes)	Initial Weight (g)	Final Weight (g)	Percentages (%)
1	12	50.7	58.8	15.9
2	10	49.4	65.6	32.8
3	36	85.1	91.7	7.7
4	20	63.7	72.7	14.1
5	45	122.3	126.5	3.5
6	36	94.6	100.1	5.8

Strength of Bio-board

Table 5 presents the height from which the load is released (cm) and the resulting condition of the bio-board upon receiving the pressure. It is observed that formulations 3, 5, and 6 exhibit greater strength compared to formulations 1, 2, and 4. Specifically, formulations 1 and 2 begin to crack into pieces when a 100g load is dropped from a height of 100cm, while formulation 4 shows significant cracking under the same conditions.

Table 5: Observation of Strength Across Different Bio-board Formulations

Formulation	Observation (Height from which the load is released)	
	50cm	100cm
1	Cracked	Cracked
2	Cracked	Cracked
3	Not Cracked	Cracked
4	Cracked	Cracked
5	Not Cracked	Not Cracked
6	Not Cracked	Not Cracked

4. Discussion

After compression with a high-temperature drying oven, the mushroom substrate exhibited excellent interfacial bonding. The study revealed that varying the amount of mushroom substrate significantly influenced the colour and density across all formulations. Moreover, each bio-board exhibited surfaces that ranged from rough to smooth, displaying shades of dark and light brown. Density is defined as the measurement of an object's mass in relation to its volume. It is a robust indicator of board strength, noting that higher densities correlate with stronger boards. To calculate the density of the formulations, both their mass and volume were measured. Additionally, measurements of thickness and weight reduction were conducted to determine the optimal amount of spent mushroom substrate required for bio-board production (Jiang, 2013). Therefore, based on the density tests conducted, it can be concluded that formulations 3, 5 and 6 containing the highest amount of spent mushroom substrate exhibit the highest densities.

The objective of the water resistance test is to assess the mycelium's capability to withstand exposure to water (Saez *et al.*, 2020). The absorption of water by the spent mushroom substrate varies with changes in its quantity. Based on the results, it can be inferred that formulation 5 exhibits the highest water resistance due to its increased amount of spent mushroom substrate,

which also contains a higher mycelium layer. Pickering *et al.*, (2007) discovered that water resistance is enhanced by the strong adhesion between mycelium-colonised sawdust fibres, which tightly bind all fibre components together. Mycelium, composed of millions of tiny fibres, forms bonds with chitin, a natural polymer like that found in crab shells. When combined, these components act as a natural glue, bonding agricultural waste such as seed husks into solid forms.

The strength test was conducted to assess the ability of an object or substance to withstand significant force or pressure. Among the properties evaluated in the formulations, internal bonding stands out as crucial for characterising the quality of bio-boards. This parameter reflects the effectiveness of mycelium as an adhesive in bonding particles within the bio-board (Jiang, 2013). Based on the results, the higher the substrate concentration, the stronger the bond formation due to high amounts of mycelium content. Formulation 5 and 6 has greater strength compared to formulation 1,2, 3 and 4.

5. Conclusion

As a conclusion, a comprehensive evaluation was performed to determine the optimal bio-board formulation based on results from density and weight reduction tests, water resistance tests and strength tests. Formulation 5 demonstrated the most favourable outcomes across all tests conducted. Therefore, it can be concluded that the objectives of this study were successfully achieved, as data were obtained for each test conducted on the bio-board formulations.

6. Implications and Direction for Future Research

Moving forward, the next step in this study will be to quantify the mycelium content in the spent mushroom substrate prior to initiating any experiments. This will provide a greater understanding of mycelium impact of producing a better bio-board in terms of strength, water resistance and durability. Furthermore, more tests analysis such as fire retardation can be done to produce a much better bio-board in the future.

Acknowledgment

We would like to express our sincere gratitude to the Agrotechnology & Bio-industry Department, Politeknik Nilai for providing access to essential facilities and equipment crucial for conducting this research. Our appreciation extends to all lab assistants for their technical assistance and all lecturers from the Diploma Biotechnology programme for their insightful discussions and feedback that greatly contributed to shaping this research. Lastly, we would like to thank the anonymous reviewers and the editorial team for their constructive comments and suggestions, which significantly improved the quality of this manuscript.

References

- Deepalakshmi, K., & Sankaran, M. (2014). *Pleurotus ostreatus*: an oyster mushroom with nutritional and medicinal properties. *Journal of Biochemical Technology*, 5(2), 718-726.
- Elsacker, Elise, Simon V, Joost B, Eveline P, and Lars De Laet. "Mechanical, physical and chemical characterisation of mycelium-based composites with different types of lignocellulosic substrates." *BioRxiv* (2019): 569749
- Fidanza, M. A., Sam fond, D. L., Beyen, D. M. and Aurentz, D. J. (2010). Analysis of fresh mushroom compost. *HortTechnology*. 20: 449–453.
- Jiang, Lai, Daniel W, Liam M, and Samuel Putney. "Manufacturing of Mycelium-based biocomposites." *SAMPE*, Long Beach, CA, June (2013): 6-9.
- Lou Z, Sun Y, Zhou X, Baig SA, Hu B, Xu X (2017) Composition variability of spent mushroom substrates during continuous cultivation, composting process and their effects on mineral nitrogen transformation in soil. *Geoderma* 307:30–37

- Mongabay. (2013, November). Malaysia has the world's highest deforestation rate, reveals Google Forest map. *Mongabay*. <https://news.mongabay.com/2013/11/malaysia-has-the-worlds-highest-deforestation-rate-reveals-google-forest-map/>
- Pickering, K. L., Li, Y., Farrell, R. L., Lay, M., 2007. Interfacial modification of hemp fibre reinforced composites using fungal and alkali treatment. *J. Biobased Mater. Bioenergy*. 1, 109-117
- Rajput, R., Prasad, G. and Chopra, A. K. (2009.) Scenario of solid waste management in present Indian context. *Caspian J. Env. Sci.* 7: 45–53.
- Saez, D., Grizmann, D., Trautz, M., & Werner, A. (2020). Analyzing a Fungal Mycelium and Chipped Wood Composite for Use in Construction. In *Proceedings of the IASS Annual Symposium* (Vol. 21).
- Soccol, C. R. and Vandenberghe, L. P. S. (2008). Overview of applied solid-state fermentation in Brazil. *Biochem. Eng. J.* 13: 205–218
- Zhang, R. H., Zeng-Qiang, D. U. A. N., & Zhi-Guo, L. I. (2012). Use of spent mushroom substrate as growing media for tomato and cucumber seedlings. *Pedosphere*, 22(3), 333-342

SOCIAL SCIENCES

**"HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY"**

Consumer Rights: What Consumers Should Know in Dealing with E-Commerce Transactions

Nur Farahin Afiqah Daud¹

¹Commerce Department, Politeknik Nilai, Malaysia

Abstract

The use of online platforms for shopping has significantly increased and has emerged as a popular trend and a convenient way to buy goods without the need to leave home. Consumers can easily browse through websites or any relevant social media platforms and make purchases without having to physically visit stores. Nevertheless, the intricate landscape of e-commerce can create uncertainty regarding consumers' legal rights. This research explores the persistent obstacles of online shopping through social media channels such as Shopee, Instagram, Tik Tok and Facebook, emphasizing crucial details for consumers to uphold their legal rights. It cites pertinent legislations related to online purchasing concerns to offer insights into consumer protections. The data collection was through library research. The library research was conducted to seek relevant information. All collected data analysed using legal doctrinal method. All data collected are mainly from textbooks and journal articles by scholars to constitute the legal basis of this study by critically analysing the various opinions expressed in these materials. Thus, the finding of this study may represent the consumers' capacity to make well-informed decisions to safeguard their rights and play a role in building a robust contemporary society relating to e-commerce transaction indirectly.

Keyword: Law, Consumer Protection, E-commerce

1. Introduction

E-commerce plays a crucial role in contemporary society, exerting a significant influence on consumers. It offers convenient access to products from the comfort of one's home or office, providing extensive product information that enhances the speed and ease of the purchasing process compared to traditional brick-and-mortar trade. While consumers are well-informed about the positive aspects of products, they may overlook potential negative impacts. Consequently, consumer rights in the realm of electronic media can be compromised by advertisements, leading to suboptimal purchasing decisions (Rahman, 2020).

The absence of a close inspection in online transactions poses a disadvantage for consumers as they are required to buy products without a clear understanding of their physical attributes. This lack of first-hand experience increases the risk of purchasing items that may not meet their actual needs. Electronic representations of products through photographs can be misleading, with discrepancies in appearance compared to physical items. Some individuals prefer visiting physical stores to scrutinize items closely, despite the additional time investment compared to online shopping. This preference stems from the realization that electronic images may not always accurately reflect the true physical characteristics of products, leading to potential discrepancies between expectations and reality in online purchases.

Various laws serve as safeguards for online shopping, including the Sale of Goods Act 1957, Consumer Protection Act 1999, Electronic Commerce Act 2006, and Consumer Protection (Electronic Trade Transactions) Regulations 2012. Despite these regulations and international standards governing e-commerce transactions, several factors can impact consumer welfare

negatively in online trade. External factors, such as limited awareness of consumer protection rights, economic considerations, increased government intervention, the need for efficient dispute resolution mechanisms between e-commerce platforms and consumers, and the necessity for effective solutions in e-commerce contracts for product sales, contribute to the ongoing scarcity of robust consumer protection legislation (Ong Tze Chin et al., 2019). This highlights the importance of addressing these challenges to enhance consumer protection in the e-commerce landscape (Naemah & Roshazlizawati, 2013).

This article aims to analyse the legal protections in place for online purchases, focusing on the responsibilities of parties involved in electronic transactions, particularly the role of e-retailers in fostering trust in e-commerce. By enhancing consumer protection, these measures benefit businesses, buyers, and the community at large. The researcher will also provide recommendations to address challenges associated with online shopping, emphasizing the importance of scrutinizing consumer rights outlined in electronic consumer contracts for the sale of goods and addressing issues related to product liability. Through these efforts, the article seeks to improve the overall online shopping experience and ensure a fair and secure environment for all stakeholders involved in e-commerce transactions.

2. Methodology

In a legal doctrinal method, the researcher can begin by gathering pertinent facts related to the legal topic under consideration. It is essential to identify the legal issues associated with the chosen area of study. Through reasoning and analysis, the researcher can delve into these connected issues to explore the laws that are relevant and applicable to the research problem (Pradeep, 2019). By systematically examining and scrutinizing the legal framework surrounding the topic, the researcher can gain a comprehensive understanding of the legal landscape and effectively address the research problem at hand. In the research process, the researcher delves into the study problem by referencing relevant statutes and other legal sources. By incorporating these legal references, the researcher can explore various dimensions of the issue at hand and analyse the implications of the law on the social system (McConville, 2007).

This approach allows for a comprehensive examination of how legal frameworks impact societal structures, norms, and behaviours. By highlighting the interplay between law and the social system, the researcher can provide valuable insights into the broader implications and consequences of legal regulations on individuals, communities, and society as a whole. In concluding the research, the researcher should provide well-founded suggestions for enhancing the legal system to promote social welfare. These recommendations should be based on the findings of the study and aim to address any identified shortcomings or areas for improvement within the legal framework. By offering practical suggestions, the research can contribute to the advancement of the legal system for the betterment of society.

3. Finding and Discussion

A. Sale of Goods Act 1957

The Sale of Goods Act 1957 (SOGA 1957) in Malaysia provides several implied terms that protect consumers in transactions involving the sale of goods. These implied terms include:

- a. Fit for the particular use required by the buyer (Section 16(1)(a)): This implies that if the buyer explicitly or implicitly informs the seller of the intended use of the goods, there is an implied condition that the goods supplied must be reasonably fit for that purpose.

- b. Merchantable quality (Section 16(1)(b)): This implies that the goods supplied must be of merchantable quality, meaning they should meet the standards that would be expected for goods of that type.
- c. Compliance with the description provided by the seller (Section 15): This implies that the goods supplied must correspond with the description given by the seller.
- d. Compliance with the sample provided (Section 17): This implies that the goods supplied must be in accordance with the sample shown or provided to the buyer.

While these implied terms grant consumers rights to take legal action against sellers in case of breach, sellers can exclude these implied terms under Section 62 of SOGA 1957. This provision allows sellers to avoid these obligations and potentially create terms that favour them over consumers.

Moreover, the rule of Caveat Emptor, which translates to "let the buyer beware," applies in contracts of sale of goods. This rule places the responsibility on consumers to protect themselves before making a purchase. However, in the context of online purchases, where physical inspection of goods may not be possible before buying, following this rule becomes challenging. This limitation can lead to injustices for consumers who may not have the opportunity to inspect goods before purchase, potentially exposing them to risks and disputes with sellers (Rahman, 2018).

B. Consumer Protection Act 1999

The Consumer Protection Act 1999 (CPA) stands out as the initial legislation explicitly designed to safeguard consumers in their acquisition of goods and services. The Act's preamble underscores its core objective of ensuring consumer protection, establishing bodies like the National Consumer Advisory Council and the Tribunal for Consumer Claims, and addressing related matters (Naemah & Roshazlizawati, 2013). This statutory framework extends protection to all consumers, irrespective of the nature or method of their transactions.

However, a notable limitation of the Consumer Protection Act is its supplementary nature, as indicated in Subsection 2(4), which states that the Act complements other laws related to contractual relations. In cases of conflict between the CPA and other statutes like the Contract Act 1950 or the Sale of Goods Act 1957, the prevailing law remains ambiguous and may necessitate legal resolution. The disparities between the CPA and the Sale of Goods Act, particularly concerning privacy and the enforcement of exclusion clauses, raise concerns about the Act's efficacy in providing robust consumer safeguards.

The CPA endeavours to shield e-consumers from deceptive practices such as misleading advertisements and market manipulation. Section 11 of the Act emphasizes the importance of furnishing consumers with accurate and reliable information to counteract issues stemming from a lack of understanding about products and suppliers. Notably, Section 13 of the CPA specifically targets misleading advertising strategies employed to lure consumers with low-priced offers as a bait-and-switch tactic (Naemah & Roshazlizawati, 2013).

Moreover, Section 51 of the CPA introduces limitations on consumer recourse against manufacturers in cases where goods fail to meet implied warranties due to factors beyond the manufacturer's control. This exclusion clause has been criticized for potentially enabling producers to evade their responsibilities, thus posing challenges to consumer protection efforts. Additionally, the Act's interpretation concerning product defects, safety standards, and consumer expectations

may lead to subjective assessments, raising questions about the Act's effectiveness in ensuring consumer safety and rights (Ghapa & Ab Kadir, 2021).

To regulate advertising practices and prevent consumer deception, the Trade Descriptions Act (TDA) 1972 plays a crucial role. While the Act does not explicitly mention internet advertising, its broad language encompassing "by any other means" suggests its applicability to online commerce. The primary objective of the TDA is to penalize businesses engaging in misleading or false descriptions that could mislead consumers into purchasing goods or services (Kamal Halili, 2012). This underscores the importance of statutory control over advertising to protect consumer interests and promote fair trade practices.

C. Electronic Commerce Act 2006

In Malaysia, the primary legislation governing e-commerce in the private sector is the Electronic Commerce Act 2006. This act was further enhanced by the E-Government Activities Act 2007, which aligns with the principles applicable to the public sector. The Electronic Commerce Act of 2006 serves as an alternative law that closely resembles the agreements of the World Organization for Electronic Communications. Additionally, the Digital Signature Act 1997 was enacted to provide security for electronic signatures. This legislation has been reinforced to support its future applicability, particularly in response to the subsequent impacts of the Digital Signature (Amendment) Act 2011 (Mohamad et al., 2021).

Commercial transactions can be conducted electronically as outlined in Section 7 of the Electronic Commerce Act 2006. Consequently, the same principles governing traditional contracts also extend to contracts formed electronically. In electronic transactions, the concept of an invitation to treat becomes relevant (Md Pauzi et al., 2021). When an online trader presents products or services on a webpage, it is typically considered an invitation to treat rather than a direct offer for sale, following the precedent set in the case of *Pharmaceutical Society of Great Britain v. Boots Cash Chemist (Southern Ltd)* [1953] 1 QB 401. This allows the online trader the discretion to decline selling a product, particularly in cases of pricing errors. However, certain circumstances may transform an advertisement into a binding offer, especially if it contains specific terms that clearly bind the parties involved. Consumers in online transactions may be vulnerable to price manipulation by online traders. To address this issue, the Parliament enacted the Price Control and Anti-Profiteering Act 2011 to safeguard consumers from unfair pricing practices. In January 2017, the Ministry of Domestic Trade, Cooperatives, and Consumerism introduced the new Price Control and Anti-Profiteering (Mechanism to Determine Unreasonably High Profit for Goods) Regulations 2016 (Regulation 2016). Unfortunately, Regulation 2016 limited to food and beverage, and household goods, leading to uncertainty regarding the coverage of goods under this regulation.

D. Consumer Protection (Electronic Trade Transactions) Regulations 2012

The Consumer Protection (Electronic Trade Transactions) Regulations 2012 serve as subsidiary legislation to the Consumer Protection Act 1999 in Malaysia. These regulations outline the mandatory information that online retailers require to disclose on their websites or online marketplaces (Nasution, 2023). Failure to comply with these obligations can result in legal consequences. The key information that online retailers must publish includes:

1. Name and registration details: The name of the business entity or individual conducting the online business, along with the registration number of the firm or business.

2. Contact information: The e-mail address, telephone number, or physical address of the business owner for communication purposes.
3. Product or service details: A description of the key qualities of the goods or services offered, the total price including shipping costs, taxes, and any additional charges. The regulation does not specify that the price must be in Malaysian Ringgit.
4. Transaction mode: Information on the mode of transaction available for purchasing goods or services.
5. Terms of service: Clear disclosure of the terms and conditions governing the purchase of goods or services, including any applicable policies or agreements.
6. Delivery timeline: The estimated time frame within which the buyer can expect to receive the products or services after making a purchase.

These regulations aim to enhance transparency in online transactions, protect consumer rights, and ensure that buyers have access to essential information before making a purchase. By mandating the disclosure of specific details, the regulations seek to promote fair and ethical practices in electronic trade transactions and safeguard the interests of online consumers (Md Pauzi et al., 2021).

4. Conclusion and Recommendation

In conclusion, the challenges and risks associated with e-commerce transactions, particularly in the context of consumer protection. It emphasizes the importance of regulations that require e-retailers to provide transparent and detailed information to consumers to enable them to make informed decisions and assess the reliability of online sellers. There are few steps that may be taken for instance, first, information disclosure which entails the E-retailers to disclose essential information such as their identity, registration details, physical location, and contact information to enhance transparency and enable consumers to verify the legitimacy of the seller. Second, enhancing the consumer empowerment such as by providing consumers with relevant information allows them to assess the advantages and risks of engaging in a transaction. Detailed product descriptions, distribution processes, and other necessary information empower consumers to make informed choices. Third, legal safeguards which focusing on the need for comprehensive reviews of existing laws, such as the Sale of Goods Act and the Consumer Protection Act, to incorporate provisions that safeguard online purchasers are highlighted. Fourth, the inclusion of Caveat Emptor (buyer beware) element in each e-Commerce transaction which may impede the importance of sellers being cautious in their online product advertising to prevent misrepresentation and protect consumers' rights. Fifth, the researcher suggests that laws such as the Electronic Commerce Act 2006, Consumer Protection (Electronic Trade Transactions) Regulations 2012, and Trade Description Act 2011 should be considered collectively to determine the responsibilities and rights of both sellers and buyers in e-commerce transactions. Hence, the need for robust legal frameworks and regulations to protect e-consumers in online transactions, address fraudulent practices, and ensure transparency and accountability in e-commerce operation.

References

- Abdullah, F., Chin, O. T., Na'aim, M. S. M., & Dayatie, N. H. (2019). Legislative Enforcement of Contractual Fairness in Malaysian Consumer Contracts. *Journal of ASIAN Behavioural Studies*, 4(13), 51-61.
- Amin, N., & Mohd Nor, R. (2013). Online Shopping in Malaysia: Legal Protection for E-consumers. *European Journal of Business and Management*
- Amin, N. (2013). E-Consumer Protection in a Contract for the Sale of Goods: A Malaysian Perspective. *International Journal of Digital Society (IJDS)*, 4(2), 798-805.

- Consumer Protection Act 1999
 Consumer Protection (Electronic Trade Transactions) Regulations 2012
 Electronic Commerce Act 2006
 Ghapa, N., & Ab Kadir, N. A. (2021). Information Regulation: A Measure of Consumer Protection. *Pertanika Journal of Social Sciences & Humanities*, 29.
 Hassan, K. H. (2012). E-commerce and Consumer Protection in Malaysia: Advertisement and False Description. *International Proceedings of Economic Development and Research, Economics and Finance Research*. Chennai, India.
 McConville, M. (2007). *Research Methods for Law* (Vol. 104). W. H. Chui (Ed.). Edinburgh: Edinburgh University Press.
 MD, P. (2019). Legal Research-Descriptive Analysis on Doctrinal Methodology. *International Journal of Management, Technology and Social Sciences (IJMTS)*, 4(2), 95-103.
 Md Pauzi, S. F., Zaini, A. A., & Azni, M. A. (2021). Online Shopping during MCO: what Consumers should Know in Dealing with Sellers on social media? *ASEAN Entrepreneurship Journal (AEJ)*, 7(1), 1-5.
 Mohamad, M. B., Kanaan, A. G., Aseh, K., Alawi, N. A., Amayreh, K. T., Al Moaiad, Y., ... & El-Ebiary, Y. A. B. (2021, June). Enterprise Problems and Proposed Solutions Using the Concept of E-Commerce. In *2021 2nd International Conference on Smart Computing and Electronic Enterprise (ICSCEE)* (pp. 186-192). IEEE.
 Nasution, T. A. (2023). E-Commerce in Malaysia from Law Perspective. *Mahadi: Indonesia Journal of Law*, 2(1), 11-15.
 Rahman, N.R.A. (2018). The Rise and Fall of Caveat Emptor in Malaysian Sale of Goods Contract. *Journal of Laws and Governance*. Vol 1 (1), 1-14
 Rahman, N. R. A. (2020). The rule of Caveat Emptor for e-commerce Transaction in Malaysia. *Journal of Law and Governance*, 3(1), 18-28.
 Sale of Goods Act 1957

Mastery Level of Generic Skills Among Students' Community College of Sarawak Region Through Teaching and Learning Processes Via General Courses (MPU)

Chong Chiew Ching¹, Liu Tse Hui² & Ngu Toh Onn³

¹Miri Community College, Sarawak, Malaysia

²Kuching Community College, Sarawak, Malaysia

³Sarikei Community College, Sarawak, Malaysia

Abstract

Various initiatives and approaches have been implemented to enhance generic skills among students in higher education institutions. However, the issue of weaknesses in mastering these skills among graduates continues to be a focal point for industries in the career realm. The purpose of this study was to assess the extent of mastery of generic skills among students at Community Colleges in the Sarawak region through General Studies (MPU) courses, and to identify significant differences among students enrolled in the ten programs offered. The study employed a quantitative design involving 321 community college students across Sarawak, selected through simple random sampling. The survey instrument was adapted from existing sources (Amiruddin et al., 2016; Norzailawati et al., 2008; Othman & Syed, 2019). Data analysis was conducted using Statistical Package for Social Sciences (SPSS) version 27.0, presenting results in terms of mean scores, standard deviations, ANOVA, and Post Hoc tests. The analysis revealed that the mean level of mastery of generic skills among students at Community Colleges in Sarawak through MPU courses is high (mean=4.12, SD 0.40). There were significant differences observed in the level of mastery of generic skills among students at Community Colleges in Sarawak. This study serves as a guide and reference for the Curriculum Division, Department of Polytechnic Education and Community Colleges (JPPKK) in implementing and improving the general curriculum and MPU units specifically at Community Colleges in Sarawak. This aims to enhance the current curriculum being implemented across all MPU courses.

Keywords: Generic Skills, General Courses (MPU)

1. Introduction

Generic skills are the most crucial element for the employability of graduates from Higher Education Institutions (HEIs) (Noor & Mas, 2022). Mohamad et al. (2023) state that employers greatly need high graduate employability to help organizations achieve their set objectives and targets. Amiruddin et al. (2016) and Othman (2019) mention that generic skills consist of five elements: communication skills, problem-solving skills, ethics and professionalism, leadership, and teamwork. The excellence of HEI students is evaluated not only in cognitive aspects but also in psychomotor and affective aspects (Ngadiman & Jamaludin, 2018). These five elements are assessed in the evaluation rubric developed by the Curriculum Division, JPPKK, through teaching and learning methods such as role-playing, field studies, presentations, projects, and assignments in General Subject Courses (MPU) across all Community Colleges in Malaysia.

In Smith et al.'s (2017) study, five factors considered in assessing graduate employability include personal abilities and competencies, interpersonal skills, cognitive abilities, specific roles, and generic skills. According to Ahmad and Safwan (2023), Ahmad et al. (2021) human skills required by workers to perform specific jobs or tasks. This includes imagination and creativity,

attitude, citizenship concepts, linguistic proficiency, communication, and teamwork, which considered important for productivity in the workplace.

1.1 Problem Statement

Employers emphasize generic skills in their employees, particularly interpersonal, leadership, teamwork, and both written and oral communication skills. According to Ahmad et al. (2021), graduates often fail to meet industry requirements due to a lack of generic skills, especially critical thinking, and communication. The study by Ong et al. (2020) also found that graduates are weak in independent learning ability, problem-solving skills, leadership skills, and the ability to use their own initiative. A media report (Samadi, 2023) showed that 29,000 graduates were still unemployed six months after graduation in 2022. Employers tend to prefer employees with good communication and critical thinking skills (Mohd & Nor, 2021). The issue of graduate employability has garnered significant attention (Mohamad et al., 2023). Therefore, this study conducted to assess the level of mastery of generic skills among community college students in Sarawak before they enter the workforce. The study's results are crucial for guiding curriculum policy and the MPU unit.

1.2 Objective of the Study

The two targeted objectives of the study are:

- i. To assess the level of mastery of generic skills among students at Community Colleges in Sarawak Region through Teaching and Learning Processes via MPU Courses.
- ii. To examine the differences in the level of mastery of generic skills among students at Community Colleges in Sarawak Region through Teaching and Learning Processes via MPU Courses based on their respective programs.

1.3 Hypotheses of the Study

- i. Ho: There is no significant difference in the level of mastery of generic skills among students at Community Colleges in Sarawak Region through Teaching and Learning Processes (PdP) via MPU Courses across different programs.
- ii. H1: There is a significant difference in the level of mastery of generic skills among students of Community Colleges in Sarawak Region through Teaching and Learning Processes (PdP) via MPU Courses across different programs.

2. Methods

This study design is quantitative, and all data analysed using the Statistical Package for Social Science (SPSS) version 27. There are five elements of generic skills: Section A: Communication Skills, Section B: Problem-Solving, Section C: Ethics & Professionalism, Section D: Leadership, and Section E: Teamwork, which are included in the MPU courses taken by students throughout their studies at community colleges in the Sarawak region. Descriptive statistics analysed to assess the mean and standard deviation for Sections A, B, C, D, E, and F, while inferential statistics, specifically the ANOVA test, were used to determine significant differences across all five elements of generic skills among the various programs.

2.1 Research Instrument

The research instrument used was a questionnaire adapted from Amiruddin et al. (2016), Norzailawati et al. (2008), and Othman and Syed (2019). The Cronbach's Alpha value was 0.9, indicating very good and effective reliability. This study was conducted among students from ten (10) programs at Community Colleges in the Sarawak region using this questionnaire instrument. A total of 321 population samples (N=321) were randomly selected. Students responded using a

five-point Likert scale with the options: 1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, and 5 - Strongly Agree. Based on the Likert scale used, the mean scores obtained were interpreted as shown in Table 1 below (Nur Hawa Hanis & Ghazali, 2018).

Table 1: Level According to Minimum Score Values in the Study

Score Value	Mean Levels
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.00	Very High

(Nur Hawa Hanis, Ghazali, 2018)

3. Results

Table 2 shows the results of the five elements of the level of mastery of generic skills among Community College students in the Sarawak region in the teaching and learning process through MPU courses taken across ten (10) programs at Community Colleges in the Sarawak region. The level of mastery in communication skills showed the highest mean (mean=4.20, SD=0.42), while the level of mastery in ethics and professionalism skills showed the lowest mean (mean=3.98, SD=0.46). However, the overall level of mastery of generic skills is still at a high level (mean=4.12, SD=0.40) among students at Community Colleges in the Sarawak region.

Table 2: Level of Mastery of Generic Skills Among Community College Students in Sarawak Region According to 5 Elements of Generic Skills (N = 321)

Bil	Generic Skills	Mean	SD
1.	Communication	4.2034	0.42296
2.	Leadership	4.1844	0.44896
3.	Teamwork	4.1966	0.44083
4.	Problem Solving	4.0555	0.49445
5.	Ethics & Professionalism	3.9813	0.46524
	Mean Score	4.1242	0.40254

Based on Table 3, the significance level is set at 0.05 (5%), $F(9, 311) = 2.057$, $p = 0.033$. This indicates that the null hypothesis is rejected because there is a significant difference in the Level of Mastery of Generic Skills among Community College students in the Sarawak region in the teaching and learning process through MPU courses according to the ten (10) programs offered.

Table 3: Post Hoc Test Results using Tukey's HSD (Honestly Significant Difference) One-way (N = 321)

	Sum of Squares	df	Mean Square	F	Sig.
Between groups	2.913	9	0.324	2.057	0.033
Within groups	48.939	311	0.157		
Total	51.852	320			

Table 4 shows the results of the ANOVA test, where Tourism Adventure Certificate students demonstrated the highest level of mastery in generic skills (mean=4.30, SD=0.41), while Interior Design Certificate students showed the lowest level of mastery in generic skills (mean=3.93, SD=0.33). The study findings indicate that the overall level of mastery of generic skills among Community College students in the Sarawak region in the teaching and learning process through MPU courses is high (mean=4.12, SD=0.40).

Table 4: One-way ANOVA Results ($N = 321$)

Program	Mean	SD
Certificate in Landscape	4.1541	.37615
Certificate in Tourism Adventure	4.2986	.40925
Certificate in Information Technology	4.0313	.40594
Certificate in Culinary Arts	4.0750	.45458
Certificate in Computer Systems and Networking	4.2530	.39075
Certificate in Electrical Technology	4.1229	.29009
Certificate in Industrial Maintenance	4.2309	.50751
Certificate in Interior Design	3.9272	.33090
Certificate in Architecture Technology	4.1523	.39098
Certificate in Fashion and Apparel	4.0972	.36806
Total	4.1242	.40254

4. Discussion

The study results have achieved the set objectives, indicating that the average level of mastery of generic skills among students at Community Colleges in the Sarawak region in the teaching and learning process through MPU courses is at an elevated level. These findings align with the results of Noor and Mas (2022). Communication is mandatory for every HEI student and is part of the employability skills listed in 21st-century learning skills (Husaina et al., 2019; Lamri, 2019). The communication level of students in this study is high (mean=4.20, SD=0.42). This shows an improvement in the level of communication skills of students (mean=3.91, SD=0.41) compared to the study by Liu and Chong (2023). This is a good effort to address the communication skill issues faced by community college students, as reported by Hamidet al. (2022), who found that TVET students lack confidence in delivering speeches and communicating.

The level of mastery in ethics and professionalism among students at Community Colleges in the Sarawak region (mean=3.98, SD=0.46) represents the lowest score. This finding is consistent with studies by Noor and Mas (2022) and Siti and Mohd (2020), which indicate that ethical values are often subject to change depending on the passage of time, location, and situation, leading to conflicts and confusion in determining right from wrong. According to the General Studies Curriculum Guidelines (MPU) Second Edition (2016), ethics and professionalism encompass four sub-attributes: work responsibility, work relationships, work ethics, and integrity. These study results are aligned with findings from Ahmad et al. (2017), where 72.9% of engineering students were found to exhibit unethical and immoral behaviours at least once during their studies. This also correlates with the findings of Hassan et al. (2020), which suggest that moral values and ethical principles, especially among HEI students, are increasingly neglected in everyday life.

There is a significant difference in the level of mastery of generic skills among students at Community Colleges in the Sarawak region in the teaching and learning process through MPU courses based on their program of study. The study findings indicate that students enrolled in the Tourism Adventure and Travel Certificate (SPL) program exhibit the highest level of generic skills. The research team found that SPL students extensively exposed to generic skills through courses such as Tourism Customer Service. This exposure includes aspects such as customer portfolio management, professional behaviour in customer service, effective front desk communication, as well as customer complaint management and feedback (JPPKK, 2020). Additionally, they are required to attend Professional Development courses covering personal grooming, protocols, etiquette, job readiness, and basic human resource management before entering the workforce (JPPKK, 2020). These additional elements provide an advantage to SPL students by emphasizing

communication skills, leadership, teamwork, problem-solving, ethics, and professionalism.

Overall, this tailored curriculum approach ensures that SPL students are well-prepared with a comprehensive set of generic skills crucial for success in their respective industries. The Certificate in Interior Design (SRD) program offered at Miri Community College shows the lowest level of mastery in generic skills among the programs studied. According to the Program Structure of SRD (JPPKK, 2020), the core courses for SRD students focus heavily on practical skills and digital skills (93.33%). This suggests that there is a need to provide SRD students with more exposure through activities or training that emphasize generic skills, so that these additional values can help them compete effectively in the job market.

Given the emphasis on practical and digital skills in the SRD program, incorporating activities or modules that specifically target generic skills such as communication, leadership, teamwork, problem-solving, and ethics and professionalism could significantly enhance the overall preparedness of SRD students for the workforce. This approach aligns with efforts to ensure that students not only excel in technical aspects but also possess the well-rounded abilities needed in today's competitive job market.

5. Implications and Direction for Future Research

The structure of the Interior Design Certificate (SRD) program needs to be reconsidered to ensure that generic skills are effectively integrated into core courses, thereby producing holistic and balanced TVET students. Expanding this evaluation to SRD students across all Community Colleges would enhance the validity of respondent data collection. In the future, studying the level of mastery of generic skills among SRD students should be conducted after restructuring the SRD program curriculum by JPPKK. This is intended to improve the effectiveness of the curriculum currently being implemented in MPU courses. By making these adjustments, SRD students can be better prepared with essential generic skills alongside technical competencies, equipping them to navigate the challenges and demands of an increasingly complex job market. This step aims to ensure that vocational education in Community Colleges provides comprehensive and relevant preparation for students.

References

- Ahmad, A. M., Hussin, Z., Malik, M. A., Yusof, F., & Jamil, M. R. M. (2017). Masalah Etika dan Akhlak Pelajar Kemahiran Kejuruteraan: Analisis Keperluan. *JuKu: Jurnal Kurikulum & Pengajaran Asia Pasifik*, 5(2), 34-45.
- Ahmad Shobah, M., Isa Mohammad Saffuan, M. S., Muhammad Sukri, S., Norfadila Mohd Amin, & Hanifah Jambarie. (2021). Kemahiran Generik untuk Memenuhi Persekitaran pekerjaan Revolusi Industri (IR 4.0). *Jurnal Persatuan Pendidikan Teknik dan Vokasional Malaysia*, 10(47-55).
- Ahmad, M. F., & Safwan, N. S. Z. (2023). Enhancing Individual Employability: The Perception of Sports Graduates in Malaysia. *International Journal of Academic Research in Progressive Education and Development*, 12(2), 853–860.
- Ahmad, M. F., Salamuddin, N., & Surat, S. (2021). The Marketability of UiTM Products: A Study of Employability Skills among UiTM Perlis Sports Graduates. *International Journal of Academic Research in Progressive Education and Development*, 10(1), 195-207.
- Amiruddin, M. H., Ngadiran, I. A., Zainudin, F. L., & Ngadiman, N. (2016). Tahap Kemahiran Generik Pelajar Malaysia dalam Proses Pengajaran dan Pembelajaran: Kajian Kes Pelajar Institut Kemahiran Mara , Johor Baharu. *Journal of Society and Space*, 3(3), 111–121.

- Hamid, N. M., Effendi, M., & Matore, E. M. (2022). Isu dan Cadangan terhadap Penilaian Pembentangan Komunikasi dalam Kalangan Pelajar TVET: Suatu Pemerhatian Awal. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 7(3), e001359-e001359.
- Hassan, R., Zain, F. M., Bakar, K. A., & Kamaruzaman, A. F. (2020). Kefahaman Nilai Etika dan Moral Pelajar di Institusi Pengajian Tinggi: Satu Sorotan Literatur. *Malim J. Pengaj. Umum Asia Tenggara (Sea J. Gen. Stud)*, 21(1), 126-141.
- Husaina, B. K., Nor, A. A., & Abdul, R. I. (2019). Gaps Between Competence and Importance of Employability Skills: Evidence from Malaysia. *Higher Education Evaluation and Development*, 13(2), 97–112. <https://doi.org/10.1108/heed-08-2019-0039>.
- Lamri, J. (2019). *The 21 Century Skills*. in *The Next Society Edition*. <https://doi.org/10.5860/choice.45-2534>
- Liu, T. H., & Chong, C. C. (2023). Tahap Keyakinan Kemahiran Komunikasi dalam Kalangan Pelajar di Kolej Komuniti Negeri Sarawak. *Internationals TVET Academic and Research Symposium 2023 (ITARS 2.0)*, 3(1). <https://itarc2020.wixsite.com/polycc>.
- Mohamad, F. A., Nur, S. Z. S., Norlena, & Shahlan, S. (2023). Perbezaan Kebolehpasaran Berdasarkan Jantina: Kajian Tinjauan terhadap Perspektif Graduan Sukan UiTM. *Jurnal Sains Sukan dan Pendidikan Jasmani* Vol 12, No 2, 2023(23-31).
- Mohd Hazwan Mohd Puad & Nor Suhaila Mad Nawe. (2021). The Influence of Student Motivation in Employability Training Program in the Industrial Revolution 4.0 era. *Sains Insani*, 6(185-193).
- Ngadiman, S. H., & Jamaludin, M. F. (2018). Hubungan di antara Kemahiran Kerja Berpasukan dan Kemahiran Komunikasi dalam Kalangan Pelajar Semester Akhir Politeknik. *International Journal of Education, Psychology and Counseling*, 3(19), 1–18. <https://doi.org/http://www.ijepc.com/PDF/IJEP-2018-19-09-01.pdf>.
- Noor Halawati Che Meh & Mas Guieta Aton. (2022). Tahap Penguasaan Kemahiran Generik dalam Proses PdP di kalangan Pelajar Politeknik Tuanku Syed Sirajuddin, Perlis. *Jurnal Kejuruteraan, Teknologi dan Sains Sosial* Vol. 8 Issue 1 (Special Issue – ICRISC2022). *International Conference on Research and Innovation in Sustainable Cities @ PUO*.
- Norzailawati Mohd Nor, Sharif Mohamed Mustafa, Razali Firdausi, & Meriam Yusoff. (2008). Kemahiran Generik di kalangan Pelajar IPT: Satu Kajian Tahap Keyakinan Merentas Jantina. *Persidangan Pembangunan Pelajar Peringkat Kebangsaan*, 22–23.
- Nur Hawa Hanis, Ghazali. (2018). Kesiediaan Guru Melaksanakan Kemahiran Berfikir Aras Tinggi dalam Pengajaran. *Jurnal Kurikulum & Pengajaran Asia Pasifik*, 22-31.
- Ong, A. L., Chang, P. K., & Arina, A. A. (2020). Penerokaan Isu Penguasaan Kemahiran Insaniah Graduan UKM dari Perspektif STOPS. *Jurnal Komunikasi: Malaysian Journal of Communication* Jilid 36(3).
- Othman, R., & Syed Ali, S. M. (2019). Tahap Penguasaan Kemahiran Generik di Kalangan Pelajar Tahun Akhir Diploma Kejuruteraan di Politeknik Kota Kinabalu. *Kajian Pendidikan Teknikal SPI Zon Sabah 2012*, February.
- Samadi Ahmad. (2023). *29,000 Graduan Menganggur, RM15 Juta untuk Bantu Mereka*.
- Siti, K. Z., & Mohd, N. D. (2020). Kemahiran Insaniah Pelajar IPTA Merentas Jantina. *International Journal of Education and Pedagogy (IJEAP)*, eISSN: 2682-8464.
- Smith, S., Smith, C., Taylor-Smith, E., & Fotheringham, J. (2017). In Search of Graduate Employability: An Exploration of Student Identity. *Asia-Pacific Journal of Cooperative Education*, 18(1), 15-24.
- Struktur Program SRD yang terkandung dalam kurikulum JPPKK versi 2022/2023

Development of Tofu Sausage Tomyam

Nur Nafisa Shafie @ Mohd Alias^{1*}, Latifah Mahmood² & Norzilahwati Md Noh³

¹Kolej Komuniti Bagan Serai, Bagan Serai, Perak, Malaysia

²Kolej Komuniti Jekebu, Kuala Klawang, Negeri Sembilan, Malaysia

³Kolej Komuniti Kelana Jaya, Kuala Lumpur, Malaysia

Abstract

Tofu sausage tomyam is the development of a meat-free food innovation product which is a sausage based on tofu from soybean products and tomyam paste. The combination of tofu and tomyam paste in making sausage is rich in nutrition and low in calories. This contrasts with the commercial sausages which are mixture of processed meat, including internal organ and contain preservatives that can increase the risk of various diseases and cancer. A study was conducted by investigating three (3) formulations developed which are F1, F2 and F3. The determination of the best formulation was done based on the results of a hedonic test conducted on 30 untrained panellists. The attribute values analysed are in term of colour, aroma, texture, taste, and overall acceptance. Based on the sensory evaluation test, these items received the highest rating among the F2 formulation, which evaluated all the formulations. In addition, a market study was conducted on this product with a total of 41 respondent involved. In this study, a questionnaire was used as a research instrument and the data collected were analysed with Statistical Package for social Sciences (SPSS 21.0) statistical program in the form of descriptive values. 75.6% of the respondents agreed that the sausages in the market contain ingredients that cause disease. The result of the study also found that 92.7% of respondents agreed tofu sausage tomyam are nutritious. This study showed that tofu and tomyam paste can be processed into sausages, which is acceptable and has several advantages because it's a high-value source of nutrients and a healthier option for consumers.

Keywords: Tofu, Tomyam, Sausage, Meat-free Products

1. Introduction

Sausage is one of the processed foods based on meat and chicken that is popular among Malaysian consumers (Huda et al., 2010). Sausages often eaten with bread, spaghetti or as topping on pizza because of its easy, simple, and quick preparation. However, the content of micronutrients in sausage that are good for the body is minimal. Sausage in the market contains nitrites, saturated fat, and high salt content as well as preservatives. By eating these commercial sausages regularly can increase the level of bad cholesterol in the body which results in an increased risk of heart disease, stroke and can bring the obesity.

Therefore, a tofu-based sausage mixed with tomyam paste was developed to provide more nutritious food to consumer. Tofu also contains good nutritional content such as protein, omega 3, vitamins, riboflavin, thiamine, niacin, pantothenic acid, biotin, vitamin b-6, vitamin b-12, folate, and minerals (calcium, phosphorus, potassium, magnesium, iron, zinc, manganese, selenium, and copper) (Ayele et al., 2019). Therefore, tofu is used as a source of protein in the daily diet for those who are vegetarian. In addition, tofu is often used as a substitute for meat, seafood, and egg in cooking menus.

Objectives

The specific objectives of this study are:

- Develop the best formulation a frozen product which is a sausage based on tofu from soybeans and tomyam paste based on the results of sensory evaluation conducted on an untrained panellist.
- Conduct a market study on tofu sausage tomyam.

2. Methodology

The ingredients used to produce tomyam paste consisting of dried chilies, shallots, garlic, lemongrass, galangal, ginger, Kasturi lime leaves, salt, tamarind, oil, and palm sugar were purchased at Bagan Serai Market, Perak. Besides that, the main ingredients for making sausages, which are tofu and potato starch were bought at Bagan Serai Market, Perak.

Table 1: Experimental Designs for all the Tofu Sausage Tomyam Formulations.

Formulation	Tofu (%)	Tomyam paste (%)	Potato starch (%)
F1	75	15	10
F2	80	10	10
F3	85	5	10



Figure 1: The Flowchart Process of Tofu Sausage Tomyam

Analysis of Sensory Evaluation Test

A sensory evaluation test was conducted by an untrained panellist consisting of thirty tasters, ages ranging from 19 to 53. Sensory evaluations were done by using hedonic test according to the method by Maizura Murad et al., 2014. The attributes evaluated were colour, aroma texture, taste, and overall acceptance. The panellists were given a questionnaire in which they were asked to evaluate each sample on a five-point hedonic scale from most acceptable to least acceptable in all qualities after tasting and observing it. The particulars were evaluated as the following (1=like very much, 2=like, 3=neither like nor dislike, 4=dislike, 5=dislike very much). The data obtained were analysed through SPSS 21.0 statistical program. The results of the analysis were expressed in mean and standard deviation.

Analysis of Market Study

A market study was conducted on this product with a total of 41 respondents involved. In this study, a questionnaire used as a research instrument. The data obtained were analysed through SPSS 21.0 statistical program. The results of the analysis were expressed in percentages and frequencies.

3. Results and Discussion

Evaluation of Sensory Test

Table 2: Sensory Evaluation of Tofu Sausage Tomyam

Formulation/ Attributes	F1		F2		F3	
	M	SD	M	SD	M	SD
Colour	2.0000	0.69481	1.9667	0.61495	2.1333	0.73030
Aroma	2.3667	0.96431	2.3333	0.95893	2.5667	0.97143
Taste	2.8000	1.15669	2.8000	1.15669	3.2333	1.13512
Texture	2.2667	0.86834	2.1667	0.87428	2.4333	0.93526
Overall Acceptance	2.5000	1.00858	2.5000	1.07479	2.8000	1.09545

In development of food products, food acceptability is important to provide quantitative information about the sensory properties. According to Table 2 showed mean and standard deviation scores attributed to each parameter evaluated which were colour, aroma, taste, texture, and overall acceptance. These items received the highest grade among the F2 formulations in the sensory test, which evaluated all the formulations.

Evaluation of Market Study

Table 3: Demographic Information of the Respondents.

Item	Frequency	Percentage (%)
Gender		
Female	24	58.5
Male	17	41.5
Age		
10-20	9	22.0
21-30	8	19.5
31-40	18	43.9
41-50	6	14.6
Race		
Malay	37	90.2
India	4	9.8
Vegetarian	4	9.8
Non-vegetarian	37	90.2

Table 4: Market Study of Tofu Sausage Tomyam

No	Item	Yes		No	
		Frequency	Percentage (%)	Frequency	Percentage (%)
1	Do you like sausage products?	35	85.4	6	14.6
2	Do you like healthy sausage without harmful preservatives?	37	90.2	4	9.8
3	Do you agree that the sausages in the market contain ingredients can cause various risk of disease?	31	75.6	10	24.4
4	Do you like tofu or tofu-based products?	33	80.5	8	19.5
5	Will you buy tofu sausage tomyam that are made from natural products without any preservatives?	30	73.2	11	26.8
6	Do you agree tofu sausage tomyam is a healthy product that are made from natural products without any preservatives?	38	92.7	3	7.3

Based on Table 3 and Table 4 showed the results of market study of Tofu sausage tomyam. It showed that 75.6 of respondents agreed that the sausages in the market contain ingredients that can cause disease. Besides that, 92.7% of respondents agreed that tofu sausage tomyam are nutritious. This product can be a healthy alternative to the commercial sausages especially to the children. It is vital to foster healthy eating habits because they are essential to children's growth and development.

4. Conclusion

Tofu sausage tomyam can be one of the alternatives to the consumer in choosing healthier and more nutritious food products. Most commercial sausages are processed meat, and they are linked to increase in risk from health complications such as cardiovascular disease or cancer. This study showed that tofu and tomyam paste can be processed into sausages, which is acceptable and has several advantages because it's a high-value source of nutrients and a healthier option for consumers.

References

- Ayele, Y., Pal, M., & Devrani, M. (2019). Tofu: A Popular Food with High Nutritional and Health Benefits. *Food & Beverages Processing, April*, 54–55. <https://www.researchgate.net/publication/332343856>
- Dey, A. (2017). Tofu: Technological and Nutritional Potential. *Indian Food Industry Magazine*, 36(3), 8–24. <https://www.researchgate.net/publication/323676422>
- Huda, N., Wei, L. H., Jean, A. T. L., & Ismail, I. (2010). Physicochemical Properties of Malaysian Commercial Chicken Sausages. *International Journal of Poultry Science*, 9(10), 954–958. <https://doi.org/10.3923/ijps.2010.954.958>
- Maizura Murad, Wan Aida Wan Mustapha & Aminah Abdullah (2014). Penerimaan dan Penggunaan Produk Soya dalam Kalangan Pengguna Semenanjung Malaysia. *Sains Malaysiana*, 43 (7). 977-985.
- Wendy Hutton (2015). The Food of Malaysia: 62 Easy-to-follow and Delicious Recipes from the Crossroad of Asia. *Periplus Edition Boston*, USA

Retail Management Education in Malaysia: Identifying and Integrating Essential Skills

Nur Aliyah Azizi^{1*} & Noor Rahayu Mohd Salleh²

¹Politeknik Nilai, Malaysia

²Politeknik Ungku Omar, Malaysia

*nur_aliyah@polinilai.edu.my

Abstract

The primary objective of this research is to identify the key retail skill sets among retail management students at Malaysian Polytechnics. This is crucial to ensure that graduates are adequately prepared to manage a retail business effectively and contribute to economic sustainability. A focus group discussion was conducted involving: One senior officer from the Curriculum Division of JPPKK, and two senior lecturers from Politeknik Nilai with expertise in retail management. The discussion lasted one and a half hours. The interview transcripts were translated, transcribed, and analyzed to extract key findings. The perspectives of both academicians and retail industry practitioners were extracted from the interview transcripts. The main skills identified were interpersonal, communication, numeracy, analytical, knowledge, practical, and leadership skills. The transcripts were analyzed using Word Cloud software to confirm the frequently mentioned skills during the discussion. A follow-up survey was conducted with the focus group panel to reach a consensus on the most important skills from an academic perspective. The academicians ranked the essential skills as follows: knowledge skills, communication skills, and practical skills. Meanwhile, industry input highlighted a different set of priorities: communication skills as the most essential skills, with leadership skills as the least important skills. This study highlights the disparity between academic and industry perspectives on the essential skills for retail management students. By addressing these findings, Malaysian Polytechnics can better prepare retail management students to meet industry demands and contribute effectively to the retail sector and the broader economy.

Keywords: Retail Management Skills, Workforce Preparedness, Academic-Industry Alignment, and Malaysian Polytechnics

1. Introduction

The analysis of feedback from industry representatives, revealed significant skill gaps among Diploma in Retail Management students. This feedback underscores the discrepancy between what educational providers offer and what the industry expects. It is evident that interpersonal and communication skills are the most critical, followed by ethics, professionalism, and practical skills. While there are many international retail skills standards, they do not always suit the Malaysian retail environment. Limited research has been conducted on the retail skill sets needed among Malaysian retail management students. The Malaysian Qualification Framework (MQF) provides general guidance but is too broad for the specific needs of social science and business studies. Hence, there is a need for focused research to develop and test the required skills in the local context. This study aims to bridge the gap by identifying the required skill sets among retail management students, contributing to both local and international literature on retail education.

2. Methods

In this study, a focus group discussion was selected as the primary qualitative data collection method. The selection of three experts with extensive experience in retail management and education, each having over five years of experience (Mohd Jamil & Mat Noh, 2020). The goal of the session was to obtain their insights into the skills required for retail management students in Malaysian Polytechnics. This qualitative approach aims to diagnose issues arising from the skills gap between academia and industry.

The focus group included: (1) One senior officer from the Curriculum Division of JPPKK, and (2) Two senior lecturers from Politeknik Nilai, experts in retail management. The session, conducted via Google Meet, involved a set of open-ended questions designed to explore both academic and industry perspectives on the skills necessary for retail management students. The discussion was digitally recorded, transcribed, and subsequently analyzed. The process of transcription and translation was meticulous. Initially, the recorded interviews were transcribed in Bahasa Malaysia and saved in Word format. These transcripts were then translated into English, line-by-line, in Excel format. The translated files were proofread by a qualified English-language lecturer to ensure accuracy and clarity.

The analysis of the qualitative data followed a systematic approach. Thematic analysis is used to process inputs from the interview sessions. Using the transcribed interview scripts, the researcher conducted a thorough reading to capture codes. The coding process involved several stages: (1) Initial Coding: Reading the transcripts to identify significant codes and noting them in a manual coding table; (2) Code Reduction: Consolidating overlapping codes to streamline the data; and (3) Theme Development: Identifying and consolidating overlapping themes from the reduced codes. This process is in line with Bahari's (n.d.) method for organizing, analyzing, and sharing qualitative data. The final themes provided insights into the current scenario in the Diploma in Retail Management (DRM) unit and highlighted the relevant skills needed for retail management students.

3. Results

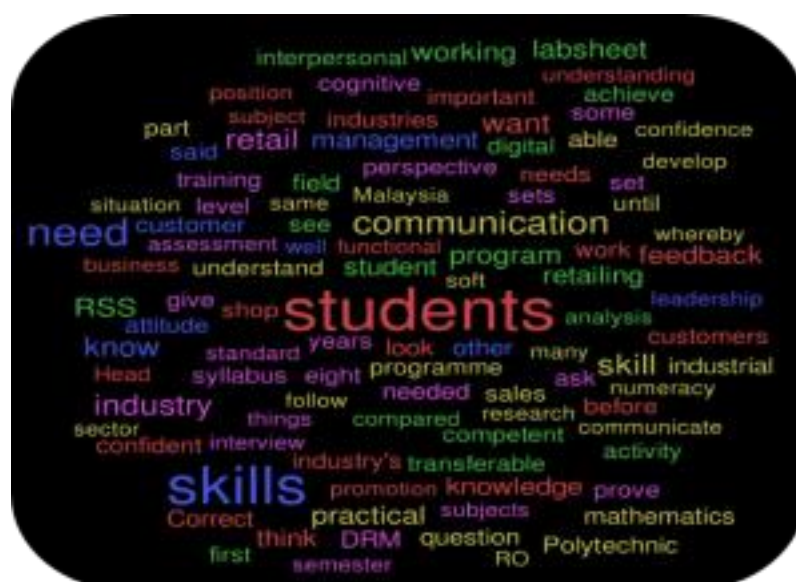


Figure 1: Word Cloud Generated based on Focus Group Discussion Transcript
Source: Researcher's findings (2022)

Figure 1 shows the word cloud produced based on the focus group discussion session with three

experts selected for this study. It demonstrates that communication, leadership, knowledge, numeracy skills are among the skills mentioned frequently by the panels and thus, helping the researcher to identify the retail skills set needed.

Table 1: Summary of Result Findings on Retail Skills Set

	Interpersonal skills	Communication skills	Numeracy skills	Analytical skills	Knowledge skills	Practical skills	Leadership skills
Study Findings – Interview Transcript							
Academic perspective	7	4	5	5	3	1	1
Industry perspective	2	5	1	1	1	2	1
TOTAL	9	9	6	6	4	3	1

Source: Researcher's findings (2022)

Based on Table 1 above, the study findings reveal a gap in the retail skills set needed among retail management students, with the industry placing the highest importance on communication skills. This encompasses both verbal and non-verbal communication with customers. For retail management students, effectively handling and engaging with customers is crucial, making customer service skills closely linked to communication skills. Additionally, strong communication skills with superiors and subordinates are vital. Non-verbal communication skills, such as copywriting for social media posts, are also essential for attracting and engaging customers. From the academic perspective, all three panelists agreed that interpersonal skills are the most important for retail management students. These skills are crucial for boosting students' attitudes and confidence levels, which should be developed during their studies before entering the workforce. The panelists also emphasized that practical sessions at the retail simulation store (RSS) help students develop these skills, fostering a sense of belonging and instilling a sense of responsibility in handling the RSS.

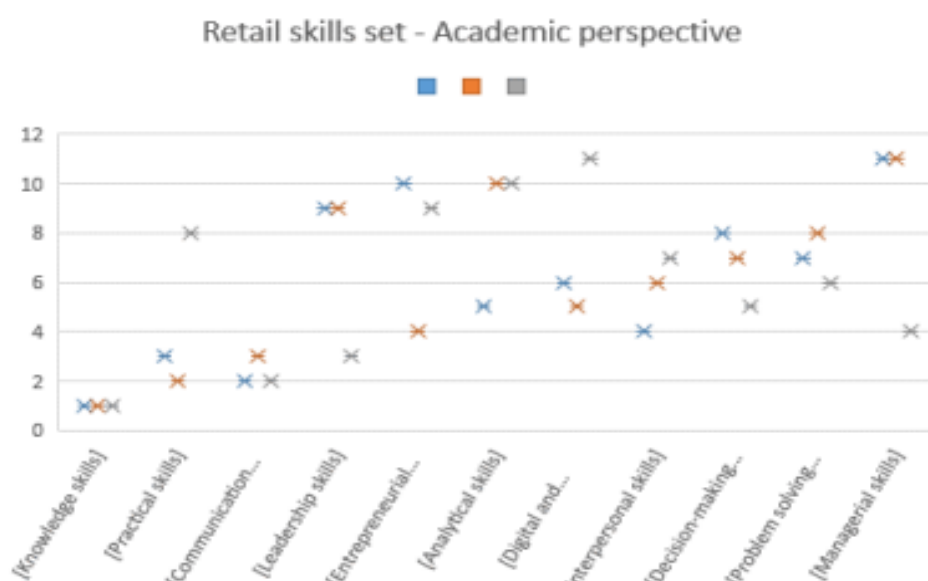


Figure 2: Ranking of the Important Retail Skills among Retail Management Student from Academic Perspective
Source: Researcher's findings (2022)

According to the follow-up survey on the focus group discussions, all three panels agreed that knowledge skills are paramount for retail management students from an academic standpoint. However, their rankings diverged on other essential retail skills. Figure 2 above illustrates that communication skills were rated higher than practical skills. Conversely, managerial skills were deemed the least important from an academic perspective, possibly due to limited emphasis in Malaysian Polytechnics' Diploma-level courses.



Figure 3: Ranking of the Important Retail Skills among Retail Management Student from Industry Perspective
Source: Researcher's findings (2022)

Figure 3 outlines the retail industry has emphasized that communication skills are the most crucial, followed by customer service, interpersonal skills, and problem-solving abilities. Leadership skills were noted as comparatively less significant. Feedback was gathered from industry players such as Mydin, Family Mart, Cosmoderm, Maybank, POS Malaysia, Aeon, and Metrojaya, who provided insights during focus group sessions with expert panels. These sessions effectively captured the retail industry's perspectives on essential skills for retail management students through participation in industrial committee meetings.

4. Discussion

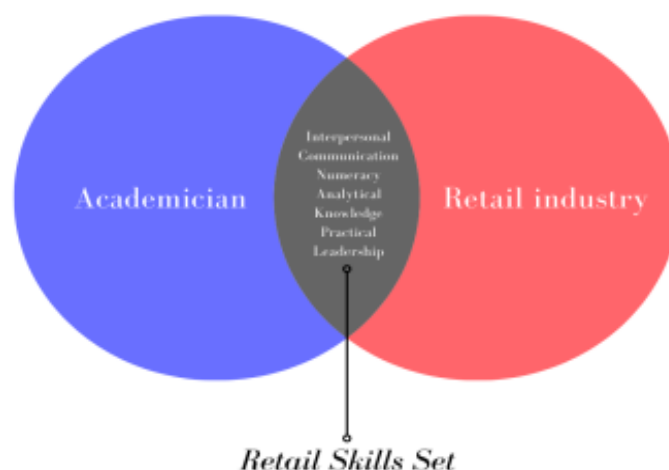


Figure 4: Identification of Retail Skills Set from Academician and Industry Perspectives Source: Researcher's Findings (2022)

Figure 4 above highlights the intersection between the perspectives of academicians and the retail

industry player on the essential retail skill sets for retail management students in Malaysian Polytechnics, as identified in this study. The findings align with the study by Hashim, Razali, & Md Taib (2019), which identified that Malaysian retail industry players consider ten skills critical when hiring retail graduates. These skills include fundamental skills, technical skills, communication skills, decision-making skills, social responsibility and humanistic values, lifelong learning and professional development, entrepreneurial skills, professional code of ethics, teamwork and leadership skills, and the ability to work independently.

This alignment also corresponds with the competency framework suggested by SkillsFuture Singapore (2017), which emphasizes the need for current skills to be updated. The retail skills set identified from this study is the interpersonal skills, communication skills, numeracy skills, analytical skills, knowledge skills, practical skills and leadership skills. Rosenberg, Heimler, & Morote (2012) observed that education institutions and industry are interrelated from a system perspective; the output of the education system is the input of industry. Therefore, it is critical to have continuous communication between industry and academia so that both needs are fulfilled.

5. Implications and Direction for Future Research

To bridge these gaps, the study suggests several recommendations for curriculum development: (1) Curriculum Alignment: Adjusting the curriculum to align more closely with industry requirements based on feedback from industry practitioners; (2) Practical Exposure: Increasing the emphasis on practical training to complement theoretical knowledge; (3) Skill Development Programs: Implementing targeted programs to develop communication, customer service, and problem-solving skills; and (4) Stakeholder Collaboration: Enhancing collaboration between academic institutions and industry stakeholders to keep the curriculum relevant and up-to-date.

The study also acknowledges the need to incorporate skills relevant to Industry 4.0 (IR4.0), such as fostering a culture of discovery, gamification, and integrated applied research. Knight, Forney, & Mihalick (2019) suggest that future retail education should focus on these areas to prepare students for the evolving retail landscape. Numeracy skills, identified in this study, are among those aligning with IR4.0 demands (MOE, 2019).

6. Conclusion

This study highlights the importance of developing a comprehensive retail skill set for retail management students at Malaysian Polytechnics. By addressing the identified skills gap and aligning academic training with industry expectations, educational institutions can better prepare graduates for successful careers in the retail sector. These efforts will contribute to the broader goal of economic sustainability by ensuring a well-equipped workforce capable of driving growth and innovation in the retail industry. The meticulous approach to data collection, transcription, translation, and analysis ensures that the findings are robust and actionable, providing a solid foundation for enhancing retail management education in Malaysia.

References

- Bahari, M. (n.d). NVivo 12 Plus: Essentials for Getting Started. Johor Bahru, Johor, Malaysia.
- Hashim, N., Razali, R. A., & Md Taib, N. A. (2019). Retailing employability skills needed by employers. *International Journal of Academic Research in Business & Social Sciences*, 1044-1051.
- Knight, D., Forney, J., & Mihalick, L. (2019). Retail Renaissance: A Case Study of Retail Education Reimagined. *Journal for Advancement of Marketing Education*, 10-16.

- Malaysia Productivity Corporation. (2019). *WayUp.my*. Retrieved from Guidebook: Talent Development Programmes to Recruit, Retain and Improve the Quality of Human Capital for Retail and F&B Subsector.
- MOE. (2019). *Laporan Kajian Pengesanan Graduan 2018*. Retrieved from Ministry of Education (MOE): [http://graduan.moe.gov.my/v/Penerbitan/SKPG%202018/Laporan%20Kajian%20Pen gesanan%20Graduan%202018.pdf](http://graduan.moe.gov.my/v/Penerbitan/SKPG%202018/Laporan%20Kajian%20Pen%20gesanan%20Graduan%202018.pdf)
- Mohd Jamil, M., & Mat Noh, N. (2020). *Kepelbagaian Metodologi dalam Penyelidikan Reka Bentuk dan Pembangunan*. Bangi: Qaisar Prestige Resources.
- Rosenberg, S., Heimler, R., & Morote, E.-S. (2012). Basic Employability Skills: A Triangular Approach. *Education + Training*, 54(1), 7-20.
- SkillsFuture Singapore. (2017, August 17). Skills Framework: Skills Map - Sales Supervisor/Brand Supervisor.

Students' Intention Towards Sustainability: The Moderating Role of Emotional Intelligence

¹Siti Yummy Faridatul Akmar Mohamad

¹*Commerce Department, Politeknik Muadzam Shah, Pahang, Malaysia,

¹sitiyummy@pms.edu.my

Abstract

Education plays a crucial role in the foundation of a civilized society. A thriving civilization prioritizes the development of its future leaders, nurturing them to embrace compassion and open-mindedness while instilling an appreciation for history and the pursuit of a brighter future. An individual's worldview is fundamentally altered through education, which increases their tolerance. Nevertheless, when we talk about sustainability, it goes beyond education. Thus, this objective of this cross-sectional study is to explore the potential influence of students' beliefs and attitudes on their intention towards sustainability. The research investigates the relationship between emotional intelligence and sustainability, as well as the interplay between these variables. A survey was carried out on a sample of 196 students from the Commerce department, Politeknik Muadzam Shah, Pahang. In order to collect the data, a 26-item questionnaire was created. Using SPSS (Statistical Package for The Social Sciences), data was gathered and descriptively examined. The findings indicate that those students who have higher emotional intelligence have greater desire to learn about sustainability. This implies that emotional intelligence has a direct impact and could be an important factor as moderator variable to increase their intention to practice sustainability. Furthermore, in order to build a more sustainable future for all, it was recommended to foster emotional intelligence in individuals.

Keywords: Belief, Attitude, Intention, Emotional Intelligence, Sustainability

1. Introduction

A substantial body of study has been produced in the recent years in response to environmental concerns that have caused people's perspectives on how people and nature interact to alter. Principles of sustainable development were thought to be best communicated through the field of education, specifically to start earlier at the young age. Related to that, educator and universities play a major role in encouraging students towards sustainability. The goal of sustainability is to promote harmony among people and between people and nature, which includes a balance of economic, social, and environmental sustainability. Nevertheless, according to Olawumi and Chan (2018), the terms sustainability and sustainable development are frequently utilized interchangeably, implying their close association. When we discussed sustainability, it refers to the balance of economic, social and environmental worldwide. This is important to maintain civilization among us and the best medium is through education. Taking into consideration, before we educate the younger generation about sustainability, we need to learn about their own perception and understanding about sustainability. The purpose of this study is to identify which factors that contribute to the intention of the students towards sustainability which consist of belief and attitude. Furthermore, the significance of emotional intelligence in the connections between attitude and intention for sustainability as well as between intention for sustainability and belief is examined.

2. Literature Review

Sustainability development is related to the civilization of human beings. In civilization, people are morally upright, work closely together, and lead distinctive lives. Thus, sustainability will be

achieved and contribute to the balance of social, environmental and social. A constant evaluation of consumer attitudes towards and involvement in sustainable consumption is necessary as corporate sustainability programs are more emphasized globally and more items connected to sustainability are offered. There is also a need to ascertain whether certain consumer traits may be indicative of how they feel about sustainability projects and respond in those situations. A shift in one's feelings towards concerns pertaining to the environment, society, or economy is referred to as an attitude change towards sustainable development. It focuses on cultivating empathy and compassion for all life, including humans and all living things, that exists on the planet earth.

Accordingly, achieving sustainability is not feasible without the involvement of young generation because they are our future. Tang (2018) highlights the crucial role that universities and educators should undertake in fostering the values, beliefs, and unwavering commitment to sustainability. It is recognized that education encompasses far-reaching advantages that extend beyond the acquisition of knowledge and skills. As a result, it will shape their attitudes towards sustainability development. Attitudes can be differentiated in two elements which is explicit and implicit attitudes. While people can report and deliberately regulate explicit attitudes, implicit attitudes are those that people do not explicitly recognize and whose activation is uncontrollable. Previous studies in the subject of sustainability have shown that implicit and explicit attitudes are not always related, showing a low congruence between explicit and implicit sustainability orientations. (Steiner et al., 2018). Students' attitudes towards sustainability are crucial because it will influence their behavior when it comes to the early stages of sustainability development, which involve product selection and daily usage.

Wyer (2018) asserts that beliefs represent an individual's perception of truth and are integral to the development of one's values and convictions. These beliefs are susceptible to modification through the acquisition of knowledge. A person's perspective is profoundly altered by education, which also makes them more tolerant, skeptical, and less prone to be duped by populist charlatans and other outmoded ideas that have long impeded humanity's progress. In line with the statement by another researcher, increasing knowledge could influence one's beliefs, values, and intentions (Perloff, 2017). When it comes to the intention, we need to prioritize our goals and mission in order to make sustainable development succeed. The preferences involved in order to make it succeed include changes of lifestyle for better sustainability, socially and environmentally responsible and wise decision when it comes to decide. Goal intention, personal standards, and attitudes are crucial for moving on to the next phase and, ultimately, for engaging in sustainable behaviour (Richter & Hunecke, 2020).

A person's capacity to control their emotions and express them in a way that is appropriate and productive is known as emotional intelligence (Goleman, 2017), otherwise known as “the individual's ability to use reason to understand and deal with emotions (own and others) and use emotions to understand the context and make more rational decisions” (Salovey, 2019). Emotional intelligence essentially has a direct and beneficial influence on people since it can inspire people to develop a variety of abilities, competencies, and skills that affect one's capacity to successfully manage environmental demands and pressures. Other attributes include social skills, self-control, motivation, empathy, and self-awareness.

This component is crucial to learning about contemporary economic, social, and environmental challenges and how to take action for greater sustainability. Consistent with the findings reported by Tsalaporta (2021), there exists a correlation between emotional intelligence and sustainable development. Furthermore, this study has the potential to investigate potential

differences in emotional intelligence levels between males and females. As noted by Magano (2020), emotional intelligence could be considered a trait, as the emotional profiles of students may vary depending on their gender and age.

Beyond that, positive competency also encourages someone to be internally motivated to accomplish their goals or objectives. As a result of learning something new or doing something new, they feel satisfied since they are inwardly motivated and enjoy discovering new things. The inspiration for sustainable development stems from the United Nations' 17 goals established in 2023. Serving as a roadmap, the Sustainable Development Goals provide a framework for achieving a more equitable and sustainable future for all individuals. These goals encompass a wide range of global challenges, such as environmental degradation, climate change, poverty, inequality, and the pursuit of peace. By attaining all 17 of these goals by 2030, we can strive to leave no one behind. Traits such as the drive for success, dedication, initiative, and optimism are closely associated with this competency.

3. Methodology

Regarding the assessment of the relationship between attitude and belief towards intention of sustainability, the questionnaire that consist of 26 structured question was developed. The target population of this study was all of the students who are currently taking Diploma in Business Studies in Politeknik Muadzam Shah, Pahang, Malaysia. Referring to the sample size table established by Krejcie and Morgan (1970), the recommended sample size has been narrowed down to approximately 196 participants. The questionnaire consists of four sections, with Section A focusing on gathering demographic information such as age and gender. Other sections include the questions about attitude (6 items), belief (6 items), intention (6 items) towards sustainability and emotional intelligence (6 items) as moderating variable towards the intention of sustainability. Five-point Likert scales (1="strongly disagree," 5="strongly agree") were used to measure these factors. The data were analyzed with SPSS 27 to statistically test the validity and reliability of the scale.

4. Result and Discussion

Table 1's findings demonstrate that each construct's Cronbach Alpha value was greater than 0.7, demonstrating the strong reliability of our survey instrument. As stated by Chan & Idris, (2017), Cronbach's alpha was presented to show the internal consistency of each questionnaire where an $\alpha > 0.7$ suggested good reliability.

Table 1: Reliability test

Construct	Cronbach Alpha
Belief	0.910
Attitude	0.940
Intention	0.928
Emotional Intelligence	0.900

Table 2: Item frequencies

	Mean	SD	Skewness	K
I feel more obliged to do something about environmental problems	4.0357	0.88506	-0.608	-0.190
I feel more morally obliged to do something about social problems	4.0051	0.87996	-0.557	-0.008
I think I should take more responsibility for sustainable development	4.0306	0.81592	-0.686	0.749

I believe that humans have the right to subdue and control nature	4.0000	0.88868	-0.709	0.498
I believe that human should adapt to nature rather than modify it to suit them	4.0255	0.88542	-0.722	0.518
I think it is important to control human population to ensure social sustainability	3.9745	0.92507	-0.813	0.663
I am more aware of current environmental, social, economic and cultural issues	4.2041	0.86480	-0.793	-0.040
I am more concerned about environmental pollutions	4.2704	0.79958	-0.710	-0.524
I make an effort to use green products and services whenever possible	4.1990	0.85707	-0.741	-0.142
I refuse the use of packaging	4.0561	0.99327	-0.811	0.125
I set aside garbage for reuse, recycling or safe disposal	4.1020	0.91696	-0.809	0.371
I make an effort to use energy and resources more efficiently	4.2194	0.84601	-0.692	-0.329
I prefer to work for an environmentally responsible employer in the future	4.1582	0.85963	-0.947	0.873
I prefer to work for socially responsible employer in the future	4.1378	0.83905	-0.844	0.777
I intend to change/continue to change my lifestyle for better sustainability	4.1429	0.79097	-0.574	0.011
I will promote the concept of sustainable development to my family and friends	4.1020	0.75773	-0.601	0.540
I will participate in campaign/causes that promote sustainable development	4.1276	0.75723	-0.575	0.373
I will apply the concept of triple bottom line more in making decision	4.1224	0.78139	-0.544	0.071
When a friend of mine wins an award, I feel happy	4.2908	0.81153	-1.046	0.903
I react calmly when I am under stress	4.1071	0.94665	-1.022	0.883
Am I really able to control my own emotions?	4.0561	0.84848	-0.616	0.001
I do my best to achieve the goals I set for myself	4.2959	0.74709	-0.916	1.003
I can understand my friends' emotions and feeling by seeing their behavior	4.2194	0.78957	-0.853	0.690
I strive to understand other people's points of view	4.2398	0.72228	-0.810	1.184

Source: Nogueira, T, Castro, R. Magano, J. (2023)

Table 2 presents the descriptive statistics for the items measuring Belief, Attitudes, Intentions, and Emotional Intelligence in the utilized instruments for this study. The distribution of data is considered normal, as indicated by the skewness and kurtosis values falling within the acceptable range. The mean value can give the researchers a good idea on how the respondents in the research have reacted to the variables in the questionnaire. Olatunde, Eyiolorunnse and Ogunode (2021) stated that means with values of 2.50 or higher were regarded as agreed, accepted, or positive responses, whilst those with values lower than 2.50 were viewed as negative and unaccepted/disagreed responses. The findings showed that intentions towards sustainability are directly impacted by attitudes and beliefs about sustainability in a statistically significant way.

Table 3: Moderation Analysis

Construct	p	ΔR^2	t	F
Belief	0.7030	0.8%	-1.8025	3.2489
Attitude	0.0307	1.05%	-2.1768	4.7387

Using PROCESS v4.2 developed by Andrew F. Hayes, a moderation analysis was conducted to examine the impact of emotional intelligence on the relationship between attitudes, beliefs, and intentions towards sustainability. In this analysis, attitudes were specified as the independent variable, intentions towards sustainability as the dependent variable, and emotional intelligence as the moderating variable. The result found that attitudes are significant and

negatively moderate the relationship (95% confidence interval, $p = 0.0307$ which is less than 0.05). Similarly, the results show that emotional intelligence has a negative and not statistically significant moderating effect on the connection between belief and intention to preserve one's lifestyle. (95% confidence interval, $p = 0.0730$).

5. Conclusion

The aim of this study was to investigate the potential moderating role of emotional intelligence in the interconnections between the beliefs, attitudes, and intentions of business students. The result indicates that both attitudes and belief have significant relationship with the intention towards sustainability. However, emotional intelligence has significant and negatively moderate the relationship between attitude and intention while belief does not. As stated by Encinas and Chauca (2020), the development of emotional intelligence may be crucial to understanding sustainable development. It is well known that it enables people to form solid relationships with others, to be more adaptable and resilient, and to approach sustainability with an open mind. Taking into consideration, they will approach sustainability issues more actively. The ultimate objective is to develop emotional intelligence in people to advance civilization and create a more sustainable future for all.

References

- Chan, L. L. L & Idris, N. (2017). Validity and Reliability of The Instrument Using Exploratory Factor Analysis and Cronbach's Alpha. *International Journal of Academic Research in Business and Social Sciences, Human Resource Management Academic Research Society, International Journal of Academic Research in Business and Social Sciences*. Vol. 7(10), pages 400-410
- Encinas, J. J., & Chauca, M. (2020). Emotional Intelligence Can Make a Difference in Engineering Students under the Competency-based Education Model. *Procedia Comput. Sci.*, 172, 960-964
- Goleman, D. (2017). *Emotional Development and Emotional Intelligence: Educational Implications*. New York, NY, USA: Basic Books
- Jack, T. C. B (2017). *Society And Environment: An Introduction to Environmental Sociology*. Benin City: Dimaf Publication
- Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*. 607-610.
- Magano, J., Silva, C., Figueiredo, C., Vitória, A., Nogueira, T., & Pimenta Dinis, M. A. (2020). Generation Z: Fitting Project Management Soft Skills Competencies - A Mixed-Method Approach. *Educ. Sci.* 10, 187.
- Nogueira, T., Castro, R., & Magano, J. (2023). *Engineering Students Education in Sustainability: The Moderating Role of Emotional Intelligence*. *Sustainability*, 15, 5389. <https://doi.org/10.3390/su15065389>
- Olatunde-Aiyedun, T. G., Eyiolorunse-Aiyedun, C. T. & Ogunode, N. J. (2021). *Post Covid-19 and Digitalization of University Lecturers in Nigeria*. *Middle European Scientific Bulletin*, 11(1).
- Olawumi, T. O., & Chan, D. W. (2018). A Scientometric Review of Global Research on Sustainability and Sustainable Development. *J. Clean. Prod.* 183, 231–250.
- Onokala, U., Banwo, A. O., & Okeowo, F. O. *Predictors of Pro-Environmental Behavior: A Comparison of University Students in the United States and China*. *J. Manag. Sustain.* 2018, 8, 127.
- Perloff, R. M. (2017). *The Dynamics of Persuasion: Communication and Attitudes in the 21st Century, 2nd ed.* Routledge: New York, NY, USA

- Richter, N., & Hunecke, M. (2022). *Mindfulness, Connectedness to Nature, Personal Ecological Norms and Proenvironmental Behavior: A Daily Diary Study*. *Current Research in Ecological and Social Psychology*, 3, 100038. <https://doi.org/10.1016/j.cresp.2022.100038>
- Salovey, P., & Mayer, J. D. (2019). *Emotional Intelligence*. Dude Publishing: Port Chester, NY, USA
- Steiner, G., Geissler, B., Schreder, G., & Zenk, L. (2018). Living Sustainability, or Merely Pretending? From Explicit Self-Report Measures to Implicit Cognition. *Sustainability Science*, 13(4), 1001–1015. <https://doi.org/10.1007/s11625-018-0561-6>
- Tang, K. H. D. (2018). Correlation between Sustainability Education and Engineering Students' Attitudes towards Sustainability. *Int. J. Sustain. High. Educ.* 19, 459-472.
- Tsalaporta, E. (2021). *Emotional Intelligence for Sustainable Engineering Education: Incorporating Soft Skills in the Capstone Chemical Engineering Capstone Design Project*. In Proceedings of the 10th Engineering Education for Sustainable Development Conference, Cork, Ireland, 14–16 June 2021; pp. 1–8.
- United Nation, (2023). Sustainable Development Goals. <https://www.un.org/sustainabledevelopment/>
- Wyer, R. S., Jr. & Albarracin, D. (2018). Belief Formation, Organization, and Change: Cognitive and Motivational Influences. In *The handbook of Attitudes*; Albarracin, D., Johnson, B. T., Zanna, & M. P., Eds.; Lawrence Erlbaum Associates Publishers: Mahwah, NJ, USA, pp. 273–322

Literasi Kewangan Pelajar Diploma Pengajian Perniagaan Jabatan Perdagangan Politeknik Ungku Omar

Sazaliana Shairali^{1*} & Yanti Yusop²

¹ & ²Jabatan Perdagangan, Politeknik Ungku Omar, Perak Malaysia

¹sazaliana@polycc.edu.my & ²yanusop@puo.edu.my

Abstrak

Kenaikan harga secara berterusan menyebabkan peningkatan kos sara hidup di pelbagai peringkat usia terutama golongan yang berpendapatan tetap dan golongan yang tiada pendapatan seperti pelajar di institusi pengajian tinggi. Kehidupan sebagai pelajar wang menjadi keperluan untuk memenuhi tuntutan sebagai seorang pelajar iaitu membeli buku rujukan, alat tulis, perbelanjaan makan seharian, rumah sewa, dan juga yuran pengajian. Pelajar perlu bijak dan mempunyai kemahiran dalam menguruskan kewangan di saat situasi ekonomi di Malaysia yang tidak menentu. Kemahiran literasi kewangan penting untuk mengelakkan berlakunya kes kebangkrutan apabila melalui fasa bekerja kelak. Objektif kajian ini adalah untuk mengkaji tahap literasi kewangan dalam kalangan pelajar (pengetahuan kewangan, tingkah laku pengurusan kewangan, pengalaman kewangan) dan mengkaji kefahaman pelajar tentang konsep keperluan dan kehendak. Kaedah analisis deskriptif digunakan dalam kajian ini, borang soal selidik secara *google form* sebagai instrumen dan diedarkan secara dalam talian kepada pelajar. Sampel kajian melibatkan seramai 110 orang responden dimana terdiri daripada pelajar Diploma Pengajian Perniagaan yang telah mengambil kursus Microeconomics dan Macroeconomics di Jabatan Perdagangan, Politeknik Ungku Omar. Hasil kajian mendapati tahap pengetahuan kewangan dan tahap tingkah laku pengurusan kewangan berada pada tahap tinggi. Walaubagaimanapun, item tahap pengalaman kewangan berada pada tahap yang sederhana. Hasil kajian ini juga mendapati, pengetahuan mengenai konsep keperluan dan kehendak dalam kalangan pelajar adalah sangat baik. Selain itu, skor min tertinggi ialah tahap pengetahuan kewangan. Oleh itu, kajian ini diharap dapat membantu pelajar dalam menguruskan perbelanjaan kewangan harian mereka pada masa akan datang.

Kata Kunci: Literasi Kewangan, Pengetahuan Kewangan, Keperluan dan Kehendak

1. Pengenalan

Statistik yang direkodkan di Jabatan Insolvensi Malaysia dari tahun 2019 hingga November 2023 mendapati, kes kebangkrutan dikalangan golongan dibawah umur 25 tahun adalah 121 kes dan berumur 25 hingga 34 tahun sebanyak 6800 kes. Walaupun nilai ini agak kecil berbanding jumlah keseluruhan 37020 kes, situasi ini tidak harus diambil mudah. Setiap bulan akan ada kes yang direkodkan.

Wang menjadi keutamaan setiap individu tambahan kepada pelajar tidak mempunyai sumber pendapatan. Pelajar memerlukan wang untuk keperluan memiliki buku rujukan, alat tulis, makan seharian, rumah sewa dan juga yuran pengajian. Kesukaran akan berlaku jika pelajar kesempitan wang dan ketidakselesaan untuk belajar akan berlaku. Menyedari masalah ini, pihak kerajaan dan pihak swasta menawarkan bantuan biasiswa, zakat dan pinjaman pelajaran kepada pelajar. Usaha ini akan membantu meringankan beban pelajar yang kesempitan kewangan. Pengurusan kewangan yang bagus akan membantu pelajar menjalani kehidupan kampus dengan lebih baik. Menurut Yasmin dan Anuar (2017), jika mahasiswa tidak berjaya untuk membuat perancang kewangan dengan baik, masalah kewangan akan berlaku. Kurangnya ilmu pengurusan kewangan bagi mengenalpasti barang keperluan dan kehendak akan menimbulkan konflik

pengurusan kewangan. Pembaziran akan berlaku jika pelajar tidak mampu membezakan antara konsep kemahuan dan kehendak sehingga boleh mendorong kepada masalah bebanan hutang.

Lantaran itu, objektif kajian adalah untuk mengkaji literasi kewangan dalam kalangan pelajar bagi faktor tahap pengetahuan kewangan, tahap tingkah laku pengurusan kewangan, dan tahap pengalaman kewangan. Objektif kedua ialah mengkaji kefahaman pelajar tentang konsep keperluan dan kehendak. Kajian yang dilakukan tertumpu kepada pelajar program Diploma Pengajian Perniagaan yang sudah mengambil kursus Microeconomics dan Macroeconomics. Kajian ini dilaksanakan di Jabatan Perdagangan, Politeknik Ungku Omar. Struktur perbincangan penulisan diteruskan dengan kajian literatur, penerangan metodologi, disusuli dapatan kajian dan hasil perbincangan serta kesimpulan.

2. Kajian Literatur

Hasil kajian Nor Syahidah dan Norasmah (2017) menunjukkan literasi kewangan pelajar berada pada tahap yang rendah disebuah institusi pengajian tinggi di Bangi. Hasil kajian yang dilakukan oleh Dahlia et al. (2009) mendapati di universiti hampir semua mahasiswa tidak mengatur perbelanjaan mereka dengan sempurna kerana ditanggung oleh ibubapa atau penjaga. Bagi pelajar yang mempunyai tahap pengetahuan literasi yang tinggi tidak menghadapi masalah kewangan berbanding pelajar yang rendah tahap literasi kewangannya. Perihal ini bersamaan dengan kajian yang dilaksanakan oleh Arofah et al. (2018) pelajar yang mempunyai tahap literasi kewangan yang tinggi menunjukkan tingkah laku kewangan yang sesuai, manakala pelajar yang mempunyai tahap literasi kewangan yang rendah menggesa mereka untuk membuat pembelian berdasarkan keutamaan peribadi.

Tahap literasi kewangan pelajar di pengaruhi oleh tahap pengetahuan, tingkah laku, pengalaman dan tahun pengajian, berikut adalah hasil kajian yang dilakukan oleh Hairunnizam dan Siti Aisyah terhadap mahasiswa UKM. Menurut Rozita et al. (2022) pengurusan kewangan mahasiswa yang baik hasil daripada faktor literasi kewangan dan mempengaruhi tahap tekanan mahasiswa secara tidak langsung.

3. Metodologi Kajian

Bahagian ini menerangkan berkaitan reka bentuk kajian, instrumen kajian, populasi dan saiz sampel serta prosuder menganalisis data kajian.

Reka Bentuk Kajian

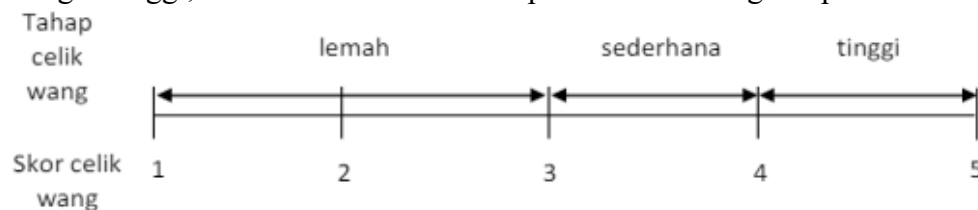
Kajian ini dijalankan untuk mengkaji tahap literasi kewangan dalam kalangan pelajar dan mengkaji kefahaman pelajar tentang konsep keperluan dan kehendak. Jabatan Perdagangan, Politeknik Ungku Omar menjadi lokasi utama kajian dijalankan. Kaedah analisis deskriptif dijalankan dalam kajian ini, borang soal selidik digunakan sebagai instrumen dan diedarkan secara dalam talian kepada responden.

Instrumen Kajian

Menurut Mohd Majid Konting (2005) sesuatu kajian dapat memberi ketepatan dan kebenaran dalam maklum balas yang diingini dengan menggunakan soal selidik. Soal selidik ini mempunyai 3 bahagian. Bahagian A merujuk kepada demografi pelajar, bahagian B mengukur tahap literasi kewangan manakala bahagian C pula mengenai pemahaman pelajar mengenai konsep keperluan dan kehendak. Bahagian B dan C adalah dalam bentuk skala likert. Responden memilih jawapan yang sesuai mengenai sesuatu item berdasarkan skala 1 hingga 5 iaitu 1- Sangat Tidak Setuju, 2- Tidak Setuju, 3- Tidak Pasti, 4- Setuju dan 5- Sangat Setuju. Populasi kajian terdiri daripada pelajar

Diploma Pengajian Perniagaan yang telah mengambil kursus Microeconomics dan Macroeconomics di Jabatan Perdagangan Politeknik, Ungku Omar. Sampel kajian adalah terdiri daripada 110 responden.

Kajian ini menggunakan pengelasan skor yang diperoleh berlandaskan tahap skor pengukuran literasi kewangan oleh Rubayah et al. (2015). Pengelasan skor dibahagikan kepada tiga tahap, tahap literasi kewangan lemah, nilai skor lebih besar daripada 1 dan kurang daripada 3. Literasi kewangan tahap sederhana, nilai skor lebih besar dari 3 dan kurang dari 4, manakala tahap literasi kewangan tinggi, nilai skor lebih besar daripada 4 dan kurang daripada 5.



Rajah 1: Garisan Nombor Bagi Skor Literasi Kewangan

Menurut Mohd Salleh (2001), instrumen yang dikaji jika bernilai kurang daripada 0.6 bersifat kebolehpercayaan yang rendah. Nilai pekali alpha yang hampir dengan 1.0 mempunyai kebolehpercayaan yang lebih positif. Nilai pekali Alpha cornbach 0.6 sepatutnya diperoleh melalui penyelidikan ini.

Jadual 3.1: Nilai Pekali Kebolehpercayaan Item Soal Selidik

Pembolehubah	N	Alpha Cronbach
Tahap pengetahuan kewangan	5	0.77
Tahap tingkah laku pengurusan kewangan	6	0.69
Tahap pengalaman kewangan	4	0.87
Pengetahuan mengenai konsep keperluan	5	0.80
Pengetahuan mengenai konsep kehendak	4	0.77

Merujuk Jadual 3.1, pekali Alpha Cronbach bagi setiap pembolehubah berada pada kedudukan 0.69 hingga 0.87, menunjukkan instrument soal selidik yang digunakan sesuai untuk kajian serta mempunyai kebolehpercayaan yang tinggi. Oleh yang demikian, hasil kajian ini layak untuk dianalisis dan dibincangkan.

4. Dapatan dan Perbincangan

Hasil kajian di bahagian A iaitu demografi responden dianalisis secara deskriptif. Manakala hasil kajian di bahagian B dan C dianalisis menggunakan skor min.

Jadual 4.1 Maklumat Demografi Responden

Demografi	Ciri	Kekerapan (N=110)	Peratusan
Jantina	Lelaki	26	23.6
	Perempuan	84	76.4
Bangsa	Melayu	85	77.3
	India	19	17.3
	Cina	4	3.6
	Lain-lain	2	1.8
Umur	Kurang 19	6	5.5
	20 -22 Tahun	104	94.5
Semester	2	21	19.1
	3	40	36.4
	4	28	25.5
	5	21	19.1

Himpunan Purata Nilai			
Mata Semasa	2.01-2.50	9	8.2
	2.51-3.00	22	20
	3.01-3.50	40	36.4
	3.51-4.00	39	35.5
Pendapatan keluarga per bulan			
	Kurang daripada RM1000	20	18.2
	RM 1001- RM 2000	27	24.5
	RM 2001- RM 3000	29	26.4
	RM 3001 – RM 4000	12	10.9
	RM 4001- RM 5000	7	6.4
	RM 5001 dan ke atas	15	13.6
Sumber kewangan sebulan			
	Biasiswa	10	9.1
	Pinjaman	30	27.3
	Ibubapa	65	59.1
	Sendiri	5	4.5

Berdasarkan jadual 4.1 maklumat demografi responden, sampel kajian adalah terdiri daripada 110 pelajar Diploma Pengajian Perniagaan, Jabatan Perdagangan di Politeknik Ungku Omar. Seramai 26 (23.6%) adalah pelajar lelaki dan selebihnya iaitu 84 (76.4%) pelajar perempuan. Bilangan pelajar perempuan melebihi pelajar lelaki. Daripada 120 responden, 85 (77.3%) pelajar berbangsa Melayu, 19 (17.3%) pelajar berbangsa India, 4 (3.6%) pelajar berbangsa Cina dan 2 (1.8%) pelajar lain-lain bangsa. Hanya 6 (5.5%) daripada responden yang berumur kurang daripada 19 tahun. Selebihnya berumur 20 hingga 22 tahun iaitu seramai 104 (94.5%).

Semua responden adalah terdiri daripada pelajar Diploma Pengajian Perniagaan yang telah mengambil kursus Microeconomics dan Macroeconomics. Oleh itu, kajian ini tidak melibatkan pelajar semester satu. Seramai 21(19.1%) responden adalah pelajar semester dua dan lima, 40 (36.4%). Manakala, pelajar semester tiga dan pelajar semester empat seramai 28 (25.5%). Lebih daripada separuh responden memperolehi himpunan purata nilai mata (hpnm) semasa 3.01 ke atas. Seramai 40 (36.4%) pelajar memperolehi hpnm 3.01 hingga 3.50. Bagi hpnm 3.51 hingga 4.00 pula seramai 39 (35.5%) pelajar.

Pendapatan keluarga per bulan RM2001 hingga RM3000 mempunyai peratusan tertinggi iaitu 26.4% manakala peratusan terendah pendapatan RM4001 hingga RM5000. Sebanyak 18.2% daripada responden pendapatan keluarga di bawah RM1000. Dari segi sumber kewangan pelajar, 59.1% dibiayai oleh ibu pada dan 27.3% dari responden membuat pinjaman untuk belajar. Hanya 9.1% mendapat biasiswa.

Jadual 4.2: Min Tahap Pengetahuan Kewangan

No	Item	Min	Tahap
1	Saya bahawa kenaikan inflasi bermaksud kos sara hidup akan meningkat	4.44	Tinggi
2	Saya menyedari bahawa kenaikan harga barang mengurangkan kuasa beli	4.14	Tinggi
3	Saya memahami semua bentuk pelaburan mampu memberikan pulangan dalam bentuk keuntungan ataupun kerugian	4.13	Tinggi
4	Saya berpendapat kadar pulangan bank mempengaruhi nilai simpanan masa hadapan	4.00	Tinggi
5	Saya mengetahui kunci kira-kira memaparkan status kewangan sesebuah entiti	4.05	Tinggi
Purata Skor Min Keseluruhan		4.16	Tinggi

Jadual 4.2 menunjukkan min tahap pengetahuan kewangan dengan skor min keseluruhan 4.16, pada tahap literasi kewangan tinggi. Skor min tertinggi ialah item mengetahui kenaikan inflasi bermaksud kos sara hidup akan meningkat dengan nilai skor 4.44. Manakala skor min

terendah dengan nilai 4.00, iaitu item kadar pulangan bank mempengaruhi nilai simpanan masa hadapan.

Jadual 4.3: Min Tahap Tingkah Laku Pengurusan Kewangan

No	Item	Min	Tahap
1	Saya tidak menangguhkan pembayaran yuran pengajian	4.55	Tinggi
2	Saya mempunyai wang tunai yang mencukupi untuk tujuan kecemasan	3.73	Sederhana
3	Saya tidak membuat pinjaman wang dari rakan atau keluarga untuk membeli barangan keperluan	4.05	Tinggi
4	Saya tidak pernah menerima notis tunggakan yuran atau sebarang bil	4.47	Tinggi
5	Saya tidak berbelanja melebihi kemampuan	3.95	Sederhana
6	Saya tidak pernah mengalami kemurungan kerana kekurangan wang	3.47	Sederhana
Purata Skor Min Keseluruhan		4.03	Tinggi

Jadual 4.3 menunjukkan min tahap tingkah laku pengurusan kewangan dengan skor min keseluruhan 4.03, pada tahap literasi kewangan tinggi. Skor min tertinggi ialah item tidak menangguhkan pembayaran yuran pengajian dengan nilai skor min 4.55. Manakala skor min terendah dengan nilai 3.47, iaitu item tidak pernah mengalami kemurungan kerana kekurangan wang.

Jadual 4.4: Min Tahap Pengalaman Kewangan

No	Item	Min	Tahap
1	Saya sentiasa merekodkan perbelanjaan saya setiap hari	3.00	Sederhana
2	Saya menyediakan bajet kewangan setiap bulan	3.52	Sederhana
3	Saya menetapkan matlamat perbelanjaan setiap bulan	3.52	Sederhana
4	Saya mengasingkan perbelanjaan untuk simpanan perbelanjaan dan kegunaan kecemasan	3.8	Sederhana
Purata Skor Min Keseluruhan		3.46	Sederhana

Jadual 4.4 menunjukkan min tahap pengalaman kewangan dengan skor min keseluruhan 3.46, pada tahap literasi kewangan sederhana. Skor min tertinggi ialah item mengasingkan perbelanjaan untuk simpanan perbelanjaan dan kegunaan kecemasan dengan nilai skor min 3.8. Dengan nilai 3.00, iaitu item sentiasa merekodkan perbelanjaan setiap hari, mendapat skor min terendah.

Jadual 4.5: Min Tahap Pengetahuan Mengenai Konsep Keperluan

No	Item	Min	Tahap
1	Saya memahami konsep keperluan merupakan kepentingan asas yang diperlukan oleh setiap manusia untuk meneruskan kehidupan	4.37	Tinggi
2	Saya mengetahui keperluan asas terdiri daripada makanan, tempat tinggal dan pakaian	4.51	Tinggi
3	Saya mengutamakan pembelian barang yang penting sahaja	4.23	Tinggi
4	Saya menggunakan duit poket untuk membeli barang keperluan sahaja	4.02	Tinggi
5	Saya, apabila mendapat sumber pembiayaan akan mengutamakan pembelian barang keperluan	4.38	Tinggi
Purata Skor Min Keseluruhan		4.30	Tinggi

Jadual 4.5 menunjukkan min tahap pengetahuan mengenai konsep keperluan dengan skor min keseluruhan 4.30, pada tahap literasi kewangan tinggi. Ini menunjukkan pengetahuan pelajar terhadap konsep keperluan adalah sangat baik. Nilai min tertinggi berada pada item kedua dengan nilai min 4.51. Ini membuktikan bahawa para pelajar sedar keperluan asas terdiri daripada makanan, tempat tinggal dan pakaian.

Jadual 4.6: Min Tahap Pengetahuan Mengenai Konsep Kehendak

No	Item	Min	Tahap
1	Saya memahami konsep kehendak adalah keinginan terhadap barang perkhidmatan untuk hidup dengan lebih selesa dan mewah daripada keadaan asal	4.26	Tinggi

2	Saya mengetahui kehendak manusia sentiasa berubah ubah dan sukar dipuaskan	4.44	Tinggi
3	Saya tidak suka berbelanja barang untuk tujuan menunjuk-nunjuk	4.39	Tinggi
4	Saya membeli barang dengan memikirkan kegunaan sebenarnya buat diri saya	4.45	Tinggi
Purata Skor Min Keseluruhan		4.39	Tinggi

Jadual 4.6 menunjukkan min tahap pengetahuan mengenai konsep kehendak dengan skor min keseluruhan 4.39, pada tahap literasi kewangan tinggi. Ini menunjukkan pengetahuan pelajar terhadap konsep kehendak adalah sangat baik. Nilai min tertinggi berada pada item keempat dengan nilai min 4.45. Ini membuktikan bahawa para pelajar membuat membeli barang dengan memikirkan kegunaan sebenarnya buat diri sendiri.

5. Kesimpulan

Secara keseluruhan, hasil kajian menemui bahawa tahap literasi kewangan pelajar Diploma Pengajian Perniagaan yang mengambil kursus Microeconomics dan Macroeconomics di Jabatan Perdagangan Politeknik, Ungku Omar berada pada tahap tinggi iaitu item tahap pengetahuan kewangan dan tahap tingkah laku pengurusan kewangan. Walaubagaimanapun, item tahap pengalaman kewangan berada pada tahap yang sederhana. Hasil kajian ini juga mendapati, pengetahuan mengenai konsep keperluan dan kehendak dalam kalangan pelajar adalah sangat baik. Kedua-dua konsep mencatat nilai 4.30 dan 4.39. Item membeli barang dengan memikirkan kegunaan buat diri sendiri mencatatkan nilai min yang tertinggi (4.45). Ini menunjukkan pelajar berbelanja hanya untuk keperluan mereka sendiri. Hasil kajian mendapati pelajar Jabatan Perdagangan, Politeknik Ungku Omar mempunyai tahap literasi kewangan yang mantap dan dapat membuat keputusan yang tepat ketika berbelanja.

Dapatan kajian ini diharap mampu membantu pihak pengurusan Politeknik Ungku Omar dalam mengedalikan aktiviti yang dapat meningkatkan tahap literasi kewangan bagi melahirkan pelajar yang celik kewangan kepada semua pelajar di Politeknik Ungku Omar. Pelajar juga perlu fokus dalam mengawal perbelanjaan dengan mendahulukan perbelanjaan untuk pembelajaran berbanding yang lain. Kajian ini diharap dapat membantu pelajar dalam menguruskan kewangan mereka di masa akan datang, justeru dapat mengurangkan statistik kes kebangkrapan di Malaysia.

Rujukan

- Arofah, A. A., Purwaningsih, Y., & Indriayu, M. (2018). Financial Literacy, Materialism and Financial Behavior. *International Journal of Multicultural and Multireligious Understanding*. 5(4), 370-378.
- Azahari, R., Sajiah, Y. & Muhammad, S. B. (2018). Tinjauan Ke Atas Pengukuran Literasi Kewangan:Perusahaan Kecil dan Sederhana (PKS). *Journal of Humanities, Language, Culture and Business (HLCB)*, 37-45.
- Baba, R., Nur Zafirah M & Juwairiah H. (2022). Tahap Literasi Kewangan, Masalah Kewangan Dan Tekanan Dalam Kalangan Mahasiswa. *Jurnal 'Ulwan*. Jilid 7 (Bil.2): 173-190
- Dahlia I, Rabitah H, Zuraidah M. I. (2009). A Study on Financial Literacy of Malaysian Degree Students. *Cross-Cult.Comm.*, 5(4): 51-59.
- Hairulnizam W & Siti Aisyah. (2020). Literasi Kewangan Dan Kesannya Terhadap Gelagat Perbelanjaan Mahasiswa di Universiti Kebangsaan Malaysia. *Jurnal Personalia Pelajar* 23(1):27-43
- Majid, M. Konting. (2005). Kaedah Penyelidikan Pendidikan.
- Mohamad Azmi Abdullah & Mohd Fauzi Hussin. (2020). Literasi Kewangan Islam: Sorotan Kajian Lepas dan Kaedah Pengukuran. *Jurnal of Business Innovation*. Vol 5, No 1

- Nor Syahidah, N. & Norasmah, O. (2017). Kualiti Pendidikan Pengurusan Kewangan dengan Tahap Literasi Kewangan. *Journal of Global Business and Social Entrepreneurship (GBSE)*, 183-193.
- Rubayah, Y., Hawati, J. & Nur Ain, K. (2015). Tahap Literasi Kewangan dalam Kalangan Pelajar Universiti Awam: Kajian di Universiti Kebangsaan Malaysia. *Jurnal Personalia Pelajar* 18(1), 75-88.
- Yasmin, H. & Anuar, A. (2017). Tahap Literasi Kewangan di Kalangan Mahasiswa. *Conference: International Conference on Global Education V "Global Education, Common Wealth, and Cultural Diversity* (pp. 2373-2387). Padang: Universitas Ekasakti, Padang

Effects of Biofeedback Training on Heart Rate Variability and Performance of College Golf Players

Huang Donghai¹, Muhammad Nubli Abdul Wahab^{2*} & Zhang Xiuling³

^{1, 2 & 3}Centre for human science, University Malaysia Pahang al-Sultan Abdullah 26600 Pekan Pahang, Malaysia

Abstract

The purpose of this study is to conduct a 4-month experiment using biofeedback training on golf athletes, analyzing its effects on golf performance, and HRV indicators of golf athletes. The results indicate that the performance of the dexterity project in time domain indicators (SDNN, RMS-SD, PNN50) and frequency domain indicators (TP, LF, LF/HF, LFnorm) were significantly lower than those of the Bodhi tree and archery projects, among which the decreases in SDNN, RMS-SD, PNN50 and TP, LF, LF/HF, and LFnorm reached very significant levels ($p < 0.01$), while HFnorm was very significantly higher than the other two groups ($p < 0.01$). In addition, the VLF index in the dexterity project was significantly lower than that in the archery project ($p < 0.05$). In the later training, the time domain indicators (SDNN, RMS-SD, PNN50) and the frequency domain indicator TP of the Bodhi tree and archery projects were significantly improved ($p < 0.01$ and $p < 0.05$), while the LF/HF ratio and LFnorm gradually decreased over time, while HFnorm gradually increased. In the Bodhi tree and archery events, the time domain indexes in the middle training period were significantly lower than those in the early training period ($p < 0.01$ and $p < 0.05$), while the LF/HF ratio was higher in the middle training period than in the early training period. After continuous training, the time domain indexes in the late training period were significantly higher than those in the early training period ($p < 0.01$ and $p < 0.05$). Long-term biofeedback training can positively affect the performance of golfers to a certain extent. Through biofeedback training, they can improve their self-regulation ability and their sports performance.

Keywords: Biofeedback Training, Heart Rate Variability, Sports Performance, Collegiate Golfers

1. Introduction

Since golf became an official Olympic event in 2016, it has garnered global attention through efforts by the International Golf Association (Millington et al, 2016). Known for its blend of athleticism, technology, and psychology, golf demands rigorous self-regulation from players navigating open courses on foot (Millard, D. 2023). Psychological fortitude is pivotal in golf, as emphasized by champions like Ban Haugen and Peter Korsty, who stress that success hinges more on mental acuity than physical prowess alone (Skelton, L. 2023). Tiger Woods' illustrious career underscores this, starting his psychological training at an early age, which he credits for much of his success (Shenk, J. W., 2014). Despite golf's increasing popularity, the scarcity of comprehensive psychological resources remains a critical issue globally, highlighting the need for expanded research and support in this vital aspect of the sport. Therefore, more suitable psychological training methods and systematic psychological training methods are urgently needed to explore and study.

Application of Biofeedback in Sports Psychology

Biofeedback technology enhances psychological skills training in competitive sports by aiding athletes in mastering relaxation, imagery, and concentration (Beauchamp et al, 2012). It effectively utilizes physiological indicators to objectively reflect athletes' psychological and physical states, facilitating improved athletic performance. However, its application in sports psychology faces

challenges. Certain biofeedback technologies may not align with specific sports' monitoring needs, limiting their effectiveness (Schack et al, 2020). Moreover, prolonged exposure to physiological data during training can lead to athlete fatigue and resistance, impacting training outcomes (Bourdon et al, 2017). Comprehensive analysis integrating both autonomic and central nervous system activities is crucial for optimizing biofeedback's efficacy in enhancing athletes' psychological control and performance levels across diverse sports disciplines (Siekańska et al, 2021). Therefore, how to increase the vividness of biofeedback training and make it more practical in the long term is also an issue worthy of study and discussion.

Research on the Application of Heart Rate Variability in Sports

Heart rate variability (HRV) is widely utilized in sports to assess autonomic nervous system activity and sympathetic-parasympathetic balance. Studies like Stephenson, M. D. et al. (2021) introduced the "HRV decay constant," correlating it with exercise power, highlighting its relevance in performance evaluation. Innovations such as the "HRV second peak" by Singh et al. (2018) enhance HRV's utility, replacing traditional metrics like anaerobic threshold evaluation. Research on runners' further underscores HRV's impact post-anaerobic exercise, revealing reduced variability and parasympathetic inhibition. These advancements expand HRV's application in sports science, enhancing its precision and scientific rigor while addressing diverse training needs. Therefore, heart rate variability covers a wide range in the field of sports, and some popular directions are studied. As an evaluation method and research technology, it provides a broad platform for scholars who love sports and explore them.

Heart Rate Variability and Biofeedback

Heart rate variability (HRV) plays a crucial role in both physiology and psychology, benefiting athletes by enhancing performance. Integration of HRV with biofeedback training allows athletes to intuitively monitor their autonomic nervous system, optimizing performance. Studies, like Matsuura (2023), show that HRV-based breathing training reduces anxiety in gymnasts, improving performance. Tosti (2024) demonstrates HRV biofeedback's efficacy in enhancing sports skills, contrasting it with alpha/theta neurofeedback, which improves timing in sports. These findings underscore HRV biofeedback as a valuable addition to traditional sports psychology interventions, enhancing athletes' overall performance and training outcomes.

2. Methodology

Participatants

10 players from the Zhengzhou Shengda College of Economics and Management golf team (average age = 19.12 ± 0.97 years; players' golf training years = 1.36 ± 0.42 years). The 10 players received a 4-month psychological training intervention, which was divided into early, middle and late stages according to the time, as shown in Table (1). This study finally selected 9 valid data (6 male players, 3 female players, average age 19.68 ± 1.15 years, average height = 1.71 ± 0.07 meters, average height of men = 1.77 ± 0.04 meters, average height of women = 1.62 ± 0.46 meters). All participants were voluntary and had no mental illness or drug use.

Table 1: Experimental Intervention Time, Location, and Number of Participants

Times	Location	Number of athletes
April 23-May 26 (early stage)	Psychology Laboratory, Zhengzhou	10 people
May 27-June 15 (mid-stage)	Shengda College of Economics,	
June 16-July 26 (late stage)	Trade and Management	

Procedure

In this experimental intervention for collegiate golfers, the within-subject design involved 4 months of emWave biofeedback training. Due to scheduling reasons, they were divided into Group A and Group B, with each group receiving biofeedback training twice a week (each training session included: Bodhi tree, archery, and skilfulness). The study collected valid data from 9 participants and analyzed heart rate variability in the early, middle, and late training phases using time and frequency domain metrics. This structured approach was designed to assess physiological responses at different training intensities and improve understanding of the impact of biofeedback on performance.

Measurement

Heart rate variability (HRV) data in this study were collected using the emWave system, focusing on 4-time domain indicators (M-HRT, SDNN, RMSSD, PNN50) and 7 frequency domain indicators (TP, LF, HF, VLF, LF/HF, LFnorm, HFnorm), totalling 11 parameters. Valid data from 18 sessions per athlete were analyzed statistically. Sports performance data were gathered based on each athlete's scores over 18 rounds, aiming to correlate HRV metrics with golfing performance, where fewer strokes indicate better performance against a standard of 72 strokes per round.

Statistical Analysis

Data were analyzed using SPSS Statistics 22 (Chinese version), employing descriptive statistics and multiple comparison analysis to examine HRV changes among athletes across feedback and time groups, as well as their relationship with performance changes.

3. Differential Analysis of Heart Rate Variability

Differences in Time Domain Indicators among Variables of Each Group

Table 2 is a further LSD multiple mean comparison of time domain index scores of different items and at different times. The results show that there is no significant difference in RMS-SD among different training feedback items ($p > 0.05$); there are significant differences in SDNN, RMS-SD and PNN50 between the dexterity item and the Bodhi tree item and the archery item ($p < 0.05$, $p < 0.01$), among which there is a very significant difference in SDNN ($p < 0.01$). Combined with Table 4-1, it can be seen that the dexterity item is very significantly lower than the Bodhi tree and archery items in SDNN ($p < 0.01$); it is significantly lower than the Bodhi tree item in RMS-SD ($p < 0.05$), and very significantly lower than the archery item ($p < 0.01$); and it is significantly lower than the Bodhi tree and archery items in PNN50 ($p < 0.05$).

Table 2: LSD Multiple Comparisons of The Mean Values of Time Domain Indicators in Each Project Group

Dependent Variable	Project	Group	Mean Difference	Sig.
SDNN	1	2	-2.736	0.281
	1	3	15.162**	0
	2	3	16.716 **	0
RMS-SD	1	2	-1.782	0.734
	1	3	8.726*	0.015
	2	3	10.252**	0.003
PNN50	1	2	0.571	0.659
	1	3	4.879*	0.025
	2	3	4.541*	0.046

*Note: * $p < 0.05$, ** $p < 0.01$; 1--Bodhi tree; 2--archery; 3--skilfulness*

Differences in Frequency Domain Indicators Among the Variables of Each Group

Table 3 is a further LSD multiple mean comparison of frequency domain index scores of different projects and at different times. The results show that there are very significant differences between

the dexterity project and the Bodhi tree project and archery project in TP, LF, LF/HF, LFnorm, and HFnorm ($p<0.01$), and there is a significant difference between the dexterity project and the archery project in VLF ($p<0.05$). Combined with Tables 4-5, it can be seen that the dexterity project is significantly lower than the Bodhi tree and archery projects in frequency domain indicators TP, LF, LF/HF, and LFnorm ($p<0.01$), and is significantly higher than the other two groups in HFnorm ($p<0.01$), and significantly lower than the archery project in VLF ($p<0.05$).

Table3: LSD Multiple Comparisons of The Means of Frequency Domain Indicators in Each Item Group

Dependent Variable	Project	Group	Mean Difference	Sig.
TP	1	2	-34.356	0.731
	1	3	523.491**	0
	2	3	458.124**	0
VLF	1	2	-18.273	0.445
	1	3	38.560	0.061
	2	3	51.040*	0.01
LF	1	2	-19.738	0.879
	1	3	386.827**	0
	2	3	406.132**	0
LF/HF	1	2	5.102	0.328
	1	3	16.719**	0
	2	3	13.186*	0.003
LFnorm	1	2	-0.320	0.865
	1	3	12.136**	0
	2	3	10.427**	0
HFnorm	1	2	0.320	0.865
	1	3	-12.136**	0
	1	3	-10.427**	0

Note: * $p<0.05$, ** $p<0.01$; 1--Bodhi tree; 2--archery; 3--skilfulness

Test of Differences between Achievement Groups

Through the inter-group difference test of 18 sports performances, as shown in Table 4, the mean performance in the late group was significantly lower than that in the early group ($p<0.01$) and significantly lower than that in the middle group ($p<0.05$). According to the description, the sports performance showed a decreasing trend.

Table 4: Description and Difference Test Between Each Score Group

Grade Group	M±SD	Comparison group	Mean Difference	Sig.
Early stage	96.30±7.90	Mid-stage	0.89	0.08
		late stage	2.15**	0
Mid-stage	90.15±5.72	Early stage	-0.87	0.06
		late stage	1.35 *	0.02
late stage	84.69±5.28	Early stage	-2.39**	0
		Mid-stage	-1.21*	0.04

Note: * $p<0.05$, ** $p<0.01$.

4. Results and Discussion

This study revealed the positive effect of biofeedback training on athletes' performance by deeply analyzing the relationship between heart rate variability (HRV) indicators and sports performance at different training stages. The study found that although the mean performance of athletes in the later stage was significantly lower than that in the early and middle stages, the time domain indicators of HRV, such as SDNN, RMS-SD and PNN50, were significantly higher in the later stage than in the early and middle stages, indicating that the increase in heart rate variability was

negatively correlated with the decrease in sports performance. In addition, the frequency domain indicators TP and LF were also significantly higher in the later stage than in the early and middle stages, reflecting the enhanced activity of the sympathetic and parasympathetic nervous systems, but the LF/HF ratio did not show a significant difference, suggesting that a single indicator is not enough to fully evaluate the balance of the autonomic nervous system.

Although there are controversies in the physiological mechanisms of LF and HF indicators, the changes in the comprehensive LF/HF, LFnorm and HFnorm are consistent with the decrease in the mean performance, supporting the hypothesis that biofeedback training has a positive impact on athletes' sports performance by regulating HRV. Although the results of the study failed to fully confirm that biofeedback training can significantly improve athletic performance while improving HRV, long-term training does have a positive impact on the athletic performance of college golf athletes, which provides strong evidence for the future application of biofeedback technology in the field of sports training. However, the limitations of the study are the diversity of the sample and the accuracy of the measurement method, which needs to be further verified in future studies by expanding the sample range and adopting more accurate measurement techniques.

5. Implications and Direction for Future Research

Future research on heart rate variability (HRV) can expand its applications in assessing athletes' autonomic nervous system (ANS) responses across different exercises, training intensities, and individual differences. It should investigate long-term training effects on ANS function to optimize sports performance and reduce injury risks. Exploring the impact of psychological interventions like mindfulness and stress management on HRV, combined with physiological training, could enhance athletes' adaptability and recovery. This research provides coaches and athletes with a valuable tool for developing personalized training plans, despite limitations in sample size, diversity, and control over lifestyle factors. Overcoming these limitations through larger samples, rigorous variable control, and improved measurement methods will strengthen future research validity and applicability.

Acknowledgment

We thank the participating athletes for their enthusiastic dedication and the experts for their invaluable advice and support, crucial to the study's success and depth.

References

- Millington, B., & Wilson, B. (2016). *The Greening of Golf: Sport, Globalization and the Environment* (p. 288). Manchester University Press.
- Millard, D. (2023). *How Golf Can Save Your Life*. Abrams.
- Skelton, L. (2023). A Black Golfer's Career Comes Full Circle: The Resiliency of Lee Elder. *Spectrum: A Journal on Black Men*, 10(2), 3-26.
- Shenk, J. W. (2014). *Powers of Two: Finding the Essence of Innovation in Creative Pairs*. Houghton Mifflin Harcourt.
- Beauchamp, M. K., Harvey, R. H., & Beauchamp, P. H. (2012). An Integrated Biofeedback and Psychological Skills Training Program for Canada's Olympic Short-track Speedskating Team. *Journal of Clinical Sport Psychology*, 6(1), 67-84.
- Schack, T., Hagan Jr, J. E., & Essig, K. (2020). New Technologies in Sport Psychology Practice. *In The Routledge International Encyclopedia of Sport and Exercise Psychology* (pp. 458-471). Routledge.
- Bourdon, P. C., Cardinale, M., Murray, A., Gastin, P., Kellmann, M., Varley, M. C., & Cable, N. T. (2017). Monitoring Athlete Training Loads: Consensus Statement. *International Journal of Sports Physiology and Performance*, 12(s2), S2-161.

- Siekańska, M., Bondár, R. Z., di Fronso, S., Blecharz, J., & Bertollo, M. (2021). *Integrating Technology in Psychological Skills Training for Performance Optimization in Elite Athletes: A Systematic Review*. *Psychology of Sport and Exercise*, 57, 102008.
- Stephenson, M. D., Thompson, A. G., Merrigan, J. J., Stone, J. D., & Hagen, J. A. (2021). Applying Heart Rate Variability to Monitor Health and Performance in Tactical Personnel: A Narrative Review. *International Journal of Environmental Research and Public Health*, 18(15), 8143.
- Singh, N., Moneghetti, K. J., Christle, J. W., Hadley, D., Froelicher, V., & Plews, D. (2018). Heart Rate Variability: An Old Metric with New Meaning in the Era of using Mhealth Technologies for Health and Exercise Training Guidance. *Part Two: Prognosis and Training*. *Arrhythmia & Electrophysiology Review*, 7(4), 247.
- Matsuura, Y., & Ochi, G. (2023). The Potential of Heart Rate Variability Monitoring for Mental Health Assessment in Top Wheel Gymnastics Athletes: A Single Case Design. *Applied Psychophysiology and Biofeedback*, 48(3), 335-343.
- Tosti, B., Corrado, S., Mancone, S., Di Libero, T., Rodio, A., Andrade, A., & Diotaiuti, P. (2024). Integrated Use of Biofeedback and Neurofeedback Techniques in Treating Pathological Conditions and Improving Performance: A Narrative Review. *Frontiers in Neuroscience*, 18, 1358481

Levels of Student Involvement in Green Programs and Their Impact on Environmental Stewardship Attitudes

Zainatun Nisa Sapaat¹ & Halizah Alwi²

¹Commerce Department, Politeknik Muadzam Shah, Pahang, 26700, Malaysia

²Commerce Department, Politeknik Merlimau, Melaka, 77300, Malaysia

¹zainatun.nisa@pms.edu.my & ²halizah@pmm.edu.my

Abstract

Environmental harm issues have recently received a lot of attention in the media and study. Many green programs have been implemented to enhance student understanding, either by higher education institutions or industry, functioning as indirect initiatives to raise awareness of green technologies and environmental problems. As a result, researchers determined that it was critical to undertake a study to examine the amount of involvement in green programs and to determine the influence of student participation in green programs on environmental attitudes. The participants in this study were students from Politeknik Muadzam Shah. A total of 121 respondents from the Department of Commerce completed a set of questionnaires provided online. A questionnaire was employed as the data collection tool. This study is a quantitative study. Descriptive analysis was the analysis technique employed, and SPSS v.26 software was used. The results of this research show that student involvement in green programs is moderate. Nonetheless, respondents agreed that green programs favourably influence their views about environmental care. Therefore, this study concludes that green initiatives should be offered with more engaging activities to increase students' participation.

Keywords: Student Involvement, Green Programs, Environment.

1. Introduction

Several studies have found that university students participate in environmental conservation programs. Ivanović & Mirčetić (2020) found that students have diverse views and understanding regarding environmental protection. Green education programs in colleges and universities aim to cultivate students' cognitive attitudes about the environment (Buissink-Smith et al., 2011). These cognitive attitudes have a direct impact on how people live their lives. Over time, there have been continual initiatives to improve ecological education in higher education institutions, with the goal of instilling correct ecological ethics and morals in college students. Existing research largely acknowledges the impact of green education in higher education institutions on college students' cognitive attitudes (RE Cotton & Alcock, 2013). McMillan et al. (2004) found that students' environmental values increased significantly after taking an environmental conservation course, leading to improved cognitive attitudes.

This provision identifies a critical role that home education plays in assisting students in developing their worldview, ethics, and values, which can improve their motivation and availability to participate in home education as individuals and groups (Zheng et al., 2018). Based on the positive feedback received, each institution must determine the effectiveness of the curriculum that they offer to students. This is because it is important for institutions to improve the quality of learning about the environment, in which the two parties, students and institutions, must work together to achieve higher levels of environmental awareness and stewardship.

2. Objective of the Study

This study was conducted to:

- a) Assess the level of participation of Politeknik Muadzam Shah students in green programs
- b) Identify the impact of Politeknik Muadzam Shah students' involvement in green programs on their environmental attitudes.

3. Literature Review

In general, environmental challenges in Malaysia have been a source of concern and alarm (Bakar et al., 2020). Litter on the streets and polluted rivers are common problems in major cities around the country (Ismail & Musa, 2020). To address the mounting concerns of environmental degradation, the public must be educated and informed about these issues. Environmental or green programs are one way for society and the government to work together to safeguard the earth from pollution and destruction. Environmental education, such as green technology awareness initiatives, is critical to provide the public, particularly kids, with the knowledge, skills, values, and caring attitudes required to actively participate in environmental problem resolution. According to Nor Farahin and Arasinah (2019), green technology can be viewed as a tool for reducing environmental deterioration and creating a healthy environment.

Green technology initiatives are essential because they may be used in schools to instill in kids a desire to appreciate the environment. According to a study conducted by Siti Intan et al. (2023), the public's willingness to embrace greener practices in their daily life is demonstrated by their behavioural intentions following green initiative events. Those who are more concerned, more informed by the media, and have a good attitude toward green programs are more likely to adopt green practices in their daily life. Roy's (2023) study illustrates how green initiatives in educational institutions influence students' environmental behaviour. Furthermore, to improve environmental well-being, higher education institutions (HEIs) can play an important role in educating students and instilling a feeling of responsibility in them. According to Hassan et al. (2019), university students are the future of society. They can contribute to a green economy, usher in a new era of sustainability, and advance green goals (Chowdhury & Alamgir, 2021; Ogiemwonyi, 2022).

4. Methodology

This quantitative research study was undertaken at Politeknik Muadzam Shah in Pahang, Malaysia. A total of 121 students filled out an online questionnaire. According to Memon et al. (2020), a sample size of 50 to 100 is enough for routine study analysis. Table 1 shows the background of the respondents. The Department of Commerce's students were sampled at random. The collected data were statistically examined using descriptive statistics to determine mean score values. The mean values were interpreted as follows, as used in Ngadiman et al.'s (2019) study: 1.00-1.99 (weak), 2.00-2.99 (low), 3.00-3.99 (moderate), and 4.00-5.00 (high).

5. Finding and Analysis

Background of Respondents

Table 1 indicates the respondents' backgrounds. The majority of students are female (66.9%), with male students accounting for 33.1%. In terms of semesters, the majority of students (52.1%) are in the second semester, followed by the fifth (18.2%), and sixth (9.9%). Academic performance shows that 33.1% of students have a GPA between 2.00 and 2.99, and 30.6% have a GPA between 3.00 and 3.33. In terms of parental income, 76.9% of students come from families earning RM4360 or less, showing that many students come from lower socioeconomic origins classified as B40.

Table 1: Respondent background

	Item	n	%
Gender	Man	40	33.1
	Women	81	66.9
Semester	1.00	9	7.4
	2.00	63	52.1
	3.00	8	6.6
	4.00	7	5.8
	5.00	22	18.2
	6.00	12	9.9
CGPA	2.00 - 2.99	40	33.1
	3.00 - 3.33	37	30.6
	3.43 - 3.67	26	21.5
	3.68 - 4.00	9	7.4
	Semester 1 (No CGPA yet)	9	7.4
Student residence	Urban	65	53.7
	Rural	34	28.1
	Suburban	21	17.4
	Remote	1	0.8
Household income	RM4360 and below	93	76.9
	RM4360 - RM9619	19	15.7
	RM9619 and above	9	7.4

The Level of Student Participation in Green Programs

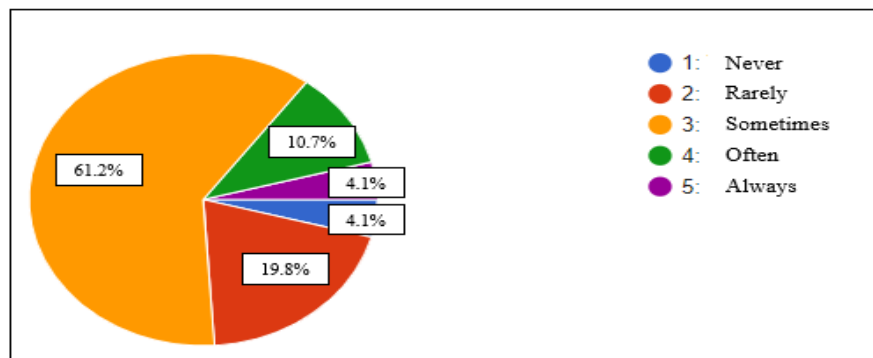


Figure 1: Frequency of Students Participating in Green Programs

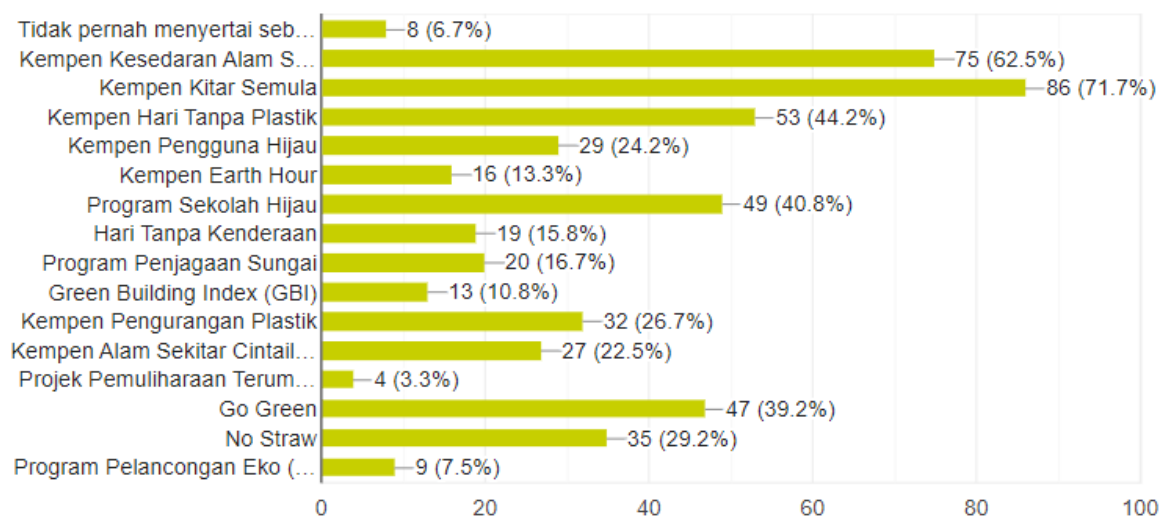


Figure 2: Forms of Participation in Green Programs

Figure 1 depicts the amount of student involvement in green programs, revealing that the vast majority of students (61.2%) participated in these programs on occasion. A tiny proportion of students are involved frequently (10.7%) and always (4.1%), whereas 19.8% are rarely involved. Only 4.1% of students stated that they have never participated in green programs. Meanwhile, Figure 2 depicts the many activities that students participated in. The Recycling Campaign received the most participation (71.7%), followed by the Environmental Awareness Campaign (62.5%) and the No Plastic Day Campaign (44.2%). This data shows that, while there is a moderate level of interest in green program initiatives, there is still opportunity for students to participate more consistently and completely through various green programs.

Students' Attitudes toward Environmental Care

Table 2: Students' Attitudes Towards Environmental Care Following Participation in Green Programs

	Item	Mean	S. D
1.	Participation in green programs has increased my awareness of the importance of caring for the environment	4.248 ³	0.799
2.	I am now more enthusiastic about caring for the environment after participating in green programs	4.207	0.836
3.	I more frequently engage in eco-friendly activities such as recycling, energy saving, and using eco-friendly products after participating in green programs	4.174	0.771
4.	I feel that I can make a positive impact on the environment through individual actions	4.248	0.710
5.	Green programs on my campus provide adequate education on environmental care	4.289 ¹	0.724
6.	I am more inclined to participate in environmental volunteer activities after joining green programs	4.182	0.796
7.	I am more aware of environmental issues such as climate change and pollution after participating in green programs	4.157	0.837
8.	I am willing to encourage others to join green programs and adopt eco-friendly lifestyles	4.215	0.858
9.	Participating in green programs helps foster a positive attitude towards environmental care among my friends	4.289 ²	0.779
10.	I feel that I have experienced a positive change in attitude or behaviour towards the environment after participating in green programs	4.248	0.778

Note: 1 Highest Mean; 2 Second Highest Mean; 3 Third Highest Mean

Table 2 depicts students' attitudes regarding environmental concern following participation in green activities. Overall, students showed a pro-environmental stance. These data show that the program is extremely effective in educating and raising awareness about environmental care. Item 5 (4.289) had the highest mean score, indicating that students believe green programs on campus provide enough environmental education. They also think that engaging in green activities encourages their peers to have a favourable attitude toward environmental care, with the same high score of 4.289 in item 9. The third highest score indicates that students feel that participation in green initiatives has raised their individual knowledge of the necessity of caring for the environment, with an average score of 4.248 in item 1. These data demonstrate that green programs on campus have successfully fulfilled their goals of educating and boosting student awareness about environmental issues.

6. Conclusion

Higher education institutions should continue to progress diverse environmental sustainability efforts in accordance with the Sustainable Development Goals (SDG) 2030 and the 13th Malaysia Plan (RMK-13). Strategic connections with a variety of industry partners and other institutions, both domestically and internationally, can generate green programs that encourage greater student participation. Students' interests in green programs on campus can be defined as moderate.

However, the vast majority of students believe that green programs can positively influence their attitudes regarding environmental stewardship. As a result, it is possible to conclude that green programs should include more engaging activities in order to increase student involvement.

Consistently promoting these activities on multiple social media channels that students may easily access is a positive step toward increasing student involvement. This has the potential to transform students' attitudes of the need of environmental preservation in a straightforward, effective, and relatable manner. Educational institutions can also plan activities that incorporate social media influencers in green programs to increase student participation. Furthermore, volunteer environmental activities should be designed in partnership with educational institutions, students, and community people in order to create an interconnected and conscious generation about the relationship between society and the environment.

Acknowledgment

We would like to thank everyone who contributed to making this study a success by being personally involved and demonstrating exceptional teamwork. We would also like to express our gratitude to all of the lecturers and students at Politeknik Muadzam Shah, Pahang's Department of Commerce, for their substantial and intangible contributions to making this study feasible.

References

- Bakar, M. A. A., Rahim, A. A., & Nasir, M. I. M. (2020). *Pengetahuan terhadap Perkhidmatan Ekosistem dan Sumbangannya kepada Kehidupan Komuniti di Kuala Sepetang, Perak* (Knowledge and Contributions of Ecosystem Services to Community Livelihood at Kuala Sepetang, Perak). *Geografia*, 16(1).
- Buissink-Smith, N., Mann, S., & Shephard, K. (2011). How do We Measure Affective Learning in Higher Education? *Journal of Education for Sustainable Development*, 5(1), 101-114.
- Chowdhury, I., & Alamgir, M. (2021). Factors Influencing Green Product Purchase Intention among Young Consumers in Bangladesh. *Society & Sustainability*, 3(2).
- Hassan, M., Jambulingam, M., Alam, M. N., & Islam, S. (2019). Redesigning the Retention Strategy against the emerging turnover of Generation Y: Revisiting the long-standing problems from 20Th to 21St century. *International Journal of Entrepreneurship*, 23(2), 1-16.
- Ismail, M. L., & Musa, S. M. S. (2020). Study on the implementation of drainage system at Universiti Tun Hussein Onn Malaysia (UTHM): Kajian Perlaksanaan Sistem Saliran di Universiti Tun Hussein Onn Malaysia (UTHM). *Journal of Techno-Social*, 12(2), 12-20.
- Ivanović, T., & Mirčetić, V. (2020). Exploring students' attitudes towards green behaviour. *Thematic Proceedings of the MEFkon 2020*, 1-18.
- McMillan, E. E., Wright, T., & Beazley, K. (2004). Impact of a University-level Environmental Studies Class on Students' Values. *The Journal of Environmental Education*, 35(3), 19-27.
- Memon, M. A., Ting, H., Cheah, J. H., Thurasamy, R., Chuah, F., & Cham, T. H. (2020). Sample Size for Survey Research: Review and Recommendations. *Journal of Applied Structural Equation Modeling*, 4(2), 1-20.
- Ngadiman, D. W. T., Yacoob, S. E., & Wahid, H. (2019). Tahap Harga Diri Kumpulan Berpendapatan Rendah yang Berhutang dan Peranan Organisasi dalam Sektor Perladangan. *Melayu: Jurnal Antarabangsa Dunia Melayu*, 12(2), 238-254.
- Nor Farahin Jasmi & Arasinah Kamis. (2019). Importance of Green Technology, Education for Sustainable Development (ESD) and Environmental Education for Students and Society. *Journal of Engineering Research and Application*. ISSN: 2248-9622 Vol. 9, Issue 2 (Series -I) Feb 2019, pp 56-59

- Ogiemwonyi, O. (2022). Factors Influencing Generation Y Green Behaviour on Green Products in Nigeria: An Application of Theory of Planned Behaviour. *Environmental and Sustainability Indicators*, 13, 100164.
- RE Cotton, D., & Alcock, I. (2013). Commitment to Environmental Sustainability in the UK Student Population. *Studies in Higher Education*, 38(10), 1457-1471.
- Roy, S. K. (2023). Green University Initiatives and Undergraduates' Reuse Intention for Environmental Sustainability: The Moderating Role of Environmental Values. *Environmental Challenges*, 13, 100797.
- Siti Intan Nurdiana Wong Abdullah, Sriganeshvarun, Fong Kean Tat, Thanam Subramaniam & Abdul Aziz Mohd Mustafa. (2023). Going Green: The Impact of Green Initiative Events on Environmental Practice Intentions. *Journal of Sustainability Science and Management* Volume 18 Number 8, August 2023: 1-23
- Zheng, Q. J., Xu, A. X., Kong, D. Y., Deng, H. P., & Lin, Q. Q. (2018). Correlation between the Environmental Knowledge, Environmental Attitude, and Behavioral Intention of Tourists for Ecotourism in China. *Applied Ecology & Environmental Research*, 16(1).

Islamic Digital Marketing Template for Asnaf in Perlis

Izwan Nurli Mat Bistaman^{1*}, Muhammad Nurfiqri Mohd Hajar² & Razinda Tasnim Abdul Rahim³

^{1,2,3}Faculty of Business and Management Sciences, Kolej Universiti Islam Perlis, Perlis, Malaysia

¹*razindatasnim@kuips.edu.my

Abstract

The rise of social media marketing has transformed how businesses connect with their audiences, play as medium of engagement, inform, and build relationships with consumers. However, the basic marketing mix elements of the 4Ps—Product, Price, Place, and Promotion can be applied in social media marketing to form new strategy in marketing which is known as digital marketing. In addition, integrating Islamic value in digital marketing is one of the initiatives to support the economy of Perlis, particularly for the asnaf. Product strategies should focus on providing halal and tayyib products that meet the specific needs of the asnaf, ensuring ethical and wholesome offerings. Price strategies must emphasize fairness and justice, incorporating Islamic principles like Zakat to make essential goods affordable for the underprivileged. Places involved in creating distribution channels should ensure accessibility for the muslim community and leverage local mosques and community centers to reach rural and marginalized areas. Promotion should adhere to ethical marketing practices, promoting honesty and integrity, and utilizing community outreach to build trust and awareness. Thus, this innovation contributes in developing an Islamic digital marketing template in order to assist asnaf in their business activities. This innovation proves in promoting Visit Perlis 2024. The template is ready through hardcopy and softcopy which act as reference and copy editing. This template benefited asnaf by increasing their knowledge, give awareness about the digitalization phase, and drive them to use Islamic digital marketing. Besides, this template has potential to be commercialized to infant entrepreneurs, micro businesses, and youth entrepreneurs.

Keywords: Digital, Islamic Marketing, *Asnaf*

1. Introduction

Digital technologies have enabled marketers to personalize their messaging and offerings based on consumer preferences and behaviors. This level of customization can lead to higher engagement and conversion rates. The abundance of data available through digital channels allows marketers to analyze consumer insights and trends to make informed decisions about their marketing strategies. This data-driven approach can lead to more effective and targeted campaigns. An article by Chaffey and Ellis-Chadwick (2021) discusses the impact of artificial intelligence (AI) and machine learning on marketing personalization. The authors highlight how AI-powered tools can analyze vast amounts of data to create personalized marketing campaigns that resonate with individual consumers. This level of personalization can lead to higher engagement and conversion rates, ultimately driving business growth.

With the proliferation of digital channels such as social media, email, and mobile apps, marketers are increasingly adopting an omni-channel approach to reach consumers across multiple touchpoints. This integrated strategy helps create a seamless and consistent brand experience. Another study by Li et al. (2024) examines the role of social media in shaping consumer preferences and purchasing decisions. The researchers found that social media platforms have become essential channels for brands to engage with their target audience, build relationships, and

drive sales. By leveraging social media effectively, marketers can amplify their reach and influence consumer behaviour in the digital age.

Social media influencers continue to play a significant role in digital marketing, with brands partnering with influencers to promote their products and services to a broader audience. Influencer marketing can help brands reach new demographics and build credibility with consumers. Additionally, a recent article by Smith and Taylor (2022) explores the rise of influencer marketing in the digital era. The authors discuss how brands are partnering with social media influencers to promote their products and services to a wider audience. Influencer marketing has become a powerful tool for reaching and engaging with consumers in an authentic and relatable way, driving brand awareness and loyalty.

Overall, these recent articles and studies highlight the continued impact of digitalization on marketing practices, emphasizing the importance of leveraging digital technologies and platforms to connect with consumers, drive engagement, and achieve business objectives in the ever-evolving digital landscape.

Economy of Asnaf

The term "asnaf" in Islamic finance refers to the eight categories of people who are eligible to receive zakat, a form of charitable giving that is one of the five pillars of Islam. According to the Quran and Islamic law, the asnaf encompass a wide range of individuals in need of financial and social assistance, including the impoverished, the destitute, those responsible for administering zakat funds and others. Marketing can raise awareness about the products and services offered by asnafpreneurs, helping them reach a wider audience and increase sales (Ali et al., 2021). Marketing strategies can help Asnafpreneurs gain access to local and global markets, thereby expanding their customer base and increasing their income (Hassan et al., 2022). Consider investing in targeted advertising campaigns through digital channels such as Google Ads, Facebook Ads, or influencer marketing to reach a specific audience interested in Asnaf's products. This can help increase brand awareness and drive traffic to the website or retail locations.

2. Problem Statement

The global Muslim population is significant and growing, presenting a substantial market for businesses. According to the Pew Research Center, the Muslim population is expected to grow by 70% from 2015 to 2060, making it one of the fastest-growing religious groups. This demographic shift has led to an increasing demand for products and services that are halal (permissible) and tayyib (wholesome).

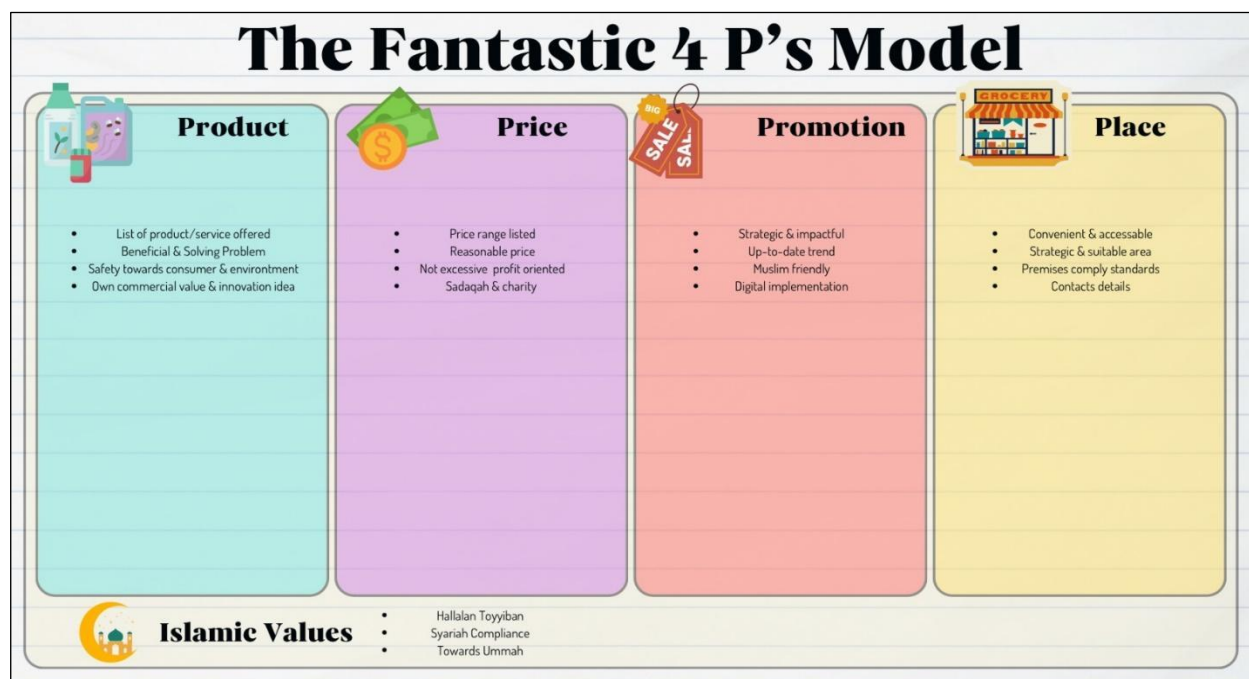
Products and services marketed must be halal and tayyib, ensuring they are permissible and wholesome according to Islamic law. Marketing strategies should be transparent, honest, and free from deception. Businesses should engage in practices that benefit society, such as charitable activities and sustainable practices and adhering to the various interpretations of Islamic law across different regions. This approach not only targets the Muslim consumer market but also adheres to the guidelines derived from Islamic teachings, including principles of fairness, honesty, and social responsibility. Websites and apps that offer halal products and services, ensuring compliance with Islamic guidelines (Hassan et al., 2022). Collaborating with Muslim influencers who can authentically promote halal products to their followers (Saleh & Rahman 2023) is the most effective strategy. Building strong brand loyalty by aligning with the values and beliefs of Muslim consumers.

Hence, Islamic digital marketing is a specialized branch of digital marketing that aligns with the principles and values of Islam. It involves the use of digital platforms and tools to promote products and services in a manner that is compliant with Islamic ethical standards. Platforms like Facebook, Instagram, and Twitter are used to engage with Muslim audiences, share halal content, and promote ethical products (Rahman et al., 2021). Blogs, videos, and articles that provide valuable information about halal lifestyles, products, and services (Ahmad & Haron, 2022) need to be used in term of promotions. Ensuring that marketing messages are culturally and religiously appropriate.

3. Template of Islamic Digital Marketing

The template of Islamic digital marketing was created based on the marketing mix, often referred to as the 4Ps. The model consists of four key elements that a company uses to promote its brand or product in the market. Firstly, the element was product. Product means that the goods or services offered by a business to meet the needs and desires of customers. Quality, design, features, branding, packaging, and after-sales service.

The product should fulfill a specific demand or need of the target market. Secondly, the element was price. Price emphasized the amount of money customers must pay to acquire the product. Pricing strategy, cost of production, perceived value, competitor pricing, discounts, and payment terms. Pricing decisions affect the perceived value of the product and can influence demand and sales volume. Thirdly, the element was place. Place was also known as distribution or location. The methods and locations used to make the product available to customers. Distribution channels, market coverage, inventory management, logistics, and retail locations. Effective distribution ensures that the product is available at the right place and time for the target market. Fourthly, the element was promotion. Promotion indicated activities and strategies used to raise awareness of the product and persuade customers to purchase it. Advertising, sales promotions, public relations, personal selling, and digital marketing. Promotion helps to communicate the benefits of the product, create brand awareness, and drive sales. Then, the Islamic values were embedded to the 4Ps elements as guidelines for the asnafpreneurs. The template was built and showed as follow:



The template brought its own novelty which was the embedded values of Islamic towards the 4Ps elements. In addition, the template expected to assist asnafpreneurs and other users to make a copywriting for their digital marketing through social media platform. Asnafpreneurs was given a training in a workshop about the digital marketing. Parallely, the asnafprenerus become our unit analysis for this research innovation.

4. Implications to Asnafpreneur

Here are some copywriting of the respondents which are the asnafpreneurs that applied the Fantastic 4P's Model:

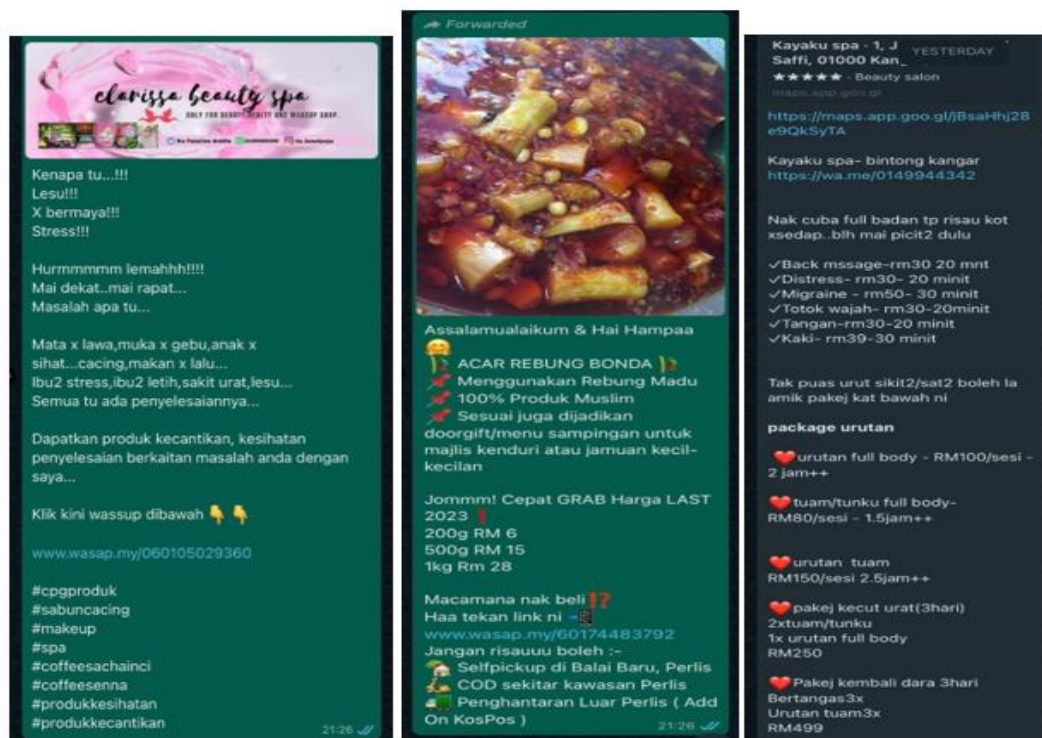


Figure 2: Outcome of Asnafpreneur Copywriting

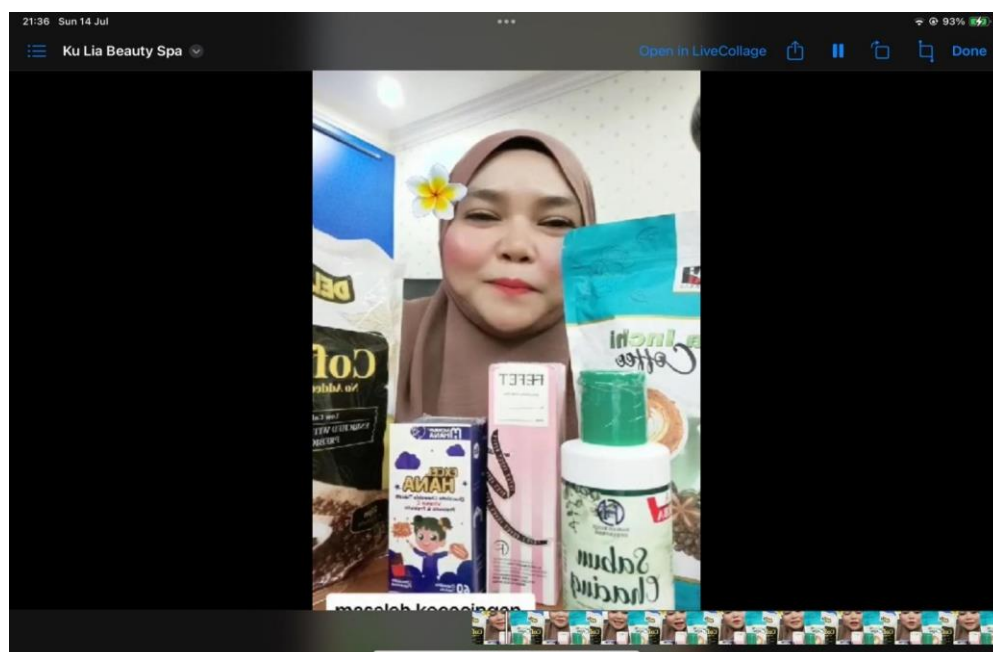


Figure 3(a): Outcome of Asnafpreneur Video Marketing

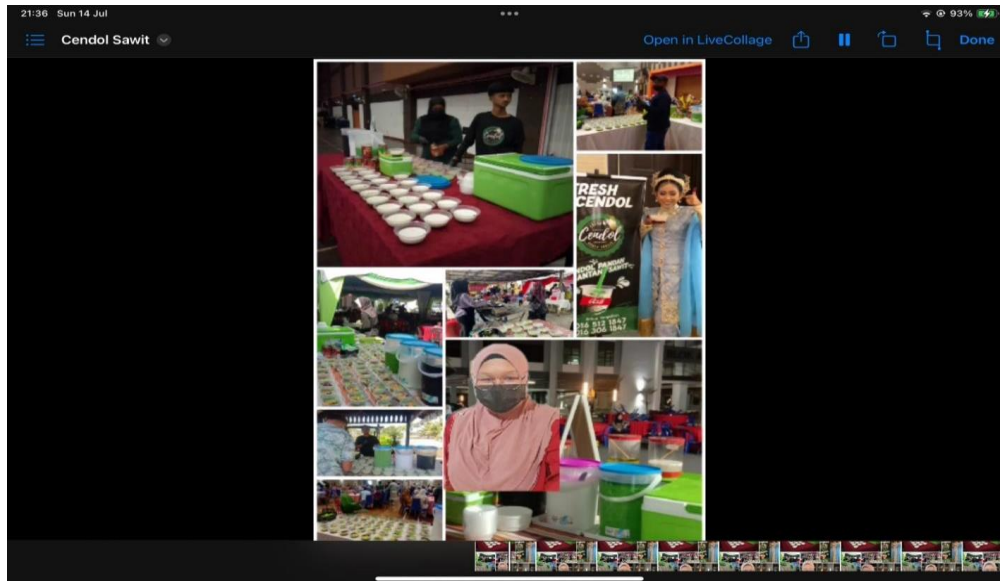


Figure 3(b): Outcome of Asnafpreneur Video Marketing

5. Discussion and Conclusion

In conclusion, this research innovation exposed the impacts of the Islamic digital marketing towards this asnafpreneurs as our first run and pilot test. Thus, we planned to continue this innovation template and measure the effectiveness towards the users.

Acknowledgment

This research study was supported by a Short-Term Grant STG 086 provided by Majlis Agama Islam Perlis and awarded to Kolej Universiti Islam Perlis. We want to record our deepest appreciation and sincere thanks for the grant awarded to us.

References

- Ahmad, N., & Haron, M. S. (2023). Branding Strategies for Asnaf Entrepreneurs: A Case Study in Malaysia. *Journal of Islamic Marketing*, 14(1), 67-82. <https://doi.org/10.1108/JIMA-11-2022-0154>
- Ali, S. M., & Rahman, M. S. (2021). The Role of Marketing in Enhancing the Economic Conditions of Asnaf Entrepreneurs. *Journal of Islamic Marketing*, 12(1), 45-60. <https://doi.org/10.1108/JIMA-04-2020-0098>
- Chaffey, D., & Ellis-Chadwick, F. (2021). *Digital Marketing: Strategy, Implementation and Practice*. Pearson UK.
- Hassan, R., & Noor, N. A. M. (2022). Market Access and the Economic Empowerment of Asnaf Entrepreneurs: Insights from Malaysia. *Journal of Islamic Marketing*, 13(2), 234-247. <https://doi.org/10.1108/JIMA-09-2021-0176>
- Li, Y., & Zhang, L. (2024). The Role of Digitalization in Shaping Consumer Behavior. *Journal of Consumer Research*, 41(4), 567-589.
- Rahman, A. A., & Abdullah, M. S. (2021). Social Media Marketing for Asnaf Entrepreneurs: A Case Study in Malaysia. *Journal of Islamic Marketing*, 12(2), 123-139. <https://doi.org/10.1108/JIMA-12-2020-0130>
- Salleh, M. C. M., & Rahman, M. S. (2023). Digital Marketing Adoption among Asnaf Entrepreneurs: Opportunities and Challenges. *Journal of Islamic Marketing*, 14(2), 123-139. <https://doi.org/10.1108/JIMA-05-2022-0104>

LOGISTICS AND SUPPLY CHAIN MANAGEMENT

**"HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY"**

The Influence of Organizational Ambidexterity, Business Strategies, and Supplier Performance on Customer Satisfaction, and Its Implications on Logistics Performance at Bandung Main Branch Office of PosIND

Yogi Sudrajat^{1*} & Saptono Kusdanu Waskito¹

¹Department of Logistics Management, Faculty of Logistics, Technology and Business,
 Universitas Logistik dan Bisnis Internasional, Bandung, Indonesia

^{1*}aogieyogi@gmail.com & ¹Saptono@ulbi.ac.id

Abstract

This research aims to determine the influence of organizational ambidexterity, business strategies, and supplier performance on logistics customer satisfaction at Bandung Main Branch Office of PosIND and the influence of customer satisfaction on logistics performance at Bandung Main Branch Office of PosIND. The total population is 440 customers. The number of respondents was 210 customers determined using the Slovin method. The research results prove that there is a positive and insignificant influence of organizational ambidexterity on customer satisfaction. Business strategies influence customer satisfaction positively and significantly. Supplier performance influences customer satisfaction positively and not significantly. Organizational ambidexterity, business strategies, and supplier performance influence customer satisfaction positively and significantly. Customer satisfaction affects performance positively and significantly. Based on the results of the research that has been carried out, what should be improved is exploiting the strengths possessed by Bandung Main Branch Office of PosIND and exploring opportunities that exist outside Bandung Main Branch Office of PosIND. PosIND has succeeded in proving that the business strategies implemented influenced customer satisfaction. Currently, PosIND is also implementing a digital transformation strategy and establishing green logistics. It would be good if there were other researchers who conducted research related to PosIND's business strategies in the form of Digital Transformation and Green Logistics.

Keywords: Organizational Ambidexterity, Business Strategies, Supplier Performance, Customer Satisfaction, Logistics Company Performance

1. Introduction

Bandung Main Branch Office of PosIND special logistics has a revenue of IDR 2,307,995,436 or 45.17% of the specified target. The realization of logistics revenue which was only 45.17% of the target proves that there is a problem in the form of logistics revenue performance at Bandung Main Branch Office. Moeheriono (2020) explained that company revenue is an indicator of company performance. The authors in this study determine that company performance as the dependent variable to be studied. Moeheriono (2020) explained that company performance is the result of a company's work at a time that is in accordance with the organization's goals. Moeheriono (2020) explained that company performance indicators consist of financial performance indicators, marketing performance indicators, operational performance indicators.

Obafemi (2023), Ndubusi (2019), Harzaviona (2020), Hasan (2022), Rauf (2023) explained that customer satisfaction influences company performance positively and significantly. Yamit (2020) explained that customer satisfaction is the condition (feeling) of customers who are happy because the realization of a company's service is greater than the customer's expectations. Yamit (2020) explained that customer satisfaction indicators consist of satisfaction with reliability, satisfaction with responsiveness, satisfaction with guarantees. Wirtz (2019), Khattak (2021),

Rohmah (2022), Clauss (2021), and Prasetyo (2022) explained that organizational ambidexterity influences customer satisfaction. Company activities to change and add types of services to suit customer needs are referred to as organizational ambidexterity (Petro, 2019). The authors conduct research on organizational ambidexterity. Rintala (2022) explained that organizational ambidexterity is the ability of logistics companies to exploit the company's competencies. There is a time to explore new opportunities that exist in society to satisfy customers and achieve company goals. Indicators of organizational ambidexterity consist of exploitation and exploration. (Rintala, 2022).

Jordaan (2022), Segoro (2020), Lyima (2022), Putri (2023), Anggraini (2023), Santos (2024) explained that business strategies influence customer satisfaction. Bandung Main Branch Office of PosIND has implemented business strategies in the form of cost leadership, differentiation and focus strategies. Referring to the opinions of researchers, it is suspected that there is a problem with the business strategies used by Bandung Main Branch Office. Paying attention to the opinions of experts and the existence of problems in the field of business strategies, the authors conduct research using the subject of business strategies as an independent variable. According to Yordaan (2019), business strategies are company activities to improve the competitiveness of the products/services sold in order to win competition in the market where the products/services are sold. Yordaan (2019) explained that business strategy indicators consist of cost leadership, differentiation, and focus on customers, focus on profit.

According to Simamora (2022), Ojoajogu (2021), Ahistasari (2023), Sowmya (2024), and Di Fan (2021), supplier performance influences customer satisfaction. The authors examined supplier performance. According to Noviani (2021), supplier performance is the result of the supplier's work at the specified time, (one trip, one day, one month) that matches the buyer's expectations. Noviani (2021) explained that supplier performance indicators consist of quality, flexibility and responsiveness. Paying attention to the problems faced by Bandung Main Branch Office and the opinions of the article writers, the author conducted research with the title "*The Influence of Organizational Ambidexterity, Business Strategies and Supplier Performance on Customer Satisfaction, and the Implications for Logistics Company Performance at Bandung Main Branch Office of PosIND*".

The state of the art that differentiates the researchers from the articles written above are:

1. The performance of the company studied was the performance of logistics companies at Bandung Main Branch Office of PosIND using logistics company performance indicators proposed by Moehariono (2020) where these indicators have never been studied simultaneously, but have been studied only partially (one indicator only).
2. The customer satisfaction studied used the customer satisfaction variable indicators proposed by Yamit (2020) where these indicators have never been studied simultaneously, but have only been studied partially (one indicator only).
3. Until now, there has been no research on indicators of the organizational ambidexterity variable at Bandung Main Branch Office of PosIND simultaneously, but only indicators of exploitation and exploration indicators have been studied.
4. Until now, there has been no research that has examined the indicators of business strategies carried out by Bandung Main Branch Office of PosIND simultaneously, but only partially.

2. Research and Result

2.1 Research Methods.

This is a quantitative, descriptive, and verification research. This research uses quantitative, descriptive and analytical methods. According to Sugiyono (2021), quantitative research methods are research methods to examine the behavior of a population or sample (part of the population). The authors conducted the research using descriptive methods. According to Nuryaman (2021), descriptive research is research that has the aim of obtaining a description or description of certain characteristics of the variables being studied. The authors conducted the research using the verification method. According to Siregar (2023), verification research is research used to test the truth of knowledge in an existing field. Verification research is used to prove experts' opinions about the influence of independent variables on intervening variables and the influence of intervening variables on dependent variables. In addition, verification research is also used to prove the positive and significant influence of organizational ambidexterities on customer satisfaction, business strategies on customer satisfaction, supplier performance on customer satisfaction, organizational ambidexterities, business strategies, and supplier performance on customer satisfaction simultaneously, and customer satisfaction on logistics company performance at Bandung Main Branch Office.

2.1.1. Research Model.

The research model in this study is presented in Figure 2.1.

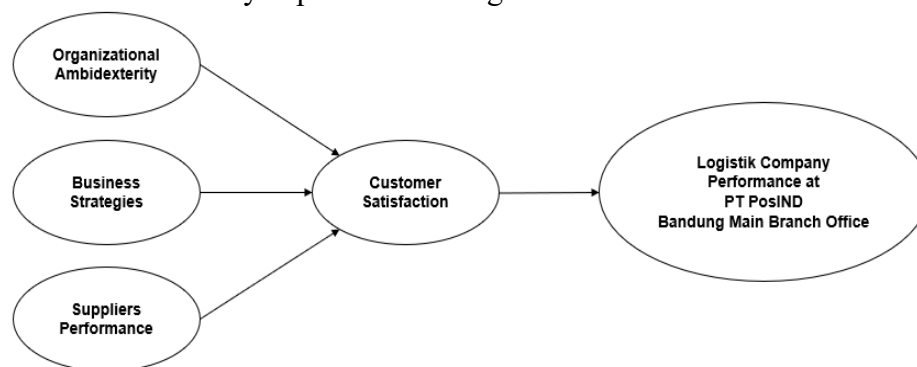


Figure 2.1. Research Models.

The total population is 440 customers. The number of samples was determined using the Slovin formula at 210 people.

2.1.2. Hypothesis:

The authors set the following hypotheses:

No Hypotheses

1. H1 : There is a positive and significant influence of organizational ambidexterity on customer satisfaction.
2. H2 : There is a positive and significant influence of business strategies on customer satisfaction.
3. H3 : There is a positive and significant influence on supplier performance on customer satisfaction.
4. H4 : There is a positive and significant influence of organizational ambidexterity, business strategies, supplier performance on customer satisfaction simultaneously.

5. H5 : There is a positive and significant influence of customer satisfaction on the performance of logistics companies at Bandung Main Branch Office of PosIND.

2.2. Results

The research results showed that the average value of each indicator was between 3.062 to 3.333 and was grouped as a fairly good variable. Because it has a fairly good value, and refers to the opinion of Waskito (2024) which states that variables that are worth researching are variables that have an average value from 1,000 to 3,400, it can be explained that the variables in this study meet the requirements to be researched.

Tool to tests the quality of the questionnaire, hence, the validity test and reliability test. Validity Test is a questionnaire testing tool to ensure that respondents are given the opportunity to convey the respondent's opinion that the respondent strongly agrees, agrees, quite agrees, disagrees, and strongly disagrees with the statements in each question in the questionnaire as well as to test that the respondent is correctly exercising his or her rights by giving an opinion of strongly agree, agree, quite agree, disagree, strongly disagree with the questions in the questionnaire.

Hasnita (2021) explains that if you use the PLS application, the data is said to be valid if the data for each variable has a loading factor value greater than 0.70. All indicators in the research variables have loading factor values above 0.70 so all variables are declared valid. The results of the research explain that the load factor value of all indicators on the variables studied is greater than 0.700. So, because all indicators have a load factor value greater than 0.700, then by referring to the opinion of Hasnita, (2021) all indicators in this research are declared valid. Hasnita (2021) explains that a variable is said to be reliable if each variable has a Cronbach's Alpha value greater than 0.700. All variables have a Cronbach's Alpha value above 0.70 so all variables are declared reliable for research.

The research results explain that the original sample value is 0.279, p value 0.267, meaning that there is a positive and insignificant influence of Organizational Ambidexterity on customer satisfaction. There is a positive and significant influence of Business Strategy on customer satisfaction with an original sample value of 0.533 with a P value of 0.003. There is a positive and insignificant influence on Supplier Performance on customer satisfaction with an original sample value of 0.133 with a P value of 0.674 which is greater than 0.05.

The research results explain that the R Square value of the simultaneous influence of Organizational Ambidexterity, Business Strategy, Supplier Performance on Customer Satisfaction is 0.855. This means that the coefficient of determination value is $0.855 \times 100\%$ or 85.50%. The meaning of the Determination Coefficient of 85.50% is that there is a positive and significant influence of Organizational Ambidexterity, Business Strategy, Supplier Performance on customer satisfaction. The information in Table 2.4, second row, explains that the R Square Logistics Company Performance value is 0.865. This means that the coefficient of determination of Customer Satisfaction in influencing Logistics Performance is 86.50%.

The overall research model can be explained in Figure 2.1 below:

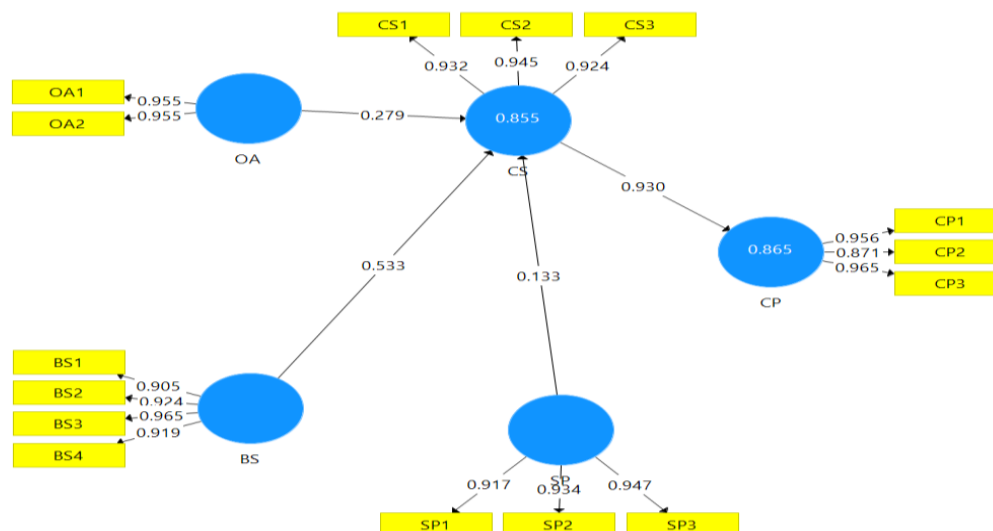


Figure 2.1. Results Research

3. Implications and Directions for Future Research

3.1. Implications

The author recommends that Bandung Main Branch Office of PosIND should increase the exploitation of strengths within the organization by implementing cheap service activities so that logistics rates can be lower than competitors, carrying out continuous improvement activities so that they are free from errors. It would be better for Bandung Main Branch Office of PosIND to improve its exploration of external opportunities by collaborating with state institutions in the field of logistics, creating new services that are in line with customer expectations. Things that need to be improved in the Business Strategy variable are determining cheaper services, setting logistics rates that are cheaper than competitors, seeking profits for the company and providing services in accordance with customer desires. Bandung Main Branch Office of PosIND should improve packing services that are error-free, timely transportation, customer complaint services that provide solutions in accordance with customer expectations, provide logistics services that are cheaper and free from errors.

The author has proven that Organizational Ambidexterity influences customer satisfaction positively but not significantly. This is different from researchers who explain in their research that there is a positive and significant influence of Organizational Ambidexterity on customer satisfaction. The author has proven that there is a positive and insignificant influence on supplier performance on customer satisfaction. This is the state of the art of this research because this research is different from the research results put forward by previous researchers.

3.2. Direction

PosIND has succeeded in proving that the Business Strategy implemented influences Customer Satisfaction. Currently PosIND is also establishing a digital transformation strategy and establishing green logistics. It would be good if there was another study that conducted research on PosIND's business strategy in the form of Digital Transformation and Green Logistics.

References

Ahtasari. (2023). Supplier Relationship Performance Measurement Model: A Case Study in a Service Company. *Proceedings of the National Seminar on Industrial Engineering (SENASTI) 2023*, 649-664.

- Anggraini. (2023). The Impact of Marketing Strategies and Service Quality on Customer Satisfaction: A Case Study of Massage Chair Service Users. *International Journal of Masters Management (IJOMM)*. vol 1 No 1, 14-27.
- Clauss. (2020). Organizational Ambidexterity and Competitive Advantage: The Role of Strategic Agility in the Exploration - Exploitation paradox. *Journal of Innovation and Knowledge*, 1-16.
- Fan, D. (2021). Gaining Customer Satisfaction Through Sustainable Supplier Development. *Transportation Research Part E: Logistics and Transportation Review.*, 1-13.
- Harzaviona. (2020). Effect of Customer Satisfaction on Customer Loyalty and Marketing Organization Performance in B2B Market Over Heavy Equipment Companies. *Journal of Multidisciplinary Academic*, 242-265.
- Hassan. (2022). The Mediating Effect of Customer Satisfaction on The Relationship Between Service Recovery Performance Factors and Business Growth A Mong Bangladesh Garment Manufacturers. *European Journal of Business and Management*. Vol 15 No 08, 58-67.
- Hasnita. (2021). *Partial Least Square Practice Module*. Palangkaraya: IAIN Palangkaraya.
- Jordan. (2022). The Relationship Between Business Strategy and Customer Satisfaction: A Study of South Africa Business Performance. *Journal of Business and Management Review*. Vol 3 No 9, 656-674.
- Khattak. (2021). Organizational Ambidexterity, Organizational Learning Capacity, and Market Orientation: A Possible Indicators of Organizational Performance. *Ilkogretim Online-Elementary Education-Online*. 2021 vol 20 No 4, 1953-1961.
- Lyima. (2022). The Effect of Customer Supplier Relationship on Customer Satisfaction in Supermarkets in Tanzania. *Olva Academy-School of Researchers*. Vol 04 No 1. pp 86-104, 86-104.
- Mary. (2023). Increasing Consumers with Satisfaction Application Based Digital Marketing Strategies. *Digital Business Startuppreneur (SABDA)*. Vol 2 No 1. April 2023, 12-23.
- Ndubusi. (2019). Customer Satisfaction and Organizational Performance of The Nigerian Banking Sub-Sector. *International Journal of Business and Management Invention*, Vol 08 No 03, 79-87.
- Noviani. (2021). Measuring Supplier Performance using the AHP Method at PT Harvest Gorontalo Indonesia. *Jambura Industrial Review*. Vol 1 No 2, 83-93.
- Obafemi. (2023). Impact of Customer Loyalty on Organizational Performance. *IIARD International Journal of Economics and Business Management*. Vol 08 No 05, 55-62.
- Ojoajogu. (2021). The Role of Supply Chain Management on Customer Satisfaction. *International Journal of Intellectual Discourse (IJID)*, 136-148.
- Petro. (2019). Organizational Ambidexterity: A Critical Review and Development of a Project-Focused Definition. *Journal of Management in Engineering*: February 2019, 1-14.
- Prasetio. (2022). *Organizational Ambidexterity as Outcome of Quality Dimension and Triple Helix: The Role of Technology Readiness and User Satisfaction*. Sustainability. vol 4, 1-15.
- Daughter. (2023). Developing Marketing Strategies to Increase Customer Satisfaction. *Journal of Business Management Focus*. Vol 13 No 2, 120-133.
- Rauf. (2023). The Effect of Customer Satisfaction and Brand Loyalty on Increasing Karawo's Business Market Share. *The ES Economy and Entrepreneurship*. Vol 01 No 03 Pp 138-143, 138-143.
- Rintala. (2022). Revisiting The Relationship Between Environment and Financial Performance: The Moderating Role of Ambidexterity in Logistics. *International Journal of Production Economics*, 1-11.

- Rohmah. (2022). HowPort ServiceIs Important for Logistics Companies? Examining the Role of Service Ambidexterity and Service Agility. *Management Analysis Journal*, 219-229.
- Santos. (2024). The Relationship Berwwn Marketing Strategies and Customer Satisfaction in The Fast-Food Restaurant Industry. *BECOSS Journal (Business Economics, Communication, and Social Sciences)* Vol 6 No 1 Pp 65-77, 65-77.
- Segoro. (2021). The Effect of Marketing Strategy and Service Quality on Customer Satisfaction and Its Impact on Customer Loyalty oF BJB Bank in Bekasi. *Advances in Economics, Business and Management Research*, Vol 187, 560-573.
- Sowmya. (2024). Impact of E-Commerce on Customer Satisfaction. *Educational Administration: Theory and Practice*. Vol 30 No 5, 7435-7349.
- Sugiyono. (2021). *Research Methods*. Bandung: Alfabeta.
- Waskito. (2023). *Skilled in Processing Regression Data, Path Analyzer, Structural Equation Model*. Bandung: Alfabeta.
- Wirtz. (2019). Organizational Ambidexterity: Cost Effective Service Excellence, Service Robots, and Artificial Intelligence. *Organizational Dynamics*.ORGDYN.719. 1-8

Analysis of Factors That Influence the Effectiveness of Export Performance (Case Study at PT. Sinergi Mitra Lestari Indonesia)

Anida Wafiq Adawiyah S. Log¹ & Erna Mulyati, S.T., M.T²

^{1,2} Prodi S2 Manajemen Logistik, Fakultas Logistik Teknologi dan Bisnis ULBI,
Jl. Sariasih No.54 Kelurahan Sarijadi, Kecamatan Sukasari, Kota Bandung 40151, Indonesia

Abstract

Exports are one of the important activities that influence a country's economic growth. For companies, especially those engaged in international trade, effective export performance is the key to achieving success and global competitiveness. This research aims to analyze the factors that influence the effectiveness of export performance, with a focus on the company PT Sinergi Mitra Lestari (SMLI). This research identifies and evaluates various internal and external factors that contribute to export performance. The internal factors analyzed include product quality, innovation, marketing strategy, operational efficiency, and human resource management. Meanwhile, external factors include government policies, global economic conditions, exchange rate fluctuations, and diplomatic relations between countries. This research methodology uses a quantitative approach by collecting data through surveys and statistical analysis. The data obtained was analyzed to measure the influence of each factor on the effectiveness of PT SMLI's export performance. The research results show that product quality and innovation have a significant influence on increasing export value. Apart from that, effective marketing strategies and competent human resource management also contribute greatly to achieving optimal export performance. This research concludes that to increase the effectiveness of export performance, PT SMLI needs to focus on improving product quality, innovation, and developing appropriate marketing strategies. Support from government policies and global economic stability are also very important in creating a conducive environment for export activities. It is hoped that the recommendations resulting from this research can help PT SMLI and similar companies in formulating more effective strategies to improve export performance and competitiveness in international markets.

Keywords: Effectiveness of Export Performance, Product Quality, Innovation, Marketing Strategy, PT Sinergi Mitra Lestari

1. Introduction

Exports are the activity of sending goods or services from one country to another country with the aim of making a profit and increasing economic welfare (Dr. Amanda J. Williams, 2020). Meanwhile, according to Prof. John H. Clark (2021), export performance is a measure used to assess the extent to which a company or country is successful in export activities, including aspects of export volume, value and growth. Through export activities, countries can earn foreign exchange, expand markets, and increase product competitiveness in international markets. Therefore, the effectiveness of export performance plays a crucial role in national economic stability, enables risk diversification, and opens up opportunities for innovation and new technology (Prof. Michael T. Anderson, 2021). For companies, especially those operating in the manufacturing and trade sectors, exports are not only the main source of income but also an important indicator in assessing global performance and competitiveness.

PT Sinergi Mitra Lestari Indonesia is a company operating in the export sector, continuing to strive to improve the effectiveness of its export performance in order to face challenges and opportunities in the international market. However, achieving effective export performance is not easy. Many factors influence the success of a company in export activities. Identifying and

analyzing these factors is very important to formulate the right strategy to improve the export performance of PT Sinergi Mitra Lestari Indonesia.

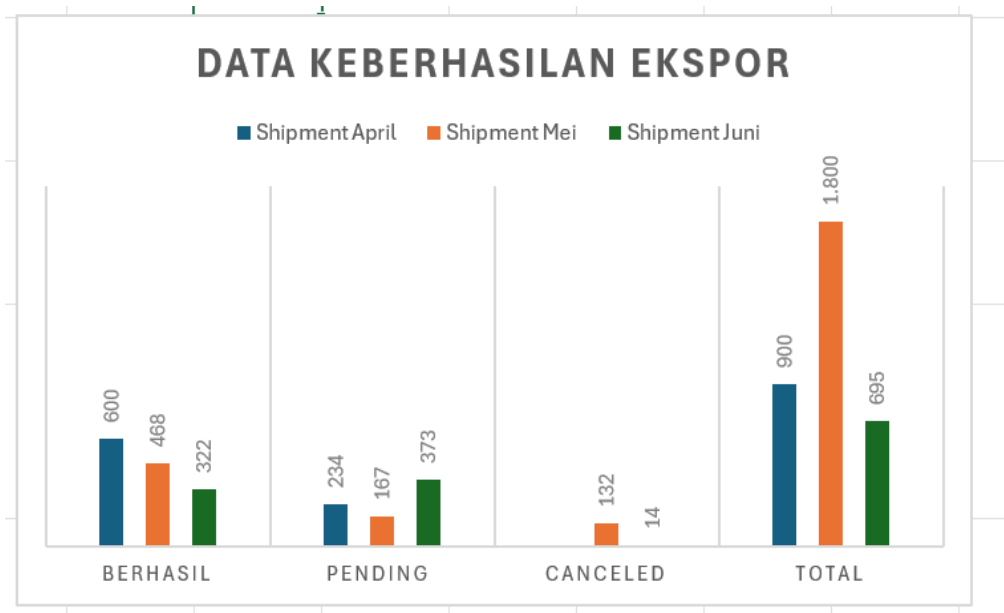


Figure 1 Export Success Data
(Source: Company Internal)

From Figure 1.1 above, we can see the level of export performance over the last 3 months, where the value of success and pending goods is quite significant so it is not only measured by the number of goods successfully sent abroad, but also by how the process is carried out efficiently, safely, and meeting customer's expectations.

Several previous researchers explained the factors that influence the effectiveness of export performance. According to Lee (2021), workforce readiness to face global challenges is one of the determining factors in a country's export success because the role of human resource skills and competencies is very crucial in managing global supply chains and adapting to the needs of diverse international markets. Leibovici1 & Louis (2021) describe a strong empirical relationship between measures of access to financial support and the level of international trade at both the firm and industry levels, indicating that financial developments have a significant impact on international trade as a whole. According to Rahma (2021), standardized SOPs help ensure consistency in the implementation of the export process, from document preparation to delivery of goods.

Dr. Andika Pratama (2022) highlights the importance of regulations governing tariffs and other trade policies to increase the competitiveness of manufactured products in the global market, as well as overcoming trade barriers that may arise. Daniswara (2022) explains that quality and efficient logistics infrastructure, especially ports and roads, will reduce trade costs and lower transportation costs so that it can improve Indonesia's export performance in aggregate. Based on previous research, this research was conducted to identify factors that influence the effectiveness of export performance, especially at PT Sinergi Mitra Lestari Indonesia. Through this research, it is hoped that various insights and recommendations can be found that can help PT Sinergi Mitra Lestari increase the effectiveness of its export performance, so that it can contribute to the economic growth of the company and the country as a whole.

Body of Paper

Research Methods

This research uses qualitative and quantitative methods. The qualitative method used is descriptive, namely explaining and revealing the factors that influence the effectiveness of export performance at the company PT Sinergi Mitra Lestari Indonesia (Sugiyono, 2021). Research data was collected using a questionnaire containing a list of questions regarding factors that influence the effectiveness of export performance. The sampling method in this research uses a saturated sampling technique, where the number of samples is the same as the population, it is said to be saturated because the sampling technique is if all members of the population are used as samples. This is usually due to the relatively small population (Borg, W.R., & Gall, M.D. in Herdarni, 2020). So, all employees involved were used as samples and then compiled based on the results of questionnaires and interviews with 60 PT Sinergi Mitra Lestari Indonesia warehouse employees. The factor analysis method was carried out with the help of SPSS Version 22 software.

Operationalization and Measurement of Variables

Table 1 Operationalization Variable

Variabel	Dimensi	Indikator	Skala
Effectiveness of Export Performance	Regulations and policies	Firmness	Differential Semantic Scale
		Certainty	
		Transparency	
		Conformity to international standards	
		Consistency	
		Harmonization	
	Human Resources	Competence	Differential Semantic Scale
		Skills	
		Knowledge	
		Satisfaction	
		Responsibility	
	Standard Operating Procedure	Document handling	Differential Semantic Scale
		Transportation arrangements	
		preparation of goods	
		Regulatory Compliance	
		Quality Inspection	
		Claims Handling	
		Payment Settings	
		Packing and Labeling	
	Logistics and Infrastructure	Reliability	Differential Semantic Scale
		Readiness	
		Management	
		Flexibility	
		Security	
		Information Technology and Systems	
		Accessibility	
	Financial Support	Financing Options	Differential Semantic Scale
		Bank Guarantee	
		Transaction Security	
		Export Credit	
		Financial Stability	
		Financial Incentives	

Source: Processed by Researcher 2024

Definition

- Effectiveness of Export Performance:** Export performance effectiveness is an assessment of how a company is able to meet export targets and increase competitiveness in international markets with efficient and innovative strategies (Martinez, 2023).
- Regulations and Policies:** Employee assessment of the effectiveness of export performance starts from firmness, certainty, transparency, conformity with international standards, consistency and harmonization (Rodriguez, A., and Ruiz, 2020).
- Human Resources:** Employee assessment of the effectiveness of export performance starting from competence, skills, knowledge, satisfaction and responsibility (Yang, Z., & Lin, 2019).
- Standard Operating Procedure:** Employee assessment of the effectiveness of SOP (Standard Operating Procedure) starting from the process of processing documents, arranging transportation, preparing goods, fulfilling regulations, quality inspections, handling claims, arranging payments, packing and labeling.
- Logistics and Infrastructure:** Employee assessment of the effectiveness of warehouse capabilities starting from reliability, readiness, management, flexibility, security, technology and information systems and accessibility.
- Financial Support:** Employee assessment of the effectiveness of goods management in the warehouse starting from financing options, bank guarantees, transaction security, export credit, financial stability and financial incentives.

3. Results and Discussion

Kaiser-Meyer-Olkin (KMO) and Barlett's Test

Tabel 2 Kaiser-Meyer-Olkin (KMO) and Bartlett's

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.729
Bartlett's Test of Sphericity	Approx. Chi-Square	1415.546
	df	465
	Sig.	.000

Source: Processed by Researcher 2024

In the KMO and Barlett test table above, the KMO Measure of Sampling Adequacy value is 0.729 and the significance is 0.000. So, we can be sure that the data is suitable for factor analysis because it has a KMO value above 0.50 and a significance value far below 0.05 (Nani Sunarmi et.al, 2021).

Communalities Test

Table 3 Communalities Test

No	Atribut	Extraction
1	Regulations and policies	0,824
2	Human Resources	0,810
3	<i>Standard Operating Procedure</i>	0,771
4	Logistics and Infrastructure	0,686
5	Financial Support	0,651

Source: Processed by Researcher 2024

In the communality value based on the extraction column, the regulatory attribute value is 0.824. This means the variance value of this attribute is around 82% which can be explained by the factors extracted in the factor analysis that will be formed. Similarly with other attributes, provided that

the greater the communality value of an attribute, the closer it will be related to the factors that will be formed.

Total Variance Explained

Table 4: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.180	32.839	32.839	10.180	32.839	32.839	5.609	18.095	18.095
2	3.645	11.758	44.597	3.645	11.758	44.597	4.936	15.921	34.016
3	2.437	7.863	52.460	2.437	7.863	52.460	2.839	9.157	43.174
4	1.715	5.534	57.994	1.715	5.534	57.994	2.369	7.643	50.817
5	1.461	4.712	62.706	1.461	4.712	62.706	2.030	6.548	57.365
6	1.405	4.532	67.238	1.405	4.532	67.238	1.855	5.985	63.350
7	1.284	4.142	71.379	1.284	4.142	71.379	1.823	5.881	69.231
8	1.047	3.377	74.757	1.047	3.377	74.757	1.713	5.526	74.757
9	.950	3.063	77.820						
10	.853	2.750	80.570						
11	.779	2.513	83.084						
12	.700	2.259	85.343						
13	.645	2.080	87.423						
14	.555	1.790	89.213						

From the Absolute Change table made sense of over, the quantity of elements to be not set in stone by joining a few models to get the quantity of variables that best suits the examination. This stage distinguishes that the level of variety can be made sense of by the elements that structure it. The models utilized are eigenvalues. Factors that have an eigenvalue of under 1 are not sufficient to be remembered for the model. From the after effects of the table above, eigenvalues that are more than one is tracked down in pointers 1 to 8. In the meantime, markers 9, etc are supposed to be less great since they have eigenvalues under 1. From these outcomes, the quantity of elements utilized is 8. The complete difference that can be made sense of by these 8 variables is 74.757%.

Rotated Component Matrix

Table 5 Rotated Component Matrix

Component Matrix ^a								
	Component							
	1	2	3	4	5	6	7	8
P1.1	.591	-.502	.214	-.203	.273	.019	-.112	.224
P1.2	.580	-.438	.045	-.312	.163	.178	.321	.021
P1.3	.545	-.430	.255	-.408	-.004	-.115	.247	-.118
P1.4	.766	-.278	-.014	.111	.186	-.104	-.095	.251
P1.5	.682	-.404	.073	.258	.291	-.215	-.198	-.103
P1.6	.723	-.307	-.231	-.028	.246	-.209	.024	.260
P2.1	.625	-.523	-.025	.299	-.122	.250	.242	-.168
P2.2	.657	-.423	-.086	.316	-.268	.200	.219	-.241
P2.3	.589	-.447	.207	.058	-.019	.153	-.331	.092
P2.4	.703	-.250	.205	.092	.006	-.280	-.150	-.091
P2.5	.619	-.278	.138	-.131	-.332	.365	.011	.062
P3.1	.745	.058	-.172	.161	-.103	.226	-.174	-.121
P3.2	.666	.218	.189	-.032	-.302	-.198	-.119	.002
P3.3	.706	.382	-.279	.011	-.010	.210	-.007	.018
P3.4	.692	.297	-.292	-.168	.102	-.159	-.074	.023
P3.5	.746	.119	-.142	-.266	-.312	-.170	.079	.166

P3.6	,690	,305	-,454	-,166	-,150	,101	-,085	,107
P3.7	,720	,370	-,450	-,093	-,067	-,034	-,032	,054
P3.8	,670	,438	-,218	,084	,007	,063	-,030	-,034
P4.1	,289	,356	,141	,387	-,146	-,118	,496	,092
P4.2	,400	,218	-,161	,211	,431	-,285	,389	,098
P4.3	,314	,313	-,062	-,488	,127	,209	,375	-,039
P4.4	,346	,360	,247	-,132	,322	-,229	,025	-,413
P4.5	,336	,186	,403	-,160	-,452	-,385	-,132	,192
P4.6	,077	,347	,349	,354	,199	,308	-,025	,532
P4.7	,529	,214	,394	-,044	,198	,163	,024	-,217
P5.1	,146	,378	,663	-,229	,156	,176	,021	,115
P5.2	,318	,305	,612	-,071	-,191	-,014	,025	-,085
P5.3	,527	,348	-,041	,024	,178	,047	-,398	-,309
P5.4	,469	,181	,228	,496	-,143	-,264	,175	-,049
P5.5	,348	,421	,175	,191	,151	,391	-,089	-,020

Extraction Method: Principal Component Analysis.

a. 8 components extracted.

Source: Processed by Researcher 2024

It very well may be found in the table over that the outcomes got demonstrate that the element stacking values between a variable and a few variables are adequately separated and prepared to be deciphered. All factors have high variable loadings on one component and have tiny element loadings on different variables. The consequences of variable investigation show that the 8 element parts shaped impact the adequacy of product execution at PT Sinergi Mitra Lestari Indonesia. Then, at that point, you can see the worth with the most noteworthy mark of 0.766, and that implies that guidelines are the principal factor affecting the adequacy of commodity execution at PT Sinergi Mitra Lestari Indonesia. Moreover, the element that has the second most noteworthy marker is SOP with a worth of 0.746, so one might say that this variable is the subsequent predominant component that impacts the viability of perilous and harmful material distribution center administration at PT Sinergi Mitra Lestari. Indonesia. Then, at that point, trailed by monetary which is the third predominant variable that impacts the viability of commodity execution at PT Sinergi Mitra Lestari Indonesia with a worth of 0.663.

4. Implications and Direction for Future Research Implications

Based on the research results, it can be concluded that there are several internal and external factors that significantly influence the company's export performance. The most influential internal factors are the quality of the company's SOP and financials. Good SOPs will improve the company's performance and sufficient financial resources will make it easier for the company to book space when exporting goods. On the other hand, external factors such as supportive government policies, stable global economic conditions, and good diplomatic relations between countries, also contributed greatly to the export success of PT SMLI. Policies that support exports, such as tax incentives and logistics support, can have a positive impact on a company's ability to compete in global markets. This research suggests that PT SMLI continues to improve HR performance in accordance with SOPs. Apart from that, companies also need to adapt to changes in global economic conditions and government policies that can affect export activities. Support and cooperation from various parties, including the government, is very important in creating a conducive environment for export activities.

Directions for Future Research

Research can be carried out by comparing the effectiveness of export performance in various industrial sectors. This will help identify specific factors relevant to certain sectors and provide more specific insights for different types of industries.

Bibliography

- Borg, W.R., & Gall, M.D. dalam Herdarni, et al. (2020). Metode Penelitian Pendidikan: Penelitian Eksploratif dan Penelitian Kausal. *Jurnal Penelitian dan Pengembangan*, 15, n, 255.
- Daniswara, A. P. (2022). *Elompok, Infrastruktur T astruktur Transportasi dan Kinerja Ekspor dari Tiga K tasi dan Kinerja Ekspor dari Tiga Kelompok Indonesia, Komoditas*.
- Dr. Amanda J. Williams. (2020). *The Dynamics of Export Performance in Emerging Markets*.
- Lee, D. M. (2021). *Productivity, Human Resource Management and Its Impact on Export*.
- Leibovici1, F., & Louis. (2021). Trade, Financial Development and International. *Federal Reserve Bank of St*.
- Martinez, P. D. S. (2023). *Strategies, Maintaining Global Competitiveness through Effective Export*.
- Nani Sunarmi, Elok Nurul Kumailia, Nanin Nurfaiza, Afifatul Khoirun Nikmah, Hani Nur Aisyah, Indah Sriwahyuni, S. N. L., & Fisika, T. (2021). *Analysis, Analisis Faktor Unsur Cuaca terhadap Perubahan Iklim di Kabupaten Pasuruan pada Tahun 2021 dengan Metode Principal Component*.
- Pratama, D. A. (2022). *Pengaruh Kebijakan Tarif dan non-Tarif terhadap Ekspor Manufaktur: Studi Kasus ASEAN*.
- Prof. John H. Clark. (2021). *Assessing Export Performance: Key Metrics and Influencing Factors*.
- Prof. Michael T. Anderson. (2021). *Economic Stability and Export Effectiveness: An Interconnected Relationship*.
- Rahma, P. I. W. dan D. S. (2021). *Optimizing Supply Chain Management in Export through SOPs*.
- Rodriguez, A., & Ruiz, M. (2020). "Impact of regulatory compliance on international trade performance." *International Journal of Trade and Global Markets*, 13(1), 45-60.
- Sugiyono. (2021). *Metode Penelitian Kuantitatif Kualitatif dan R&D (M.Dr. Ir. Sutopo, S.Pd (ed); ke2 ed*.
- Yang, Z., & Lin, K. (2019). The Role of Logistics Service Quality in Enhancing Export Performance." *International Journal of Physical Distribution & Logistics Management*, 49(5), 484-501.

Analysis of Factors That Influence the Effectiveness of Hazardous and Toxic Materials Waste Warehouse Management at the Company PT Sinergi Mitra Lestari Indonesia

Muhammad Andrey Alfian, S. Log.¹, Dr. Erna Mulyati, S.T., M.T.²

^{1&2} Prodi S2 Manajemen Logistik, Fakultas Logistik Teknologi dan Bisnis ULBI,
Jl. Sariasih No.54 Kelurahan Sarijadi, Kecamatan Sukasari, Kota Bandung 40151, Indonesia

Abstract

This research aims to analyze the factors that influence the effectiveness of the hazardous and toxic materials waste warehousing and export process from PT Aneka Tambang carried out by PT Sinergi Mitra Lestari Indonesia. The research method used is a quantitative method which then explains and reveals the factors that influence the effectiveness of hazardous and toxic materials waste warehouse management. The data was processed using the factor analysis method. From the results of factor analysis, it was obtained that 7 factor components were formed that influence the effectiveness of hazardous and toxic materials waste warehouse management at PT Sinergi Mitra Lestari Indonesia. Of the seven factors, the one with the largest loading factor is storage capacity with a value of 0.875. This proves that storage capacity is the main factor influencing the effectiveness of B3 warehouse management at PT Sinergi Mitra Lestari Indonesia.

Keywords: Warehousing, Location of Warehouse, Warehouse Capabilites, Capacity, Hazardous and Toxic Materials Waste.

1. Introduction

Warehousing is an activity of storing goods, while a warehouse is a space for storing goods, which starts from the activities of receiving, recording, entering, storing, organizing, maintaining, issuing and distributing which ends in the responsibility report of the warehouse manager (Robiah Adawiyah, 2022). Effectiveness in warehouse management involves increasing productivity, reducing costs, optimizing resource use, and implementing best practices in organization, stock control, operational efficiency, risk management, and analysis and measurement (Arcelina Cindy Naomi, 2023). Warehouse management itself is an activity related to optimizing large warehouse capacity, warehouse location, speed of product selection, speed of loading and unloading, flow of goods in the warehouse, procedures for receiving and selecting products, maintenance procedures, work tools, warehouse security management, storage, product quality management, etc. (Haryono, 2020). Hazardous and toxic materials waste is a type of waste produced from industrial processes and other human activities that contains hazardous materials that can pose health and environmental risks (Pratama, 2023).

PT Sinergi Mitra Lestari Indonesia is a company that plays an important role in managing B3 waste in Indonesia, especially in warehousing and exporting hazardous and toxic materials waste. As a company engaged in hazardous and toxic materials waste management, PT Sinergi Mitra Lestari Indonesia provides adequate and safe warehousing services for hazardous and toxic materials waste produced by mining companies in Indonesia. One of the main clients of PT Sinergi Mitra Lestari Indonesia is PT Aneka Tambang, a leading mining company that produces various types of hazardous and toxic materials waste from its mineral extraction and processing activities. One of the wastes managed in the warehousing of PT Sinergi Mitra Lestari Indonesia for further export is ferronickel. Ferronickel waste is waste produced from the ferronickel production process, which contains dangerous and toxic materials such as heavy metals (nickel, chromium and

cadmium) and chemical compounds that can pollute the environment and endanger human health if not managed properly (Sutikno, 2019).

As a hazardous and toxic materials waste management partner for PT Aneka Tambang, PT Sinergi Mitra Lestari Indonesia is responsible for managing this waste in a safe, efficient manner and in accordance with national and international regulations. Along with increasing industrial activity at the company PT Aneka Tambang, the volume of hazardous and toxic materials waste produced also continues to increase. Increasing ferronickel production without proper planning for waste handling can cause waste to accumulate in warehouse areas. This creates a challenge for PT Sinergi Mitra Lestari Indonesia to manage the flow of hazardous and toxic materials waste movement in the warehouse area before export without causing goods to pile up in the warehouse area. Dr. Ehrman (2021) found that ferronickel buildup in warehouses can lead to exposure to heavy metals, which poses a risk of causing respiratory problems and skin diseases for exposed workers.

Several previous researchers explained the factors that influence the effectiveness of hazardous and toxic materials waste warehouse management. Hartati (2019) stated that structured and consistently implemented SOPs in hazardous and toxic materials waste warehouses are very important to ensure that all waste handling processes are carried out in accordance with safety and environmental standards. Santoso (2020) explained that the effectiveness of hazardous and toxic materials waste warehouse management takes into account the selection of hazardous and toxic materials waste warehouse locations so that they are easy to access for transportation and monitoring. Novita (2021) emphasized the importance of training and education for all employees involved in B3 waste management. Every staff must be trained in safety procedures, storage techniques and emergency response to ensure they can handle hazardous and toxic materials waste safely and efficiently.

Fauzi (2022) emphasized that good inventory management can increase the operational efficiency of hazardous and toxic materials waste warehouses, with an effective inventory system, the process of receiving, storing and dispensing waste can be carried out more quickly and precisely. Putri et al (2024) added that good warehouse capabilities are very important for the safety and efficiency of hazardous and toxic materials waste management. This includes the ability to identify and manage risks, ensuring that all waste is stored and treated in accordance with regulations, as well as the ability to respond to incidents quickly and effectively. Based on previous research, this research was conducted to identify what factors influence the effectiveness of hazardous and toxic materials waste warehouse management, especially at PT Sinergi Mitra Lestari.

2. Body of Paper

This research uses qualitative and quantitative methods. The qualitative method used is descriptive, namely explaining and revealing the factors that influence the effectiveness of hazardous and toxic materials waste warehouse management. The quantitative method used is factor analysis, where this method is used to identify groups of variables that contribute significantly to the effectiveness of hazardous and toxic materials waste warehouse management. This method was chosen because it is suitable for describing the phenomena that occur and the relationships between the variables studied (Sugiyono, 2021). The factor analysis method was carried out with the help of SPSS software version 22. Research data was collected using a questionnaire containing a list of questions regarding factors that influence the effectiveness of hazardous and toxic materials waste warehouse management. Then, it was compiled based on the

results of questionnaires and interviews with 60 PT Sinergi Mitra Lestari warehouse employees. So, the sampling method used is a saturated sampling technique, where the entire population is taken as a sample. This technique was chosen because the population directly involved in managing hazardous and toxic materials is relatively small and allows it to be collected entirely (Arikunto, 2023).

Operationalization and Measurement of Variables

Table 1: Operationalization Variable

Variable	Dimensions	Indicator	Scale
Effective ness of Warehou se Manage ment	Location of Warehouse	Accessibility	Differential Semantic Scale
		Distance from port to warehouse	
		Distance between warehouse and residential area	
		Availability of supporting infrastructure	
		Warehouse location security and safety	
		Regulatory Compliance	
	Human Resources	Work motivation	Differential Semantic Scale
		Job satisfaction	
		Work experience	
		Qualifications and competencies	
		Occupational Health and Safety	
	Standard Operating Procedure	Receiving	Differential Semantic Scale
		Storage	
		Picking	
		Shipping	
	Warehouse capabilities	Capacity	Differential Semantic Scale
		Availability and quality of equipment	
		Technology and information systems	
		Emergency preparedness and response	
		Storage space management	
	Inventory Management	Accuracy	Differential Semantic Scale
		Availability	
		Stock rotation rate	
		Lead time	
		Storage costs	
		Shipping costs	

Source: Researcher 2024

Definition

- Warehouse Management Effectiveness: Warehouse Management Effectiveness is the ability to manage all aspects of warehouse operations including location of warehouse, human resources, standard operating procedure, warehouse capabilities, and inventory management.
- Location of Warehouse: Employee's assessments of the effectiveness of warehouse locations start from accessibility, distance from the port to the warehouse, distance between the warehouse and residential areas, availability of supporting infrastructure, security and safety of the warehouse location, and regulatory compliance.
- Human Resources: Employee's assessments of the effectiveness of the performance process start from work motivation, job satisfaction, work experience, qualifications and competencies, work health and safety.
- Standard Operating Procedure: Employee's assessments of the effectiveness of SOP (Standard Operating Procedure) start from the activities of receiving, storage, picking, and shipping.
- Warehouse Capabilities: Employee's assessments of the effectiveness of warehouse capabilities start from storage capacity, availability and quality of equipment, technology and information systems, emergency preparedness and response, and storage space management.

- f. Inventory Management: Employee's assessments of the effectiveness of goods management in the warehouse starting from accuracy of availability, stock rotation rate, lead time, storage costs and shipping costs.

3. Results

Kaiser-Meyer-Olkin (KMO) and Bartlett's Test

Table 2: Kaiser-Meyer-Olkin (KMO) and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.800
Bartlett's Test of Sphericity	Approx. Chi-Square	1084.873
	df	325
	Sig.	.000

Source: Processed by Researcher 2024

In the KMO and Bartlett's test table above, the KMO Measure of Sampling Adequacy value is 0.800 and the significance is 0.000. So, it can be ascertained that the data is suitable for factor analysis because it has a KMO value above 0.50 and a significance value far below 0.05 (Nani Sunarmi et. al, 2021).

Communalities Test

Table 3: Communalities Test

No.	Attribute	Extraction
1	Location of Warehouse	0.779
2	Human Resources	0.790
3	Standard Operating Procedure	0.764
4	Warehouse capabilities	0.807
5	Inventory Management	0.669

Source: Processed by Researcher 2024

In the communalities value based on the extraction column, the attribute value for Location of Warehouse is 0.779. This means that the variance value of this attribute is around 77%, which can be explained by the factors extracted in the factor analysis that will be formed. Similarly with other attributes, provided that the greater the communalities value of the attribute, the closer the relationship with the factors that will be formed.

Total Variance Explained

Table 4 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.266	39.486	39.486	10.266	39.486	39.486	6.157	23.679	23.679
2	2.838	10.916	50.403	2.838	10.916	50.403	3.561	13.694	37.374
3	1.757	6.757	57.160	1.757	6.757	57.160	2.965	11.404	48.777
4	1.455	5.598	62.758	1.455	5.598	62.758	2.498	9.608	58.385
5	1.220	4.692	67.450	1.220	4.692	67.450	1.532	5.893	64.278
6	1.130	4.348	71.799	1.130	4.348	71.799	1.518	5.838	70.116
7	1.062	4.085	75.884	1.062	4.085	75.884	1.500	5.768	75.884
8	.867	3.333	79.217						
9	.728	2.799	82.016						
10	.656	2.525	84.540						
11	.578	2.222	86.762						
12	.555	2.133	88.895						
13	.492	1.894	90.789						

Source: Processed by Researcher 2024

From the Total Variance Explained table shown above, the number of factors to be formed is determined by combining several criteria to get the number of factors that best suits the research. This stage identifies that the percentage of diversity can be explained by the factors formed. The criteria used are eigenvalues. Factors that have an eigenvalue of less than 1 are not good to include in the model. From the results of the table above, eigenvalues that have more than one value are found in indicators 1 to 7. Meanwhile, indicators 8 and so on are said to be not good because they have eigenvalues below 1. From these results, the number of factors used is 7. The total variance that can be explained by these 7 factors is 75.884%.

Rotated Component Matrix

Table 5 Rotated Component Matrix

Rotated Component Matrix ^a							
	Component						
	1	2	3	4	5	6	7
PA1	,062	,039	-,051	,244	-,182	,815	,203
PA2	,804	,111	,222	-,106	-,052	,114	,155
PA3	,480	,287	-,318	,109	,409	-,038	,485
PA4	,515	,269	,351	,189	,456	-,033	,000
PA5	,241	,303	,814	-,006	-,113	,127	,041
PA6	,439	,248	,699	,130	,126	-,084	,117
PA7	,336	,492	,413	-,002	,359	,309	,309
PA8	,329	,749	,391	,007	,002	,060	,107
PA9	,531	,609	,236	,086	,109	,183	-,026
PA10	,403	,470	,362	,409	-,041	-,178	,221
PA11	,633	,588	-,117	,063	-,184	-,055	-,172
PA12	,224	,724	,102	,045	,056	,236	-,307
PA13	,173	,720	,279	,205	,147	-,265	,052
PA14	,744	,185	,222	,286	,075	,015	-,094
PA15	,494	,249	,638	,167	,157	-,210	-,100
PA16	,875	,108	,099	,017	-,028	-,052	,218
PA17	,741	,262	,202	-,008	,172	,136	-,136
PA18	,105	,108	-,038	,817	,009	,017	-,019
PA19	,794	,150	,181	,197	,125	,015	,024
PA20	,539	,177	,375	,199	,264	,441	-,190
PA21	-,009	,247	-,198	,561	,038	,308	,258
PA22	,136	-,100	,266	,681	-,193	,297	-,025
PA23	,003	-,014	-,022	,299	-,750	,153	,137
PA24	,733	,336	,174	-,020	-,095	,084	,283
PA25	,105	-,168	,110	,188	-,166	,212	,715
PA26	-,024	,050	,300	,617	-,329	-,050	,318

Source: Processed by Researcher 2024

It can be seen in the table above that the results obtained show that the loading factor values between a variable and several factors are sufficiently differentiated and ready for interpretation. All variables have a high loading factor on one factor and have a fairly small loading factor for the other factors. The results of the factor analysis showed that 7 factor components formed influenced the effectiveness of hazardous and toxic materials waste warehouse management at PT Sinergi Mitra Lestari Indonesia. Then, it can be seen that the value with the highest indicator is 0.875, which means that warehouse capacity is the main factor that influences the effectiveness of hazardous and toxic materials waste warehouse management at PT Sinergi Mitra Lestari Indonesia. Furthermore, the factor that has the second highest indicator is Technology and Information Systems with a value of 0.817 so it can be said that this factor is the second dominant factor that

influences the effectiveness of hazardous and toxic materials waste warehouse management at PT Sinergi Mitra Lestari Indonesia. Then, followed by accessibility which is the third dominant factor that influences the effectiveness of hazardous and toxic materials waste warehouse management at PT Sinergi Mitra Lestari Indonesia with a value of 0.815.

4. Implications and Direction for Future Research

Implications

Based on the results of factor analysis conducted by researchers, it was found that the storage capacity at this company needs to be increased further considering that the hazardous and toxic materials waste warehouse requires a large area to avoid the risk of leaks, contamination and other dangers. Then, it is important to ensure that waste does not accumulate for too long and can be processed or exported on schedule. It is necessary to increase warehouse capacity because with the right capacity, storage space can be optimized for efficient storage, maximizing space use without compromising safety. Then, after the warehouse capacity has been expanded, the company needs a more sophisticated information and technology system to keep up with global competition. This is to make it easier to record and track every item of hazardous and toxic materials waste entering and leaving the warehouse with high accuracy, reducing the risk of errors in inventory management and ensuring compliance with strict regulations. Accessibility at this company's hazardous and toxic materials waste warehouse also needs to be improved because good accessibility also includes easy access to supporting services such as waste processing facilities, special transportation services for hazardous and toxic materials waste, and related administrative facilities.

Directions for Future Research

Optimizing the hazardous and toxic materials waste warehousing and export process at PT Sinergi Mitra Lestari Indonesia is an important strategic step to face existing operational and regulatory challenges. Future research is expected to find the right strategy, which can improve operational performance, reduce costs, and minimize environmental risks, thereby contributing to more efficient and sustainable hazardous and toxic materials waste management.

References

- Adawiyah, R. (2022). *Faktor-faktor yang Mempengaruhi Efektivitas Pengelolaan Gudang*. *Jurnal Bisnis, Logistik dan Supply Chain*, 2(2), 72-77.
- Arcelina Cindy Naomi, L. F. (2023). *Penyimpanan, Tingkat Efektivitas dalam Proses Gudang, Barang di Penulis*.
- Arikunto, S. (2023). *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Cipta., Rineka.
- Ehrman, D. (2021). *Health Impacts of Heavy Metal Exposure in Industrial Settings: The Case of Ferronickel Storage*.
- Fauzi, I. A. (2022). *Judul Penelitian: "Evaluasi Kapabilitas Infrastruktur Gudang dalam Pengelolaan Limbah B3*.
- Hartati, D. S. (2019). *Industri", Judul Penelitian: "Analisis Kapabilitas Gudang dalam Pengelolaan Limbah B3 di Kawasan Gudang, Pentingnya Kapabilitas*.
- Haryono, C. G. (2020). *Ragam Metode Penelitian Kualitatif Komunikasi*. Jawa Publisher), Barat: CV Jejak.
- Nani Sunarmi, Elok Nurul Kumailia, Nanin Nurfaiza, Afifatul Khoirun Nikmah, Hani Nur Aisyah, Indah Sriwahyuni, S. N. L., & Fisika, T. (2021). *Analysis, Analisis Faktor Unsur Cuaca terhadap Perubahan Iklim Di Kabupaten Pasuruan pada Tahun 2021 dengan Metode Principal Component*.
- Novita, D. R. (2021). *Judul Penelitian: "Kapabilitas Teknologi dalam Gudang Limbah B3:*

Tantangan dan Solus.

- Pratama, R. (2023). *AMA Penyimpanan Konsorsium Bacillus Spp. dalam Limbah Padat untuk Pengendalian Penyakit Layu Bakteri.*
- Putri, D. L., & 3. (2024). *Judul Penelitian: "Pengaruh Kapabilitas Gudang terhadap Keselamatan dan Efisiensi Pengelolaan Limbah B.*
- Santoso, P. D. A. (2020). *Judul Penelitian: "Peningkatan Kapabilitas Gudang untuk Pengelolaan Limbah B3 yang Efektif.*
- Sugiyono. (2021). *Metode Penelitian Kuantitatif Kualitatif dan R&D (M.Dr. Ir. Sutopo, S.Pd (ed); ke2 ed.*
- Sutikno, H. (2019). *"Definisi dan Karakteristik Limbah B3 Ferronikel: Potensi Bahaya terhadap Lingkungan dan Kesehatan Manusia.*

Challenges and Strategies for Rice Price Stability: A Systematic Review of Supply Chain Dynamics in Indonesia During Critical Periods

Rizki Alifnur Harmawan^{1*} & Erna Mulyati²

^{1&2}Department of Master of Logistics Management, Faculty of Logistics, Technology and Business, Universitas Logistik dan Bisnis Internasional, Indonesia
rizkialif2024@gmail.com

Abstract

This study aims to analyze the challenges of rice price stability in Indonesia, especially during critical periods such as Idul Fitri and other holidays. The main problem faced is rice price instability due to limited supply, surge in demand, and weak anticipation during the holiday period. To evaluate government policies, distribution networks, and production factors that affect rice prices, this study utilizes a logical framework approach. The methodology used includes a systematic review of the literature and analysis of market data. Data were collected from various sources, including government reports, market data, and academic studies. The results show that limited rice supply, spikes in demand during holidays, and weak government anticipation contribute significantly to price instability. The main factors affecting rice prices include high production costs, logistical issues, and international market fluctuations. The role of the National Logistics Agency (Bulog) in managing national rice reserves and stabilizing market prices also proves crucial. This study concludes that early anticipation, coordinated policies, and improved supply chain efficiency are essential to maintain rice price stability. Proposed strategies include agricultural intensification, improved distribution systems, and strategic reserve management. The findings provide valuable insights for policymakers and market players to reduce price volatility and ensure food security in Indonesia in a sustainable manner, particularly in an effort to achieve rice price stabilization in the 2025 Idul Fitri period.

Keywords: Rice Price Stability, Supply Chain, Logical Framework, Price Volatility, Critical Periods

1. Introduction

Rice is a staple food commodity consumed by almost all people on the Asian continent as well as other parts of the world, especially in Asia, Africa and Latin America. As the main source of carbohydrates, rice plays an important role in food security and social stability in many countries (Dhungel & Acharya, 2017). As stated on the Goodstat website, China is one of the countries with a population that has a high interest in consuming rice, which is 160 million tons in 2023 (Khor et al., 2015). In Southeast Asia itself, many countries also consume rice as a staple or source of carbohydrates.

By looking at the results of countries that have the highest indicators in consumption, we can see the involvement of various parties in the supply chain. This supply chain involves several actors, ranging from rice farmers, traders, rice millers, importers, to consumers (Octanica, 2019). These linkages are directly related to various distribution channels, from downstream to upstream. This supply chain is vulnerable to various factors that can hinder operations, such as weather changes, diseases, trade policies, price fluctuations, and public interest in staple foods such as rice (Davis et al., 2021). These factors can negatively impact food security and the global economy when it comes to the quality and price of rice. Based on the described drivers of inflation-inducing fluctuations, effective supply chain management plays an important role in stabilizing rice prices and improving food security (Kalkuhl et al., 2019). Effective supply chain management strategies

reduce disruptions or bottlenecks in the process, increase efficiency, and improve market transparency (Patel, 2023). This impacts all actors in the supply chain, from farmers to end consumers, who benefit in the form of price stability and more secure supply.

Discussing supply chains, a country that also has high complexity is Indonesia. Supply chain actors in Indonesia are very diverse, starting from farmers spreaded throughout the island and have rice granaries in each region (Connor et al., 2023). Indonesia is an Asian country whose culture requires rice consumption (Wijaya, 2019). Many controversies have occurred during the sale of rice in Indonesia related to the previous factors. As well as having a role in national food stability and countries that cooperate in rice imports, one of which is Thailand. The rise in rice prices in Indonesia has been triggered by various interrelated factors. Extreme weather changes such as droughts and floods have disrupted rice production, reduced yields, and increased rice prices due to reduced supply (Sekhar, 2018). In addition, pest and disease attacks on rice plants also reduce yields.

Another contributing factor is government policies related to rice imports, subsidies, and minimum prices that affect the price of rice in the domestic market (Wurdiana, 2019). In addition, rising production costs, such as the price of fertilizers, pesticides, and labour, add to the burden on producers, which in turn is passed on to the selling price of rice. Distribution and logistics issues, such as poor infrastructure and high transportation costs, also add complexity to the supply chain. Furthermore, growing demand as the population grows also puts pressure on rice supply, while price fluctuations in the international market impact domestic prices, especially when Indonesia has to import rice (Linn & Maenhout, 2019).

In recent times, Indonesia has faced various obstacles related to rising rice prices. The main causes of these price increases are usually limited supply and a drastic increase in demand. Rice price increases often occur around national holidays such as Ramadan and Eid al-Fitr (Hamzah, 2022). This phenomenon recurs every year, and is considered normal by the public as it is difficult to avoid. High demand during this period, coupled with weak anticipation of price increases during Eid, causes rice prices to spike. In addition, poor economic conditions also exacerbate the situation. Other factors affecting rice price increases include raw material shortages, problems in the production and distribution process, and government policies. Empty or depleted stocks in regional granaries also contribute to price increases. Therefore, early anticipation and appropriate policies are needed to address this issue.

Based on previous research data, journals that discuss supply-side price instability include *Dynamic Impacts of External Uncertainties on the Stability of the Food Supply Chain: Evidence from China* by (Li & Song, 2022), *Rice Price Formation in the Short Run and the Long Run: The Role of Market Structure in Explaining Volatility* by (Timmer, 2012), and *A Contribution to the Empirics of Food Price Behavior: The Case of Rice Price Dynamics in Italy* by (Barboza et al., 2021). Prices that experience instability are caused by the factors previously described. The study conducted is different from previous research because this research is directly related to a phenomenon that often occurs in Indonesia, namely price increases on certain days or periods. This research will use a method in the form of a rice market stability strategy with a logical framework approach.

In the next section, we will discuss the methods used, results obtained, and conclusions. The methods used will be related to the stability strategy to determine the supply chain dynamics of rice prices. This study will evaluate how government policies, distribution, and production affect

rice prices and identify measures that can be taken to reduce price volatility in the future. The results of this study are expected to provide concrete recommendations for policy makers and market players to maintain rice price stability in Indonesia.

2. Research Methodology

The research method used in the research is a systematic literature review, the method described has a sequence in reviewing, summarizing, and interpreting the findings or phenomena found (Deperiky et al., 2020). The research raised is current issues that have occurred in Indonesia in recent years. The literature used aims to direct the research to avoid mistakes and be subjective. Figure 1 explains that this research is supported by the gap research approach, conceptual and framework developed from the research.

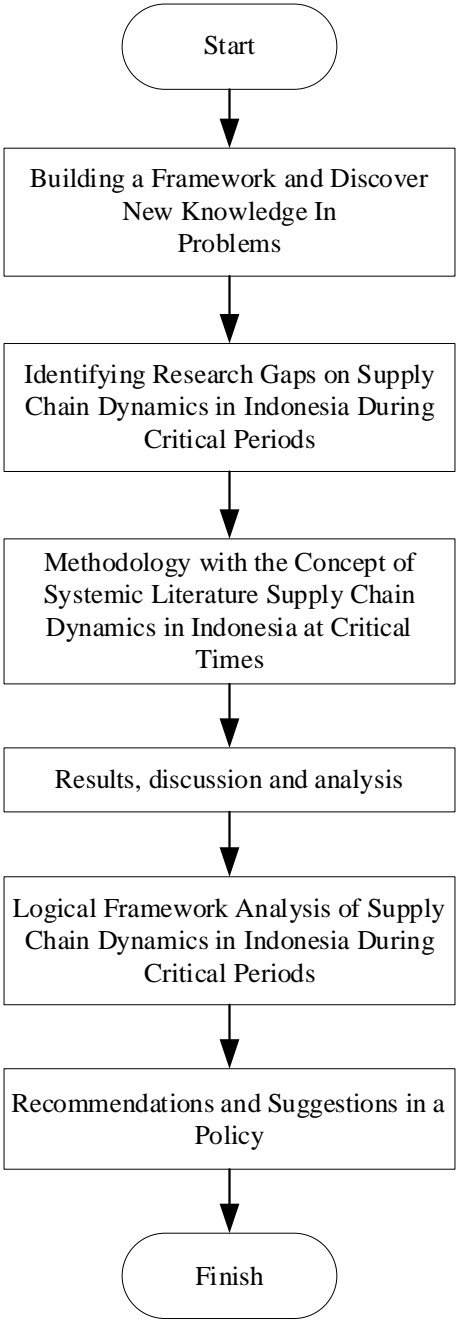


Figure 1: Process of Literature Review and Analysis
 Source: Author, 2024

This flowchart illustrates the systematic process of conducting a literature review and analysis of supply chain dynamics in Indonesia during critical periods. The process starts with building a framework and discovering new knowledge in the problem at hand (Pre-Review). The next step is to review the conceptual knowledge on supply chain dynamics in Indonesia during critical periods based on previous research, and build a system framework for the literature review (Theoretical Framework). After that, identifying research gaps related to supply chain dynamics in Indonesia during critical periods.

In the methodology stage, the concept of systemic literature review was used to understand supply chain dynamics in Indonesia during critical periods. Results, discussion and analysis were conducted at the advanced review stage. Then, a logical framework analysis of supply chain dynamics in Indonesia during critical periods is conducted, followed by a framework overview and suggestions. Finally, policy recommendations and suggestions are provided based on the analysis conducted. The process ends once all stages have been completed and conclusions have been drawn.

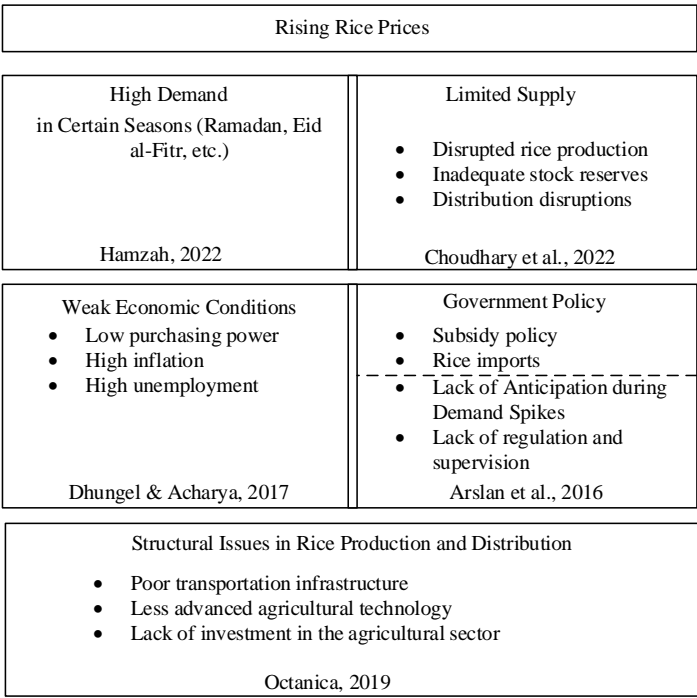


Figure 2: Supply Chain and Rice Prices: Analysis of Dynamics and Impact of Critical Periods
Source: Author, 2024

The price of rice, a staple food for Indonesians, fluctuates frequently, especially during certain periods. This phenomenon causes unrest in the community and impacts national food security (Rozaki, 2020). Rice price increases are triggered by various interrelated factors, ranging from seasonal demand, limited supply, macroeconomic conditions, government policies, to structural problems in the rice production and distribution system. High demand during certain seasons, such as during Ramadan and Eid al-Fitr, causes a surge in rice consumption. The tradition and culture of Indonesians in welcoming these holidays increases the demand for rice significantly. A similar phenomenon also occurs on other national holidays such as Christmas and New Year. Natural disasters such as earthquakes, floods, or droughts can disrupt rice production and distribution, triggering a spike in demand and prices. Rice supply limitations may occur due to production disruptions caused by extreme weather, plant pests and diseases, or conversion of agricultural land (Fahad et al., 2018). National rice reserve stocks managed by Bulog may not be sufficient to meet demand when consumption spikes occur.

Other factors that worsen the situation are distribution disruptions due to poor transportation infrastructure, inefficient logistics, and hoarding of rice by speculators. Weak economic conditions such as low purchasing power, high inflation, and high unemployment can depress rice demand and affect prices (Mane, 2014). Poorly targeted rice subsidy policies can lead to inefficiencies and encourage overconsumption, which in turn increases prices. Uncontrolled rice imports can also disrupt the domestic market and depress local rice prices. Weaknesses in the regulation and supervision of the rice market provide opportunities for fraudulent practices and price manipulation, which exacerbate rice price fluctuations. Government policies on rice subsidies can help ease the burden on the poor, but need to be well-targeted and sustainable to avoid inefficiencies and an overall increase in rice prices (Silalahi et al., 2019). Rice imports can help fulfill supply shortages, but must be done in a timely manner and diversify import sources to protect local farmers. The government needs to conduct an in-depth analysis of rice demand and maintain adequate rice reserves to anticipate spikes in demand and maintain price stability. Strong rice market regulations and strict distribution supervision are needed to prevent fraudulent practices, hoarding, and price disparities.

Structural issues in rice production and distribution such as poor transportation infrastructure, inadequate road networks, and inefficient transportation systems can increase rice distribution costs and push up prices (Choudhary et al., 2022). Traditional farming technologies and lack of adoption of modern technologies hinder the improvement of rice productivity and lead to higher rice prices. Lack of investment in infrastructure, research, and development in the agricultural sector also slows down the increase in rice production and price stability.

3. Result and Discussion

Based on books and journals in several literatures with a total of 11 out of 21 sources that discuss rice price increases and supply chain strategies, a total of 21 sources were used in compiling this paper. The purpose of the research summary table is to provide a comprehensive overview of the research related to the Rice Price Stabilization and Enhancement of National Rice Reserves in Indonesia project (Arslan et al., 2016). The table not only presents a summary of the key findings of each study but also serves as an analytical tool to identify the main focus, key findings, and relevance of each study to the project.

With this table, comparisons between different studies become easier, which can help in understanding the key factors affecting rice price stability and supply chain management. Furthermore, the table provides a solid foundation for formulating effective strategies to achieve food security. In this context, the table serves not only as a tool for researchers and policy makers but also as a guide for other stakeholders in identifying research gaps and priority areas that require further attention (Hawwash et al., 2018). By presenting structured information, the table 1 facilitates the literature review process, enables more effective communication of research findings to various stakeholders, and supports evidence-based decision-making within the project. Overall, this summary of Table 1 is an invaluable tool for understanding and integrating research relevant to rice price stabilization efforts and increasing national rice reserves developed from research (Yuniarti, 2015). By utilizing the information presented in this table, stakeholders can formulate better and more effective strategies to achieve the project's objectives of rice price stability, increased national rice reserves, and food security for all Indonesians.

Table 1: Matrix Framework logic of Rice Price Stabilization and National Reserve Increase

Project Summary	Indicators	Means of Verification	Risks / Assumptions
Goal	Stabilize rice prices on the big Eid al-Fitr holiday next year (2025) and increase national rice reserves	Percentage change in rice prices in Idul Fitri 2025 compared to Idul Fitri 2024 - Increase in the amount of national rice reserves stored in Bulog	- Rice price report from Bulog - Rice reserve Data from Bulog
Outcome	Rice price stability and increased national rice reserves	- Percentage change in rice prices in Idul Fitri 2025 compared to Idul Fitri 2024 - Increase in the amount of national rice reserves stored in Bulog	- Rice price report from Bulog - Rice reserve Data from Bulog
Outputs	1. Increased national rice production	- Increased productivity of Rice farming land	- Rice production reports from the Ministry of Agriculture
	2. Improved rice distribution and logistics system	- Reduction of post-harvest Rice losses	- Distribution and logistics reports from Perum Bulog
	3. Stable and effective government policies on rice imports and minimum rice prices	- More stable and effective Rice import policy	- Policy documents from the Ministry of Agriculture and Ministry of Trade
	1. Increase national rice production through agricultural intensification and extensification programs	- Increased productivity of Rice farming land	- Training and mentoring reports - Seed and Fertilizer Assistance and subsidy reports
	- Training and mentoring of farmers in applying modern Rice cultivation techniques that are more productive		
	- Assistance and subsidies for superior seeds		
	- Fertilizer Assistance and subsidies		
	2. Improve the rice distribution and logistics system	- Reduction of post - Harvest Rice loss	- Rice storage infrastructure report - Transportation network report - Information technology Utilization report
	- Improve Rice storage infrastructure		
	- Improving transportation network for more efficient Rice Distribution		
	- Utilization of information technology to monitor Rice stocks and Distribution		
	3. Regulating government policies on rice imports and minimum rice prices	- A more stable and effective Rice import policy	- Policy documents from the Ministry of Agriculture and Ministry of Trade
	- Establish a prudent Rice import policy based on national stock assessments		
	- Review of the minimum Rice price policy		

4. Conclusion

Based on the project logframe for rice price stabilization and increasing national reserves, more detailed conclusions can be outlined as follows. The project aims to achieve rice price stabilization in the Eid holiday period of 2025 and increase the number of national reserves stored in the Badan Urusan Logistik (Bulog). To achieve this goal, several strategic steps must be taken, including increasing rice production through agricultural intensification and extensification. This includes training farmers in applying modern cultivation techniques, superior seed assistance, as well as fertilizer subsidies to increase rice land productivity.

In addition, improving the rice distribution and logistics system is key in reducing post-harvest losses and ensuring that rice is efficiently available throughout Indonesia. This includes improving rice storage infrastructure and developing a more effective transportation network. In addition, the government's policies on rice imports and minimum rice pricing should be strengthened to ensure long-term market stability. Consistent and prudent policy implementation, supported by continuous monitoring of national stocks and global market conditions, is key to the project's success in achieving the objectives of stabilizing rice prices and increasing national reserves in a sustainable manner.

5. Future Research for Rice Price Stabilization

The Rice Price Stabilization and National Rice Reserve Enhancement Project offers a long-term solution to Indonesia's food security. Its success depends not only on effective implementation, but also on continuous research and development. A holistic approach that includes increased production, improved distribution, and effective policy settings has the potential to stabilize rice prices and enhance food security. Rigorous monitoring and evaluation will ensure project effectiveness and goal achievement. The success of this project has a direct impact on the welfare of the Indonesian people by maintaining the affordability of rice as a staple food.

For future research, several important areas need to be addressed. First, in-depth rice demand research is needed to study complex demand patterns and accurately predict rice demand, so as to anticipate demand spikes and prevent shortages. Second, optimization of the distribution and logistics system needs to be done by utilizing the latest technology to increase efficiency, transparency, and minimize post-harvest losses. Third, diversification of rice import sources should be identified, by establishing mutually beneficial long-term cooperation with reliable alternative supplier countries. Fourth, the development of superior rice varieties is a priority, by investing in research and development of rice varieties that are more productive, pest and disease resistant, and adaptive to climate change. Fifth, the utilization of information and communication technology (ICT) is essential, by developing digital platforms to connect rice market players and applying educational technology to improve farmers' knowledge. Finally, the impact of global policies and economics needs to be analyzed, by examining the impact of international policies and global food price fluctuations on the domestic rice market, and developing risk mitigation strategies.

By focusing on these research areas, Indonesia can strengthen the foundation of the Rice Price Stabilization and National Rice Reserve Improvement Project. Continued research and development will contribute to the achievement of lasting food security, rice price stability, and ultimately improve the welfare of the Indonesian people.

Acknowledgements

This paper is a result of the project "Challenges and Strategies for Rice Price Stability: A Systematic Review of Supply Chain Dynamics in Indonesia During Critical Periods" conducted by Rizki Alifnur Harmawan. I would like to express my deepest gratitude to Ms. Erna Mulyati for her guidance and support during this research. Finally, I would like to thank my family and friends for their encouragement and support.

References

- Arslan, Hermanto, A. S., & Bahri, D. S. S. (2016). Rice Price Policies in Indonesia: A Computable General Equilibrium (CGE) Analysis. *AgEcon Search*, 18.
- Barboza, G., Gavinelli, L., Pede, V., Mazzucchelli, A., & Di Gregorio, A. (2021). A Contribution to the Empirics of Food Price Behavior: The Case of Rice Price Dynamics in Italy. *British Food Journal*, 123(1), 419–440. <https://doi.org/10.1108/BFJ-12-2019-0937>
- Choudhary, D., Banskota, K., Khanal, N. P., McDonald, A. J., Krupnik, T. J., & Erenstein, O. (2022). Rice Subsector Development and Farmer Efficiency in Nepal: Implications for Further Transformation and Food Security. *Frontiers in Sustainable Food Systems*, 5(January), 1–14. <https://doi.org/10.3389/fsufs.2021.740546>
- Connor, M., Gummert, M., & Singleton, R. G. (2023). *Closing Rice Yield Gaps in Asia*.
- Davis, K. F., Downs, S., & Gephart, J. A. (2021). Towards Food Supply Chain Resilience to Environmental Shocks. *Nature Food*, 2(1), 54–65. <https://doi.org/10.1038/s43016-020-00196-3>
- Deperiky, D., Santosa, S., Hadiguna, R. A., & Nofialdi, N. (2020). Agroindustry Supply Chain Management: A Literature Review. *INVENTORY: Industrial Vocational E-Journal on Agroindustry*, 1(1), 1. <https://doi.org/10.52759/inventory.v1i1.17>
- Dhungel, S., & Acharya, P. (2017). Role of Rice in Food and Nutrition Security in Nepal. *Rice Science and Technology in Nepal, Cdd*, 77–85. <http://www.ricestat.irri.org>
- Fahad, S., Adnan, M., Noor, M., Arif, M., Alam, M., Khan, I. A., Ullah, H., Wahid, F., Mian, I. A., Jamal, Y., Basir, A., Hassan, S., Saud, S., Amanullah, Riaz, M., Wu, C., Khan, M. A., & Wang, D. (2018). Major Constraints for Global Rice Production. *Advances in Rice Research for Abiotic Stress Tolerance, February*, 1–22. <https://doi.org/10.1016/B978-0-12-814332-2.00001-0>
- Hamzah, I. N. (2022). *Understanding Indonesian Most Strategic Food Consumption Pattern and Welfare Impact of Price Increase Events: A Household Microdata Analysis*. <https://stud.epsilon.slu.se/18092/>
- Hawwash, D., Pinxten, W., Bonn, N. A., Verstraeten, R., Kolsteren, P., & Lachat, C. (2018). Perspective: Consideration of Values when Setting Priorities in Nutrition Research: Guidance for Transparency. *Advances in Nutrition*, 9(6), 671–687. <https://doi.org/10.1093/ADVANCES/NMY039>
- Kalkuhl, M., Braun Von, J., & Torero, M. (2019). Food Price Volatility and Its Implications for Food Security and Policy. In *Transforming Agriculture in Southern Africa: Constraints, Technologies, Policies and Processes*. https://doi.org/10.1300/j144v06n01_02
- Li, J., & Song, Z. (2022). Dynamic Impacts of External Uncertainties on the Stability of the Food Supply Chain: Evidence from China. *Foods*, 11(17), 1–31. <https://doi.org/10.3390/foods11172552>
- Linn, T., & Maenhout, B. (2019). The Impact of Environmental Uncertainty on the Performance of the Rice Supply Chain in the Ayeyarwaddy Region, Myanmar. *Agricultural and Food Economics*, 7(1), 1–29. <https://doi.org/10.1186/s40100-019-0128-6>
- Mane, R. (2014). Assessing Food Policy Options in Asia to Reduce Price Volatility of Rice Market. *Theses and Dissertations Retrieved from* <https://Scholarworks.Uark.Edu/Etd/2146>.

- Octanica, G. (2019). *The Government's role in the Indonesian rice supply chain*. 32.
- Patel, K. R. (2023). BULLET: Jurnal Multidisiplin Ilmu Enhancing Global Supply Chain Resilience: Effective Strategies for Mitigating Disruptions in an Interconnected World. *Jurnal Multidisiplin Ilmu*, 2(1), 257–264. <https://journal.mediapublikasi.id/index.php/bullet>
- Rozaki, Z. (2020). *Free Information in English and Mandarin on the Novel Coronavirus COVID-Food Security Challenges and Opportunities in Indonesia post COVID-19*. January, 1–51.
- Se, C. H., Khor, B. H., & Karupaiah, T. (2015). Prospects in Development of Quality Rice for Human Nutrition. In *Malaysian Applied Biology* (Vol. 44, Issue 2).
- Sekhar, C. S. C. (2018). Climate Change and Rice Economy in Asia: Implications for Trade Policy Background Paper for The State of Agricultural Commodity Markets (SOCO) 2018. In *Fao*. <http://www.wipo.int/amc/en/mediation/rules>
- Silalahi, N. H., Yudha, R. O., Dwiyantri, E. I., Zulvianita, D., Feranti, S. N., & Yustiana, Y. (2019). Government Policy Statements Related to Rice Problems in Indonesia: Review. *3BIO: Journal of Biological Science, Technology and Management*, 1(1), 35. <https://doi.org/10.5614/3bio.2019.1.1.6>
- Timmer, C. P. (2012). Rice Price Formation in the Short Run and the Long Run: The Role of Market Structure in Explaining Volatility. *Global Uncertainty and the Volatility of Agricultural Commodities Prices*, 172, 151–184. <https://doi.org/10.3233/978-1-61499-037-6-151>
- Wijaya, S. (2019). Indonesian Food Culture Mapping: A Starter Contribution to Promote Indonesian Culinary Tourism. *Journal of Ethnic Foods*, 6(1), 1–10. <https://doi.org/10.1186/s42779-019-0009-3>
- Wurdiana, L. (2019). Factors Affecting the Domestic Price of Rice in Indonesia. *Jurnal Edudikara*, 9(1), 19.
- Yuniarti. (2015). Application of the Logical Frame Works Program Model. *Pena Jurnal Ilmu Pengetahuan Dan Teknologi*, 29(1), 47–53

Analysis and Implementation of the User-Centered Design Method in Designing a Web-Based Bidding Participation Information System: A Case Study at PT Pos Indonesia (PERSERO)

Kokoh Handoko^{1*} & Agus Purnomo¹

¹Department of Logistics Management, Faculty of Logistics, Technology and Business,
Universitas Logistik dan Bisnis Internasional, Bandung, Indonesia

^{1*}211230056@std.ulbi.ac.id & ¹aguspurnomo@ulbi.ac.id

Abstract

This research aims to design a web-based information system for monitoring PT Pos Indonesia's bidding participation activities using the User-Centered Design (UCD) methodology. The UCD approach ensures that the system is tailored to meet the needs and preferences of its users, thereby enhancing usability and user satisfaction. The study begins with a detailed analysis of the current bidding management processes at PT Pos Indonesia, identifying key challenges and requirements. Through iterative design and continuous user feedback, the proposed system is developed to streamline the bidding participation workflow, improve data accuracy, and facilitate better decision-making. The findings indicate that implementing a UCD-based information system significantly improves the efficiency and effectiveness of managing bidding activities. Users reported higher satisfaction levels due to the system's intuitive interface and enhanced functionality. Moreover, the system's ability to provide real-time data and analytics supports better strategic planning and operational decision-making. In conclusion, the study demonstrates that a user-centered approach to system design can lead to substantial improvements in both user experience and organizational performance. The web-based bidding information system developed for PT Pos Indonesia serves as a model for other organizations looking to enhance their bidding management processes through technology.

Keywords: User-Centered Design, Bidding Management, Bidding Participation, System Information, Procurement

1. Introduction

Procurement, or the procurement of goods and services, is an important process in supply chain management that involves purchasing goods and services needed by an organization to carry out its operations (A. Malik, 2017). From the perspective of goods and services providers, this procurement process does not only mean selling products or services but also acting as a strategic partner in meeting needs and ensuring the client's operations run smoothly. Providers of goods and services have a crucial role in ensuring that the goods or services required by the organization are available at the appropriate quality, quantity, price, and time. They must be able to understand the specific needs of customers and offer the most effective solutions (Tukimun, 2024).

PT Pos Indonesia, a large company operating in the field of postal and logistics services, is often involved in project tenders, both from the government and the private sector as a courier and logistics service provider. The participation of PT Pos Indonesia in the procurement process of goods and services is not only carried out by the Central Post. Headquarters in Jakarta or Bandung but also by all its branches throughout Indonesia. Because all branches can participate in the procurement of goods and services, of course, PT Pos Indonesia must supervise the participation in the procurement of goods and services/tenders to win the tenders that are followed and also ensure the suitability of the services offered.

Table 1 PT Pos Indonesia Tender Participation in 2023

No	Region	Description	Number of Tenders	Project Value (Billion)
1	Head Office	National	55	2.296,90
2	Reg 01 Medan	Sumatera	11	1,26
3	Reg 02 Jakarta	DKI Jakarta & Banten	150	141,90
4	Reg 03 Bandung	West Java	4	0,30
5	Reg 04 Semarang	Central Java & DI Jogjakarta	13	15,46
6	Reg 05 Surabaya	East Java, Bali, NTT & NTB	6	177,70
7	Reg 06 Makassar	Kalimantan, Sulawesi, Maluku & Papua	4	160,81
Grand Total			243	2.794,33

Source: Bidding Department of PT Pos Indonesia (Persero)

However, the process of supervising tender participation by PT Pos Indonesia is currently still facing various obstacles because it is still done manually. Some of them are errors in data recording, delays in document collection, and inaccuracies in information. This not only has an impact on operational efficiency but can also reduce the chances of PT Pos Indonesia winning the tender. In an era of increasingly fierce business competition, having an effective system to manage tender participation activities is very important (K. Agustian et al., 2023).

The use of web-based information systems is considered the right solution to overcome this problem (C. Barry, 2003). The web-based information system allows for wider and real-time access, facilitates data integration, and supports collaboration between divisions involved in the tender process (M. Salahuddin & B. Maulana, 2023). However, the development of an effective information system depends not only on the technology used but also on how well the system meets the needs of the end user. The User-Centered Design (UCD) method is an approach that puts the user at the center of the system design process. By using UCD, system designers will focus more on the needs, preferences, and limitations of the end user (M. Agarina & A. Suryadi Karim, 2019). The UCD process involves users at every stage of development, from requirements gathering to system testing and evaluation. Thus, the resulting information system is not only effective from a technical point of view but also easy to use and according to the needs of users.

Various studies have shown that the application of UCD can improve the quality and acceptance of information systems by users. For example, research by Abran et al., (2003) shows that systems designed with UCD principles tend to be easier to use and accept by end users. Another study by Gould and Lewis (1985), emphasized the importance of user involvement in the design process to ensure that the system developed is truly tailored to their needs. In addition, a study by Beyer and Holtzblatt (1998) underlines that understanding the user's working context through methods such as direct observation and in-depth interviews can result in a more relevant and useful system design.

In the context of PT Pos Indonesia, this study aims to design a web-based tender participation activity information system using the UCD method. With this approach, it is hoped that the information system developed can overcome existing problems and improve the efficiency and accuracy of the tender participation process. In addition, this research is expected to contribute to the development of science, especially in the field of information system development with the UCD approach. This research can be a reference for the development of similar information systems in other fields, and a reference for further research on the application of UCD in different contexts.

2. Methods

This study uses a qualitative approach with a type of descriptive research which is research based on the philosophy of postpositivism used to research on the condition of natural objects where the researcher is the key instrument (Sugiyono, 2021). The approach in this study was taken because the researcher wanted to describe and get an overview of the tender participation activities that are being researched by observing and interviewing the parties involved in the tender process directly and also collecting the data and information needed as the basis for designing a web-based tender participation information system. The population in this study is all regional and central Bidding champions totaling 21 people. For samples using the Proportionated Stratified Random Sampling method with a sampling error rate of 10%, with the formulation of Slovin, the sample taken amounted to 20 people according to the details of their position level.

The analysis model of this study uses the User-Centered Design (UCD) model which is a design process that emphasizes the importance of understanding the needs of the end-user and integrating this understanding into each stage of product or system development. Figure shows the stages of UCD according to ISO (2010).

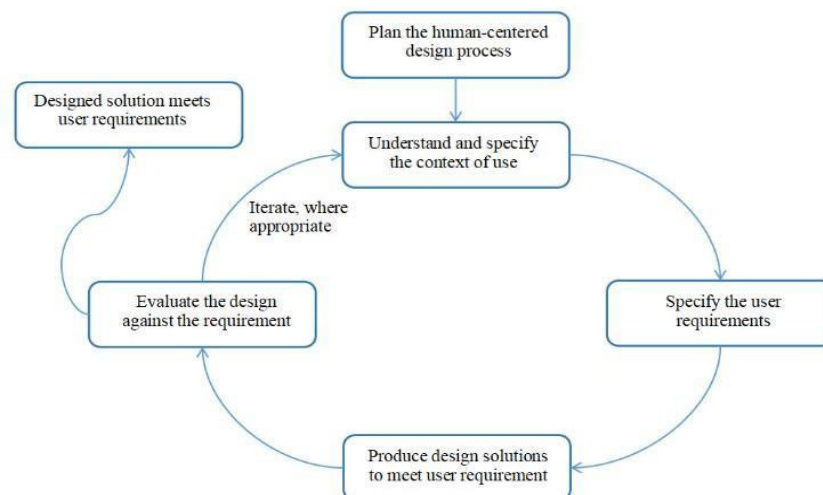


Figure 1 Stages of UCD
Source: ISO 9241-210

3. Result and Discussion

Plan the Human-Centered Process

The stages will be carried out by collecting data on information system stakeholders with interviews to find out who the users of the system are and determine the goals and tasks of the system users. Interview questions can be seen in Table 3.1 below:

Table 2 Results of Bidding Stakeholder Interviews

No	Question	Answer
1	What must be collected in the system?	This system is used to collect data on potential offers. Then the data will be updated in the bidding activity process until the final result is win or lose. If you win, the data must be updated again to find out the realization of the bid won. Apart from that, the system is also a storage place for documents for tender purposes.
2	Who will be involved in using the system?	System users will consist of Super admin, Senior Manager/bidding manager and bidding champion.
3	Before the system was created, How to collect data the?	The bidding section uses Google forms and Excel files which are shared on Telegram groups and other media to collect data. The speed of response to each other depends on the busy conditions of each person.

No	Question	Answer
4	What is the level of information which can be accepted by each user system?	super admin is the highest level who has access rights to the entire system menu. super admin can also manage users, references and access to upload documents for tender purposes. The senior manager/Bidding Manager has the task of approving potential bidding data submitted by the bidding admin. Apart from that, you also have access to view reports on bidding potential, bidding activity and the realization of won projects. Bidding Champions have access to increase bidding potential, update bidding activity and access all reports.
5	What is the environment in which the system will be implemented?	The environment where it is implemented consists of people who are experienced and in an environment where many information systems are implemented.
6	In the system that will be designed, what processes can the system carry out?	The system is able to store data on potential bids and can accommodate bidding activities starting from registration, meeting/not fulfilling the requirements, explanation/aanwijzing, proposal submission to winning/losing. The system is also expected to be able to present data reports in graphical form from the collected data.
7	In the system to be designed, what needs to be displayed on the system?	The system displays data on bidding potential, bidding activity, realization of won projects as well as updated documents for bidding purposes. The system also displays reports from each of these activities and also provides a dashboard that displays the winning ratio of bidding, project realization versus project value obtained and control of each bidding activity.

Specify the Context of Use

Based on the results of interviews and observations, it was found that the system design process will include 3 Users, namely Super admin, Bidding Manager, and Bidding Champion. Furthermore, the analysis will be described in the form of a use-case diagram which is an overview of the model of system interaction with users used to determine the system's functional needs (O. Fitria et al., 2016).

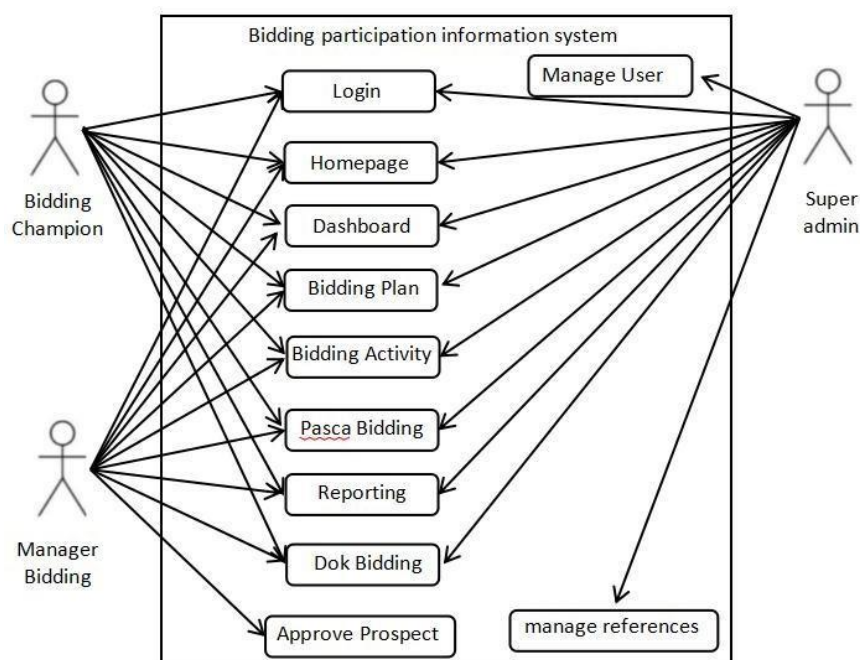


Figure 2 Use Case Diagram Bidding Participation Information System

Specify User and Organization Requirements

Stages that aim to find out the needs and determine the functional requirements for the user's system. The result of the analysis at this stage is how the level of access rights of each system user is the need for system functionality. Of the three users who will operate the system, there are different levels of access to the system depending on the needs and capacity of the user. The following is an explanation of the analysis of the functionality needs of the users:

1. Super admins have access rights in the form of system management, managing user access rights, adding users, managing references, and updating bidding documents.
2. Bid managers have access rights to approve bid lead submissions, view reports and dashboards.
3. Bid Champion has access rights in the form of bidding prospect data input, bidding activity update input, post-bidding data input, bidding document download, viewing reports, and dashboards

Product Design Solutions

The design of the tender participation information system interface is as follows:



Figure 3 Mockup Login Page



Figure 4 Mockup Homepage & dashboard

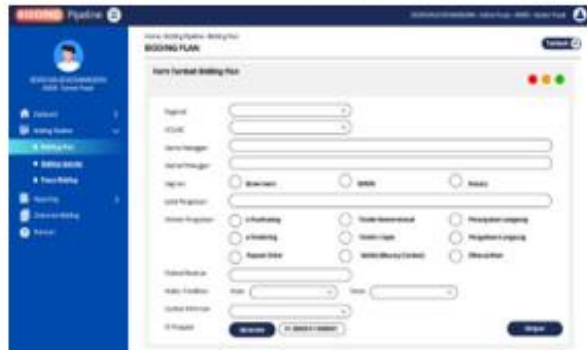


Figure 5 Mockup Input Data Prospect



Figure 6 Mockup Update Bidding Activity



Figure 7 Mockup Input update Pasca Bidding



Figure 8 Mockup Reporting Prospect Bidding

preferences are prioritized at every stage of development. Second, the active participation of users in the design process has allowed for more accurate and efficient identification and troubleshooting, ultimately improving the efficiency and effectiveness of the system. Third, the use of this method also has the potential to increase user adoption and satisfaction rates, as the system is designed to truly match their expectations and needs.

Based on the results of this study, there are several directions that can be used as a focus for future research. First, further research can be conducted to test and evaluate the effectiveness of user-centered design methods in the context of other information systems, in order to generalize these findings. Second, a deeper exploration of the integration of the latest technologies, such as artificial intelligence and machine learning, into auction participation information systems could provide new insights into how they can improve performance and user experience. Third, longitudinal studies that observe the long-term impact of implementing user-centered design on user satisfaction and retention can provide more comprehensive data on the benefits of this method. Finally, research on the adaptation and adaptation of these methods in various cultural and organizational contexts can also provide practical guidance for the broader application of user-centered design.

References

- A. Abran, A. Khelifi, W. Suryn, and A. Seffah, "Usability meanings and interpretations in ISO standards," in *Software Quality Journal*, Kluwer Academic Publishers, 2003, pp. 325–338. doi: 10.1023/A:1025869312943
- A. Malik, *Theory of Procurement of Public Goods and Services*, 2017, [Online]. Available: <https://www.researchgate.net/publication/333667316>.
- C. Barry, "Web-based Information Systems-Time for the Revisionists," 2003. [Online]. Available: <https://www.researchgate.net/publication/254999236>
- H. Ledgard, J. D. Gould, and C. Lewis, "Human Aspects of Computing Designing for Usability: Key Principles and What Designers Think," 1985. doi: <https://doi.org/10.1145/3166.3170>
- H. Beyer and K. Holtzblatt, "Contextual Design: Defining Customer-Centered Systems," 1998. Accessed: Jun. 06, 2024. [Online]. Available: <https://dl.acm.org/doi/book/10.5555/2821566>
- J. Agustian, A. Pohan, A. Zen, W. Wiwin, and A. J. Malik, "Human Resource Management Strategies in Achieving Competitive Advantage in Business Administration," *Journal of Contemporary Administration and Management (ADMAN)*, vol. 1, no. 2, pp. 108–117, Oct. 2023, doi: 10.61100/adman.v1i2.53.
- M. Salahuddin & B. Maulana, "Designing a Web-Based Information System for Scholarship Management: Supporting Access and Rapid Dissemination of Information Bachtiar Maulana," *ITEJ*, vol. 8, pp. 14–33, 2023, [Online]. Available: <https://syekhnurjati.ac.id/journal/index.php/itej>
- M. Agarina and A. Suryadi Karim, "User-Centered Design Method in the Analysis of User Interface Design of the Department of Informatics System's Website," 2019.
- O. Fitria, N. Hasanah, M. Pd, and R. S. Untari, *Software Engineering Textbook*. 2020.
- Sugiyono, "Research methods," Bandung: Alfabeta, 2021. ISO 9241-210, "Ergonomics of human-system interaction-Human-centred design for interactive systems," 2010
- Tukimun, *Procurement management*. 2024. [Online]. Available: www.sulur.co.id
- Z. Sharfina and H. B. Santoso, "An Indonesian Adaptation of the System Usability Scale (SUS)," 2016. doi: 10.1109/ICACISIS.2016.7872776

The Impact of Digital Transformation, Logistics Competence, Transformational Leadership on Business Model Innovation and Its Implications for Company Performance

Realyta B. U. Sirait¹ & Saptono Kusdanu Waskito²

¹University Of Logistics and International Business, Indonesia

Logistics management master's study program

Jl. Sariasih No 54, Sarijadi, Bandung City

¹realitasirait@gmail.com & ²saptono@ulbi.ac.id

Abstract

PT PosIND's revenue realization reached 80%. This means there is a company performance problem. The author examines the influence of digital transformation, logistics competency, leadership transformation on business model innovation, and business model innovation on company performance. The results show there is a positive and significant influence of transformation leadership on business model innovation and logistics competence on business model innovation. Next, there is a positive and insignificant influence of digital transformation on business model innovation. In addition, there is a positive and significant influence of business model innovation on company performance. It is recommended that companies increase improvements in logistics competence and digital transformation because they have no significant impact.

Keywords: Digital Transformation, Logistics Competence, Transformational Leadership, Business Model Innovation, Company Performance

1. Introduction

PT PosIND's revenue realization in 2023 is only 80% of the target. This information proves that there are problems with the performance of the PT PosIND company. Company performance refers to the results of an organization's performance in achieving its goals and effectiveness, which can be influenced by various factors such as organizational culture, structure, strategy, and management knowledge. (Martínez-Caro et al., 2020). Company performance can generally be defined as the company's ability to achieve the desired goals and results, both financially and non-financially. Company performance covers various aspects such as profitability, productivity, operational efficiency, innovation, customer satisfaction, and business growth. Evaluation of company performance is usually carried out by measuring and comparing the results that have been achieved with previously set targets (Büchi et al., 2020). The dimensions of company performance according to (Damayanti et al., 2023) consist of financial performance, marketing performance and operational performance.

Company performance can be defined as the result of various activities and decisions carried out by the company which are reflected in the achievement of the company's overall financial, operational, and strategic goals (Chege & Wang, 2020). Economic performance is all about financial performance (Yusliza et al., 2020). Company performance in the context of includes financial, social and environmental aspects, which are in line with the "Triple Bottom Line" (TBL) concept. Company performance is not only seen from a financial perspective, but also includes contributions to the three traditional pillars of sustainability: environmental, social, and economic (Ortiz-Martínez et al., 2023). Company performance can be defined as the results or output achieved by a company in carrying out its business activities, which includes financial and non-financial aspects.

This performance reflects the company's effectiveness and efficiency in achieving its strategic goals and meeting stakeholder expectations (N. Burhan & Rahmanti, 2012). Company performance can be interpreted as the company's ability to meet the growing market demand for these products by producing devices that have high energy and power density (Yuan et al., 2023). Company performance is influenced by business model innovation. According to Haftor & Climent Costa (2023), business model innovation is defined as the process of creating, modifying, or defining the fundamental structure and components of a business model to create new value propositions, capture new market opportunities, and gain a competitive advantage. The dimensions of business model innovation consist of exchangeables, activities, and machines.

Digital transformation is generally defined as “the use of new digital technologies, such as mobile, artificial intelligence, cloud, blockchain, and the Internet of Things (IoT), to enable significant business improvements (Omrani et al., 2024). Digital transformation is the process of integrating digital technology into all aspects of business operations, fundamentally changing the way an organization operates and delivers value to customers. This process involves the adoption of new technologies, changes in organizational culture, and business model innovation to increase efficiency, responsiveness, and competitiveness in an increasingly digital marketplace. Digital transformation covers various aspects such as process automation, use of analytical data for decision making, development of digital products and services, as well as improving customer experience through technology (Jing et al., 2023). Digital transformation is a company's ability to redesign business components, processes, culture, and strategy to meet market needs thanks to digital advances.

This transformation allows companies to optimize business processes, predict market demand, and create value for customers (Chen et al., 2024). Digital transformation is a significant approach to dealing with managerial issues such as human resources, business efficiency, and business process redesign, enabled by the integration of modern information and communication technologies (Zuzaku & Abazi, 2022). Digital transformation in a government context involves the application of digital technologies among departments, the adjustment of resources, the reform and development of organizational structures, administrative processes, and business procedures (Xiao et al., 2023). Business model innovation is influenced by digital transformation. According to Udovita (2020), digital transformation is the integration of digital technology into all areas of a business, fundamentally changing how you operate and deliver value to customers. Dimensions of Digital Transformation are personalized service, asset sharing, organization (Udovita, 2020).

Logistics competence can be defined as the capability and proficiency in managing and executing logistics activities effectively and efficiently. It involves having the necessary knowledge, skills, and resources to plan, coordinate, and optimize the flow of goods and services from the point of origin to the point of consumption. Logistics competence is crucial for organizations to meet customer demands, reduce costs, and improve overall supply chain performance (Lu & Lin, 2012). Logistics competence is the skills and knowledge required to effectively and efficiently manage and coordinate the movement of goods, materials, and information in global supply chains (Leonova, 2022). Logistics competence is the ability of individuals, divisions or organizations to acquire, manage and apply knowledge effectively and efficiently in order to improve logistics performance (Radzi et al., 2020). Logistics capabilities are defined as the specialized skills, attributes and knowledge within a firm that helps it to manage its logistics activities such as transportation and distribution of raw materials and finished goods, in an efficient, safe and effective way (Mandal et al., 2017).

Logistics capabilities are one of the key dynamic capabilities of a firm, affecting the creation of business models, as well as the formulation of the firm's business strategies. They have been identified as being important in relation to responding to unexpected events or supply chain disruptions. According to Matwiejczuk (2020), logistics capabilities can be developed in both the "real sphere" where they are associated with processes such as transport, storage, and handling, and in the "regulatory sphere" where they are associated with decision processes such as the flow of materials and information, and the subsequent management of these (Al-Madi et al., 2021). Business model innovation is influenced by logistics competence. According to Thepmongkorn & Pitchayadejanant (2020), logistics competence include knowledge, skills, attitude of staff in logistics activities.

Transformational leadership (TL) can be understood as the ability of a leader to influence the behavior of his or her workers through the use of charisma, inspiration, intellectual stimulation and individualized consideration (García-Morales et al., 2008). Authors such as Al-Husseini et al (2021) determined that the relationship between TL and innovation is due to the fact that some key dimensions of TL such as idealized influence, intellectual stimulation, and individualized consideration, favor the innovation process of work teams, considerably increasing the creative thinking of employees and encouraging them to share their ideas with their leader and peers. Transformational leadership is a leader's ability to inspire and motivate followers to achieve higher shared goals, exceed minimum expectations, and bring about significant positive change (Mai et al., 2022), Transformational leadership centers on establishing and conveying a vision that is broader than personal interests.

This vision develops naturally through direct interaction, both verbal and nonverbal, between leaders and followers. The transformational motivation that exists between leaders and their followers is a topic of in-depth research (Greimel et al., 2023). Transformational leadership stands out as a leadership style that is able to lead organizations to achieve higher goals. Leaders with this style have a clear and inspiring vision, motivating their followers to exceed expectations and work together to make that vision a reality (Chen et al., 2024). Business model innovation is influenced by transformational leadership. Transformational leadership is a style of leader who influences sub ordinate to perform beyond the expectation. The dimensions from Transformational Leadership are an intellectual stimulation, inspirational motivation, and individual consideration (Hilton et al., 2023).

The differences that separate the researcher from the articles written above are:

1. There is a positive and insignificant influence of digital transformation on business model innovation.
2. There is a positive and insignificant effect of logistics competency on business model innovation.
3. Until now, there has been no quantitative research that examines the influence of business model innovation on company performance.

2. Body of Paper.

Research Methods

This research uses quantitative, descriptive and analytical methods. According to Arikunto (2021), quantitative research methods are research methods to examine the behavior of a population or sample (part of the population). The author conducted research using descriptive methods. According to Sudaryanyo (2021), descriptive research is research to obtain a description or picture of certain characteristics of the variables being studied, usually described in the form of an average

value of a variable. The author conducted research using the verification method. According to Siregar (2023), verification research is research used to test the truth of knowledge in an existing field. Verification research is used to prove the opinions of experts regarding the influence of independent variables on intervening variables, the influence of intervening variables on dependent variables.

Research Model

The research model in this study is presented in Figure 2.1.

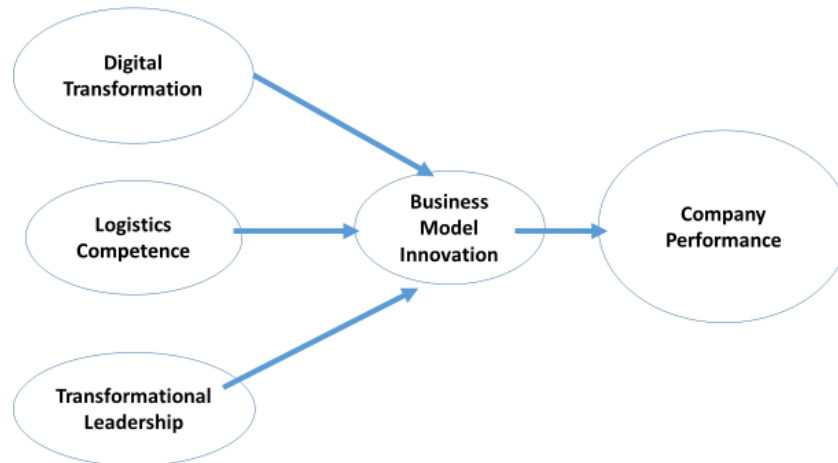


Figure 1: Research Model.

Total population is 240 employees at PT PosIND Head Office. The number of samples was determined using the Slovin formula as 150 people.

Hipotesis

The author sets the following hypotheses:

No Hypotheses

1. H₁ : There is a positive and significant influence of digital transformation on business model innovation.
2. H₂ : There is a positive and significant influence of logistics competence on business model innovation.
3. H₃ : There is a positive and significant influence of transformational leadership on business model innovation.
4. H₄ : There is a positive and significant influence of digital transformation, logistics competence, transformational leadership on business model innovation simultaneously.
5. H₅ : There is a positive and significant influence of business model innovation on company performance.

3. Results

The research results explain that the average value of each indicator is between 2.773 to 3.220 and is grouped as a fairly good variable. Waskito (2023), elaborates that variable that are worth researching are variables that have an average value from 1,000 to 3,400. Based on Waskito's opinion (2023), it can be explained that the variables in this research meet the requirements for research.

The research results explain that the load factor value of all indicators on the variables is between 0.736 and 0.983. This value is greater than 0.700. So, because all indicators have a load

factor value greater than 0.700, then by referring to Hasnita's opinion (2021), all indicators in this research are declared valid. Hasnita (2021) explains that a variable is said to be reliable if each variable has a Cronbach's Alpha value greater than 0.700. All variables have a Cronbach's Alpha value between 0.928 to 0.982 and are above 0.70, so all variables are declared reliable for research.

The results of the research explain that the path coefficient value of transformational leadership for business model innovation is 0.450 with a p value of 0.007. This means that there is a positive and significant influence of transformational leadership on business model innovation. In addition, there is also a positive and insignificant influence of digital transformation on business model innovation with a path coefficient value of 0.264 (positive) with a p value of 0.178. Next, there is a positive and insignificant influence of logistics competence on business model innovation with a path coefficient value of 0.222 with a p value of 0.113 which is greater than 0.05. The research results explain that the R Square value is 0.838. which means that there is a positive and significant influence of digital transformation, logistics competence, transformational leadership on business model innovation.

The Path Coefficient value of the influence of business model innovation on company performance is 0.778 with a p value of 0.000. This means that there is a positive and significant influence of business model innovation on company performance. The overall results of the research using the Structural Equation Model (SEM) with the PLS application are presented in Figure 2.2 below:

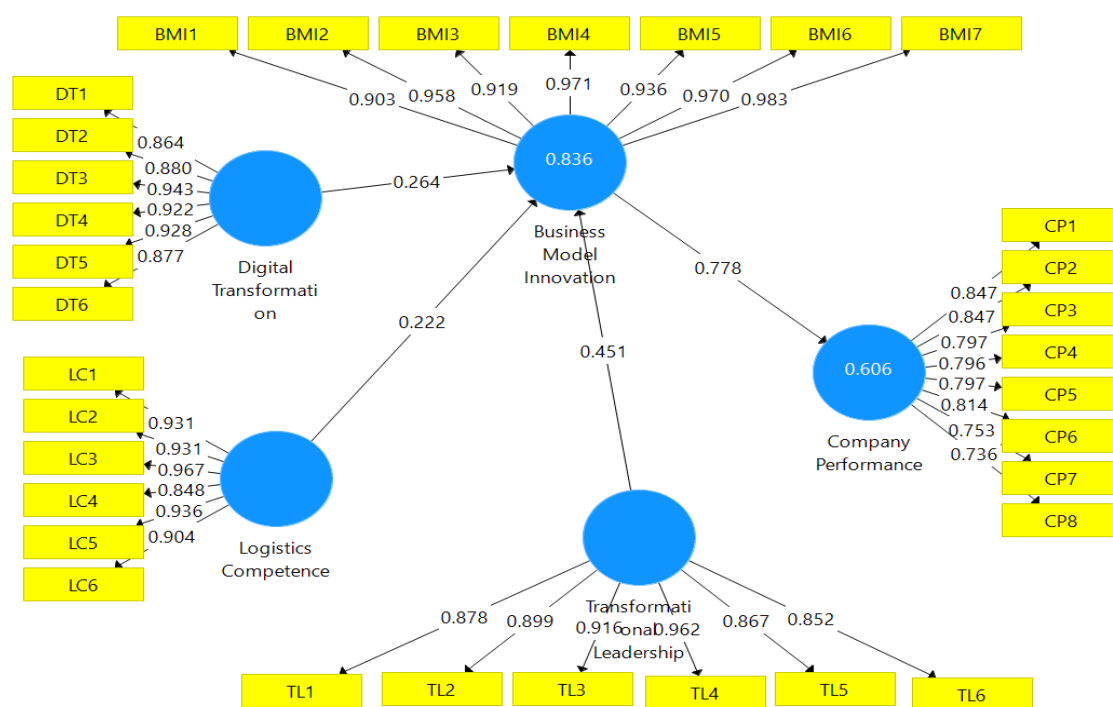


Figure 2: Result Research

4. Implication and Direction for Future Research

Implication

The author recommends that PT PosIND should increase the influence of digital transformation by increasing the use of assets belonging to PT PosIND and those belonging to suppliers hired by PT PosIND and increasing the organization's agility in dealing with dynamic customer desires. PT PosIND should increase its organizational agility to provide fast, precise and safe service to

customers. PT PosIND should also improve the knowledge, skills, and attitudes of staff so that they are ready to provide service excellence to customers. PT PosIND leaders should continuously increase intellectual stimulation for staff by holding training which is expected to improve service to customers. PT Pos IND should increase staff motivation so that they are motivated to improve staff performance to support company performance. PT PosIND should increase awareness of staff, so that staff are inspired to improve performance.

Direction

The author has succeeded in proving that Business Model Innovation influences the Corporate Company PT Pos Indonesia. But the contribution is only 0.778 or 77.80%. There is still an opportunity for other researchers to examine other variables that can influence the Company. For example, the variables Agility Logistics, Lean Logistics.

References

- Al-Madi, F., Alfalah, T., Shraah, A & Abu-Rumman, A. (2021). Supply chain practices and organizational performance: Evidence from Jordanian medical devices firms. *Uncertain Supply Chain Management*, 9(4), 831-840.
- Al-Husseini, S., El Beltagi, I., & Moizer, J. (2021). Transformational leadership and innovation: the mediating role of knowledge sharing amongst higher education faculty. *International Journal of Leadership in Education*, 24(5), 670–693. <https://doi.org/10.1080/13603124.2019.1588381>
- Büchi, G., Cugno, M., & Castagnoli, R. (2020). Smart factory performance and Industry 4.0. *Technological Forecasting and Social Change*, 150(October 2019), 119790. <https://doi.org/10.1016/j.techfore.2019.119790>
- Chege, S. M., & Wang, D. (2020). The influence of technology innovation on SME performance through environmental sustainability practices in Kenya. *Technology in Society*, 60(November 2019), 101210. <https://doi.org/10.1016/j.techsoc.2019.101210>
- Chen, A., Li, L., & Shahid, W. (2024). Digital transformation as the driving force for sustainable business performance: A moderated mediation model of market-driven business model innovation and digital leadership capabilities. *Heliyon*, 10(8), e29509. <https://doi.org/10.1016/j.heliyon.2024.e29509>
- Damayanti, D. A., Fitriani, R., & Wahyudin, W. (2023). Analisis Pengukuran Kinerja Perusahaan Melalui Key Performance Indicator Pada PT. XYZ. *Jurnal Serambi Engineering*, 8(2), 5099–5105. <https://doi.org/10.32672/jse.v8i2.5682>
- García-Morales, V. J., Lloréns-Montes, F. J., & Verdú-Jover, A. J. (2008). The effects of transformational leadership on organizational performance through knowledge and innovation. *British Journal of Management*, 19(4), 299–319. <https://doi.org/10.1111/j.1467-8551.2007.00547.x>
- Greimel, N. S., Kanbach, D. K., & Chelaru, M. (2023). Virtual teams and transformational leadership: An integrative literature review and avenues for further research. *Journal of Innovation and Knowledge*, 8(2), 100351. <https://doi.org/10.1016/j.jik.2023.100351>
- Haftor, D. M., & Climent Costa, R. (2023). Five dimensions of business model innovation: A multi-case exploration of industrial incumbent firm's business model transformations. *Journal of Business Research*, 154(July 2022), 113352. <https://doi.org/10.1016/j.jbusres.2022.113352>
- Hilton, S. K., Madilo, W., Awaah, F., & Arkorful, H. (2023). Dimensions of transformational leadership and organizational performance: the mediating effect of job satisfaction. *Management Research Review*, 46(1), 1–19. <https://doi.org/10.1108/MRR-02-2021-0152>
- Jing, H., Zhang, Y., & Ma, J. (2023). Influence of digital ambidextrous capabilities on SMEs'

- transformation performance: The mediating effect of business model innovation. *Heliyon*, 9(11), e21020. <https://doi.org/10.1016/j.heliyon.2023.e21020>
- Leonova, S. (2022). *Competency based model for logistics and supply chain management Analysis of the last research*. 12(2022).
- Lu, C. S., & Lin, C. C. (2012). Assessment of national logistics competence in Taiwan, Vietnam, and Malaysia. *Asian Journal of Shipping and Logistics*, 28(2), 255–274. <https://doi.org/10.1016/j.ajsl.2012.08.006>
- Mai, N. K., Do, T. T., & Phan, N. A. (2022). The impact of leadership traits and organizational learning on business innovation. *Journal of Innovation and Knowledge*, 7(3). <https://doi.org/10.1016/j.jik.2022.100204>
- Martínez-Caro, E., Cegarra-Navarro, J. G., & Alfonso-Ruiz, F. J. (2020). Digital technologies and firm performance: The role of digital organisational culture. *Technological Forecasting and Social Change*, 154(February), 119962. <https://doi.org/10.1016/j.techfore.2020.119962>
- N. Burhan, A. H., & Rahmanti, W. (2012). the Impact of Sustainability Reporting on Company Performance. *Journal of Economics, Business, and Accountancy | Ventura*, 15(2), 257. <https://doi.org/10.14414/jebav.v15i2.79>
- Omran, N., Rejeb, N., Maalaoui, A., Dabic, M., & Kraus, S. (2024). Drivers of Digital Transformation in SMEs. *IEEE Transactions on Engineering Management*, 71, 5030–5043. <https://doi.org/10.1109/TEM.2022.3215727>
- Ortiz-Martínez, E., Marín-Hernández, S., & Santos-Jaén, J. M. (2023). Sustainability, corporate social responsibility, non-financial reporting and company performance: Relationships and mediating effects in Spanish small and medium sized enterprises. *Sustainable Production and Consumption*, 35, 349–364. <https://doi.org/10.1016/j.spc.2022.11.015>
- Radzi, N. A. M., Wahab, S. N., & Bahar, N. (2020). An Inquiry on Knowledge Management in Third-party Logistics Companies. *International Journal of Business Innovation and Research*, 1(1), 1. <https://doi.org/10.1504/ijbir.2020.10024101>
- Thepmongkorn, S., & Pitchayadejanant, K. (2020). Competence Requirements for Logistics and Supply Chain Management Students by Adopting BLM and APICS Competency Framework: An Importance-Expertise *Development Journal*. <https://so01.tci-thaijo.org/index.php/HRODJ/article/view/240597>
- Udovita, P. V. M. V. D. (2020). Conceptual Review on Dimensions of Digital Transformation in Modern Era. *International Journal of Scientific and Research Publications (IJSRP)*, 10(2), p9873. <https://doi.org/10.29322/ijsrp.10.02.2020.p9873>
- Xiao, J., Zhang, H., & Han, L. (2023). How Digital Transformation Improve Government Performance: The Mediating Role of Partnering Agility. *IEEE Access*, 11(June), 59274–59285. <https://doi.org/10.1109/ACCESS.2023.3284793>
- Yuan, G., Wan, T., BaQais, A., Mu, Y., Cui, D., Amin, M. A., Li, X., Xu, B. Bin, Zhu, X., Algadi, H., Li, H., Wasnik, P., Lu, N., Guo, Z., Wei, H., & Cheng, B. (2023). Boron and fluorine Co-doped laser-induced graphene towards high-performance micro-supercapacitors. *Carbon*, 212(February). <https://doi.org/10.1016/j.carbon.2023.118101>
- Yusliza, M. Y., Yong, J. Y., Tanveer, M. I., Ramayah, T., Noor Faedah, J., & Muhammad, Z. (2020). A structural model of the impact of green intellectual capital on sustainable performance. *Journal of Cleaner Production*, 249, 119334. <https://doi.org/10.1016/j.jclepro.2019.119334>
- Zuzaku, A., & Abazi, B. (2022). Digital Transformation in the Western Balkans as an Opportunity for Managing Innovation in Small and Medium Businesses - Challenges and Opportunities. *IFAC-PapersOnLine*, 55(39), 60–65. <https://doi.org/10.1016/j.ifacol.2022.12.011>

A Literature Review: Analysis of Courier Business Strategies in Facing Global Challenges

Emay Marsita¹ & Maniah²

^{1&2}Master of Logistic Management, Universitas Logistik dan Bisnis Internasional, Bandung 40151, Indonesia

Abstract

Indonesia's courier sector is expanding rapidly as a result of new technology such as e-commerce and shifting consumer behavior. The Courier Express Parcel (CEP) section accounts for more than half of total production, with a projected 12.55% increase in 2029. This study investigates the elements that influence profitability fluctuations, focusing on liquidity, company size, and appropriate capital structure. Future study should look into scale verification, customer patience impact, digitalization effects, implementation difficulties, and expectations for new technology. Optimisation strategies for courier dispatching systems and collaborative models are also covered. This study will identify using the literature study with 12 articles selected between 2017 and 2022.

Keywords: Study Literature, Courier Business, Strategies, Global Challenges

1. Introduction

In the current era of globalization and digitalization, the courier industry has become an integral part of the global supply chain. Industry with the emergence of new technologies such as e-commerce and changes in consumer behavior, courier companies are faced with increasingly complex challenges. Diversification will be SF's main strategy in the future (S.M. Yuen & Yu, 2019). The e-commerce market makes the largest contribution to the CEP (Courier Express Parcel) segment in Indonesia with an average contribution of >50% of total production, so there is a big opportunity to increase market share in CEP logistics. The e-commerce market in Indonesia also has very good growth, namely with a CAGR of 44% and causing e-commerce logistics growth of CAGR of 31%.

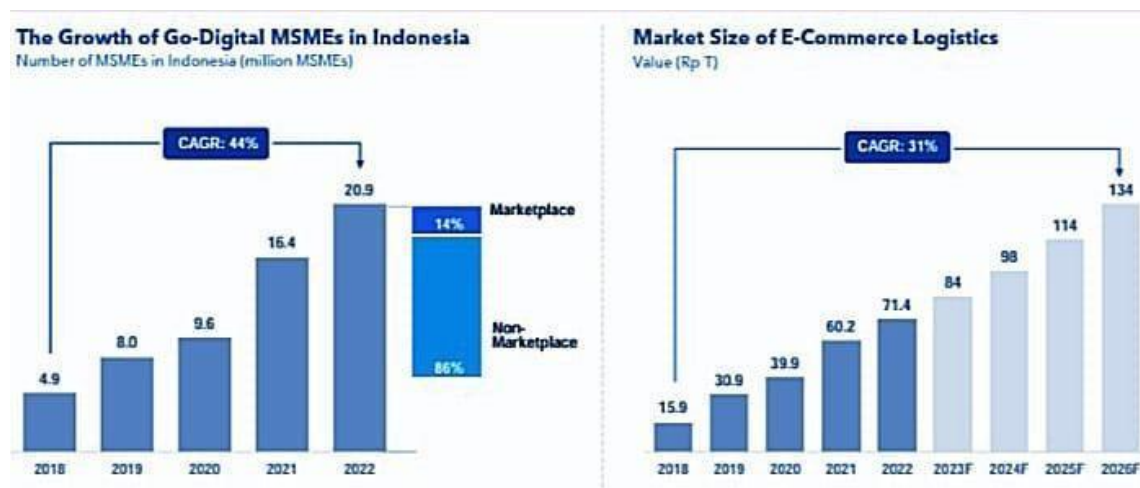


Figure 1: Diagram of the Growth of E-Commerce MSMEs and the E-Commerce Logistics Market in Indonesia
Source: Indonesian Ministry of Communication and Information, Indonesian Data

With the challenges and opportunities of the current potential of the courier business market in Indonesia, the growth of the courier industry in Indonesia is very rapid. Although companies have created their own added value, have a team of dedicated employees, an established

workplace, innovation, and so on, but the motive of this research is the need to explore the internal and external factors that drive changes in profitability levels. Profitability cannot be measured individually, but it relates to one another (Abdul Manaf et al., 2022). This study will analyze factors that can influence the probability of creating a business strategy to face increasingly fierce market competition. The researchers have employed a panel-data technique, which has included the time-series and cross-sectional data, to ensure that all the essential data have been acquired (Abdul Manaf et al., 2022).

According to Siddik dan Chabachib (2017) and Panjaitan et al., (2023), liquidity affects company value. According to Thaib (2017) and Panjaitan et al., (2023), profitability is the level of profit a company obtains when carrying out its operations. High profitability demonstrates the company's ability to earn high profits for its stockholders (Nugroho, 2019). Panjaitan et al., (2023) states that company size is the size or amount of assets owned by the company. According to Kartika and Dana (2015), an optimal capital structure is a capital structure that optimizes the balance between risk and return, thereby maximizing stock prices. The input criteria are assurance, empathy, and real nature is the criterion effective to improve in order to improve business performance (Teoh et al., 2020).

2. Research Methodology

The study of literature is a way to solve the issue by searching for the sources of writing that have ever been made before. According to M. Nazir in his book entitled *Methods of Research*, the study of libraries or literature studies is a technique of data collection by conducting investigative studies of books, literature, records, and reports that are related to solved problems (Salmaa 2023). Whereas SLR (Systematic Literature review is a method used in research to analyze or review and summarize the result of previous studies and the result of this SLR can be used as recommendations for researchers to conduct subsequent studies (Maniah et al. 2022).

After conducting a systematic search, the author obtained 12 international articles in 2017–2022 from several foreign university countries, such as Malaysia, Kenya, Korea, China, Hong Kong, Indonesia, Colombia, and Bulgaria. These are research articles with open access and can be opened in full. The subject of this study is the strategy that courier business companies are implementing to deal with global challenges.

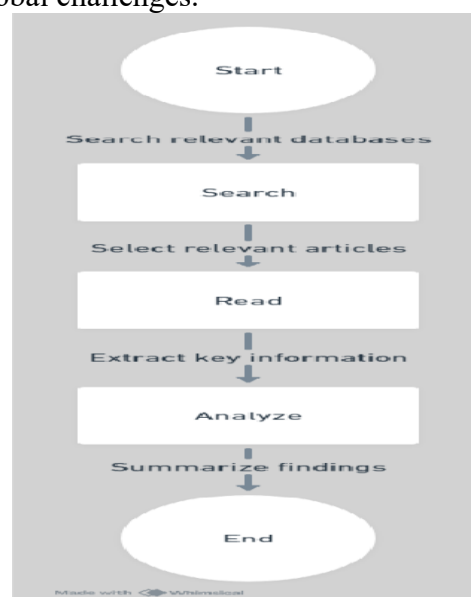


Figure 5: The Step used in Literature Review Study

Source: (Salmaa, 2023)

3. Result and Discussion

The writers looked over twelve articles published abroad. Articles matching the keywords courier business and courier company, which correspond to the titles of the writings the author raised, are the ones that were used in the literature study. The author presents the findings from her review of twelve papers in the following table.

Table 1: Result Study Literatur Analysis of Courier Business Strategies in Facing Global Challenges

No	Title	Author	TL; DR	Problem Statement	Method	Conclusions
1	Analysis of the Performance of Courier Companies in Selected Listed Counters in Malaysia	(Abdul Manaf, Mohd Said, and Adenan 2022)	In this study, the writers analyzed the factors that affect courier firms' profitability during an eight-year period (2014-2020). They utilized the Random Effects Model to analyze profitability.	Factors affecting profitability of Malaysian courier companies. Impact of firm size, liquidity, leverage, inflation, and unemployment	Random Effects Model used for profitability analysis. Variables: firm size, liquidity, leverage, inflation, unemployment discussed	Firm size, liquidity, leverage positively affect profitability. Unemployment rate negatively impacts profitability of courier companies in Malaysia.
2	Innovations in the courier services	(Cywiński 2022)	In this article, the impact of innovation on the courier services market, resulting in savings and improved efficiency is discussed, as well as organizational solutions that improve the market and make savings.		IT systems are the basis for innovative solutions in courier services. Organizational solutions are also used to improve efficiency and save money.	Innovations in courier services lead to cost savings. IT systems and organizational solutions improve market efficiency.
3	Last Mile Logistics Innovations in the Courier-Express-Parcel Sector Due to the COVID-19 Pandemic	(Sułkowski et al. 2022)	In this paper, the authors present a diagnostic of the possibilities of utilizing the potential of customer experience for the development of firms based on last-mile delivery technology, using Poland as an example.		Primary (fragmented) explanatory study that is descriptive and illustrative. Diagnostic survey using a computer-assisted web interview (CAWI)	Impact of COVID-19 on last mile logistics services. Recommendations for technologization of last mile deliveries

4	Determinants of Courier Service Quality in e-Commerce from Customers' Perspective	(Gulc 2020)	In this paper, the authors presented a complex review of literature concerning determinants of courier service and the original scale, which can be used to measure courier service quality in e-commerce.	Identify determinants of courier service quality in e-commerce. Develop a scale to measure courier service quality	Literature review on determinants of courier service quality. Survey method to collect data from online shoppers in Poland.	Key dimensions affecting courier service quality: reliability, visual identification, service complexity, relational capital, social responsibility, responsiveness, technical quality. Further research needed to verify the scale and explore other stakeholders' perspectives.
5	Courier Dispatch in On-Demand Delivery	(M. Chen and Hu 2021)	A courier dispatching problem in an on-demand delivery system where consumers are sensitive to delay is investigated, and it is discovered that the dispatching strategy is significantly dependent on customers' patience level, the size of the service zone, and the firm's ability to endogenize demand.	Courier dispatching strategies in on-demand delivery systems. Effect of temporal pooling vs. dedicated strategy on delivery efficiency.	Dedicated strategy (one order per trip). Pooling strategy (batch of sequential orders per trip)	Pooling strategy optimal for large service areas with endogenized demand. Dedicated strategy preferable for large service areas with exogenous demand.
6	Strategies for Improving the Quality of Logistics Courier Services Through Priority Problem-solving Based on Multiclass Classification	(Hendayani and Dharmawan, 2020)	In this paper, the authors used a sentiment analysis method with classification models of Naive Bayes Classifier and Support Vector Machine as well as multiclass classification to evaluate and find strategies to improve the quality of logistics services.	Identify and prioritize problems in JNE's logistics services. Improve response time and personnel contact quality for customer complaints.	Naive Bayes Classifier. Support Vector Machine	JNE faces high priority issues in Personnel Contact Quality and Timeliness. Negative sentiment dominates JNE's Twitter mentions with 97.82%.

7	Data Envelopment Analysis for Malaysia Courier Services Performance and Customer Satisfaction	(Teoh, Abu Hasan, and Zahari 2020)	This study presents a practical approach for determining the level of consumer satisfaction with courier service firms using Data Envelopment Analysis, using 4r courier services selected in Hulu Terengganu: Poslaju, City-Link Express, J&T Express, and GD Express.	Efficiency of courier services in Malaysia. Identifying customer satisfaction levels towards courier services	Data Envelopment Analysis (DEA). Questionnaire survey.	Poslaju is ranked as the most efficient courier service. GD Express is ranked as the least efficient courier service.
8	Trends in Courier Services in Terms of Digitalization of Commerce	(Gramatiko va 2019)	In this article, the authors examine changes in the logistics industry and supply chain due to the development of artificial intelligence (AI), the growing role of Internet of Things (IoT) in the delivery industry, the autonomous vehicle management, the use of 3D printing for custom production and other current trends to accelerate delivery time and customer satisfaction.	Low digital skills and internet usage in Bulgaria. Lack of specialists in STEM fields in Bulgaria.	Artificial intelligence (AI). Internet of Things (IoT)	Changes in logistics industry due to digitalization. Trends to accelerate delivery time and customer satisfaction
9	Corporate Strategy and Tactics of SF Express in Domestic and International Courier Market	(S.M. Yuen and Yu 2019)	In this paper, an overview of mainland express market development and changes are discussed & a case analysis and in-depth interview are made to identify and evaluate the corporate strategy & business tactics of SF Express in local & international Courier	Analyzing corporate strategy and tactics of SF Express. Identifying challenges in local and international courier market	Literature review of documents, reports, journals, and interviews conducted. Analysis of SWOT, strategies, and tactics of SF Express.	SF Express should expand to international express delivery service. Diversification and total logistics solutions are key strategies for SF.

			Market.			
10	Can Sophisticated Dispatching Strategy Acquired by Reinforcement Learning? - A Case Study in Dynamic Courier Dispatching System.	(Y. Chen et al. 2019)	By utilizing historical data and considering long-term revenue gains, MARL achieves better performance than myopic online algorithms and is able to construct the mapping between complex scenarios to sophisticated decisions such as the dispatching rule. It also has the scalability to adopt in large-scale real-world scenarios.	Courier dispatching problem in online pickup-service platform. Objective: Maximize revenue with limited couriers over time.	Formulated as Markov decision process (MDP). Utilized multi-agent reinforcement learning (MARL) techniques	MARL outperforms myopic algorithms in revenue gains. MARL maps complex scenarios to sophisticated dispatching decisions.
11	Collaborative and Sustainable Network Design in Courier Services	(Moon et al. 2018)	A nucleolus-based profit allocation method is applied for fair allocation of the profits to each participating company based on a cooperative game theory and an illustrative example problem demonstrates the applicability and efficiency of the proposed model.	Applying sharing economy to courier services for competitiveness. Developing equitable profit allocation method based on cooperative game theory.	Collaboration model for competitiveness enhancement. Nucleolus-based profit allocation method for fair distribution.	Collaboration is a survival strategy for courier service companies. Proposed fair profit allocation model for collaboration sustainability.
12	Factors affecting the performance of courier service industry: a survey of courier companies in Kenya	(Jacinta Wahu Nyaga 2017)	In this paper, a descriptive survey study design was used to analyze the factors influencing the performance of courier companies in Kenya. The study discovered that employees in courier firms were highly motivated, as demonstrated by their attitude toward work and promotion factors.	Factors affecting courier service industry performance in Kenya. Impact of employee training, motivation, and customer service on performance.	Descriptive survey study design. Stratified random sampling technique.	Properly trained workforce contributes to the success of courier service sector. Employees are motivated by work and promotion factors, but not pay.

A summary results of these papers are firm size, liquidity, and leverage are significant for profitability, inflation is positive but not significant for profitability, and unemployment factor is

negative and significant for profitability, (Abdul Manaf, Mohd Said, and Adenan, 2022). Innovations in courier services result improve efficiency and cost savings, (Cywiński, 2022). Examined trends in courier services due to digitalization of commerce, focus on AI, IoT, autonomous vehicles, 3D printing for delivery, (Gramatikova, 2019). Pooling strategy optimal for large service areas with endogenized demand, dedicated strategy preferable for large service areas with exogenous demand (M. Chen and Hu, 2021). JNE has 97.82% negative sentiment and 2.18% positive sentiment, high priority issues: Personnel Contact Quality and Timeliness. (Hendayani & Dharmawan, 2020).

To achieve good performance, service companies' couriers must carry out value creation, which can be realized by the company because of the support of strategic orientation and absorptive apability. For increasing the company's strategic orientation, one must optimize adaptation to external environmental forces, while to optimize the company's absorptive capability, one must optimize resource development company power (Suryana, 2015). Criteria which are prioritized by respondents in choosing a logistics service provider are reliability with a weight of 0.4018, followed by the cost criterion, with weights 0.2275, then the convenience criterion with a weight of 0.1886, and the last is services criteria with weights 0.1820. Based on global priority, it is found that JNE has value the highest of 39.15% is superior compared to TIKI and POS (Astuti and Fatma, 2017).

The main contributor to the growth of couriers in Indonesia is the change in consumer behavior from conventional shopping like going to shops to online shopping activities. This can be seen in the following table diagram, where the increase in online shopping users followed by high and frequent transactions will increase the demand for delivery services. A huge number of logistics firms, especially the large-scale ones, have already offered various services, for example, penetrating freight, freight merger, reverse logistics, post-sales service, distribution, order fulfilment, and departing freight. Moreover, demands for logistics services have increased because of trends, such modernisation, online shopping, and globalization (Abdul Manaf et al., 2022).

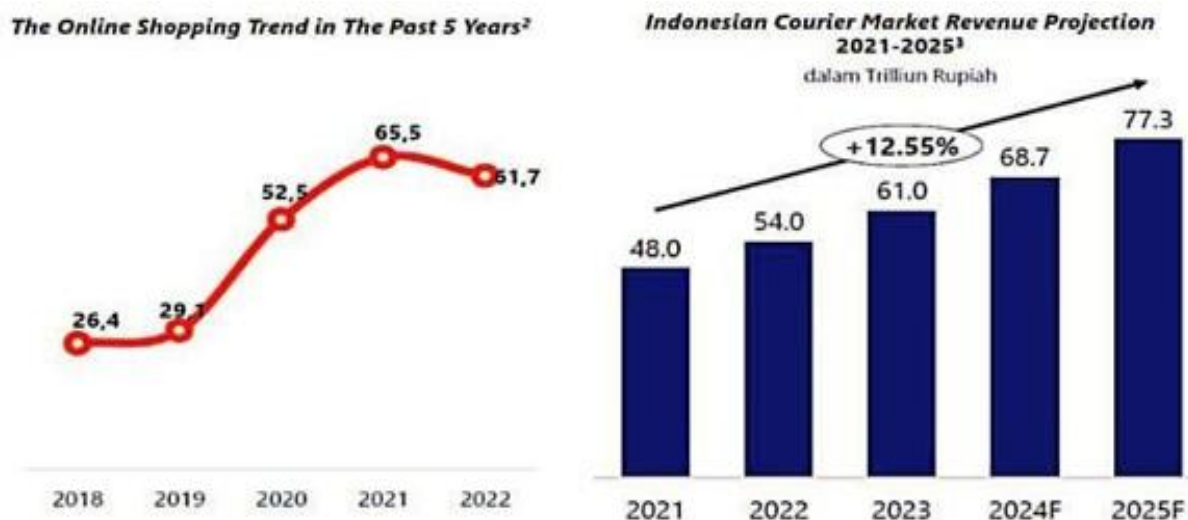


Figure 2: Online Shopping Trend Diagram and Courier Market Revenue Projections in Indonesia Source: Indonesian Ministry of Cooperatives and Small and Medium Enterprises: Indonesian MSMEs (2023); MarkPlus Analysis (2024).

With the large growth and contribution in the logistics sector, the prospect of the courier business or CEP (Courier Express Parcel) has huge market potential, especially in the retail segment. This can be seen in the following diagram.

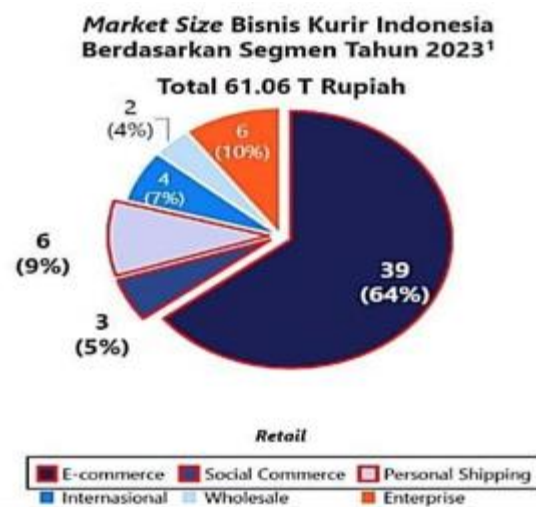


Figure 3: Courier Business Market Size Diagram in Indonesia Source: Markplus Analysis (2023).



Figure 4: CEP Market Growth Projection Diagram in Indonesia Source: Allied Market Research Report (2022)

From this diagram, it can be seen that the CEP market potential in 2029 will grow by 12.55% with a transaction value of 124 trillion depending on how courier business companies in Indonesia can capture these global opportunities and challenges for the future.

4. Implications and Direction for Future Research

Future research should focus on scale verification using the CFA method, analyzing factors from online shops and courier companies' perspectives. The study should also explore customer's patience impact on dispatch strategy. Naive Bayes Classifier and ABC analysis can be used to determine priority dimensions in problem-solving. The study should also analyze digitalization effects on businesses, implementation barriers, and expectations regarding new technologies. Further optimization techniques for courier dispatching systems and the application of MARL in dynamic service industries are also discussed. Collaboration models and the economy of sharing are also explored for efficiency. Future authors can utilise more structured methods such as SLR (Systematic Literature Review) method to get more extensive and more credible articles especially

for the development of courier business in Indonesia. The author's limitation in the English language is a challenge in understanding every article that is the source of the literature of study in the writing of this article.

Acknowledgment

The author thanked the family as well as the tutoring lecturer who gave instructions and input in writing this article so that it could be completed on time.

References

- Abdul Manaf, Suhaily Maizan, Nur Shafini Mohd Said, and Nur Dalila Adenan. 2022. "Analysis of the Performance of Courier Companies in Selected Listed Counters in Malaysia." *Jurnal Intelek* 17 (2): 91–101. <https://doi.org/10.24191/ji.v17i2.18170>.
- Astuti, Juli, and Erika Fatma. 2017. "Evaluasi Pemilihan Penyedia Jasa Kurir Berdasarkan Metode Analytical Hierarchy Process (Ahp)." *Jurnal Manajemen Industri dan Logistik* 1 (1): 28. <https://doi.org/10.30988/jmil.v1i1.5>.
- Chen, Mingliu, and Ming Hu. 2021. "Courier Dispatch in On-Demand Delivery." *SSRN Electronic Journal*, no. Jargon. <https://doi.org/10.2139/ssrn.3675063>.
- Chen, Yujie, Yu Qian, Yichen Yao, Zili Wu, Rongqi Li, Yinzlii Zhou, Haoyuan Hu, and Yinghui Xu. 2019. "Can Sophisticated Dispatching Strategy Acquired by Reinforcement Learning? A Case Study in Dynamic Courier Dispatching System." *Proceedings of the International Joint Conference on Autonomous Agents and Multiagent Systems, AAMAS* 3:1395–1403.
- Cywiński, Marcin. 2022. "Innovations in the Courier Services." *Globalization, the State and the Individual* 30 (2): 49–56. <https://doi.org/10.5604/01.3001.0016.1998>.
- Gramatikova, Elitsa. 2019. "Trends in Courier Services in Terms of Digitalization of Commerce." *Izvestia Journal of the Union of Scientists - Varna. Economic Sciences Series* 8 (3): 17–27. <https://doi.org/10.36997/ijusv-ess/2019.8.3.17>.
- Gulc, Aleksandra. 2020. "Determinants of Courier Service Quality in E-Commerce from Customers' Perspective." *Quality Innovation Prosperity* 24 (2): 137–52. <https://doi.org/10.12776/QIP.V24I2.1438>.
- Hendayani, R., and M. C. Dharmawan. 2020. "Strategies for Improving the Quality of Logistics Courier Services through Priority Problem-Solving Based on Multiclass Classification." *IOP Conference Series: Materials Science and Engineering* 879 (1). <https://doi.org/10.1088/1757-899X/879/1/012051>.
- Jacinta Wahu Nyaga. 2017. "Factors Affecting the Performance of Courier Service Industry: A Survey Of Courier Companies In Kenya Jacinta Wahu Nyaga Factors Affecting The Performance Of Courier Service Industry: A Survey Of Courier Companies."
- Maniah, Benfano Soewito, Ford Lumban Gaol, and Edi Abdurachman. 2022. "A Systematic Literature Review: Risk Analysis in Cloud Migration." *Journal of King Saud University - Computer and Information Sciences* 34 (6): 3111–20. <https://doi.org/10.1016/j.jksuci.2021.01.008>.
- Moon, Ilkyeong, Gyu M. Lee, Jinwoo Park, Dimitris Kiritsis, and Gregor von Cieminski. 2018. "Preface." *IFIP Advances in Information and Communication Technology* 535: v–vi. <https://doi.org/10.1007/978-3-319-99704-9>.
- Panjaitan, Florencia Rani, H.Kresna Minan, and Muhammad Arief. 2023. "The Effect of Liquidity, Profitability and Company Size on Company Value with Capital Structure as An Intervening Variable in Manufacturing Companies Listed on The Idx In 2016- 2020." *International Journal of Economics and Management* 1 (01): 19–29. <https://doi.org/10.54209/iem.v1i01.3>.

- S.M. Yuen, Simon, and JohnS.C. Yu. 2019. "Corporate Strategy and Tactics of SF Express in Domestic and International Courier Market." *Journal of Business & Economic Policy* 6 (3): 73–81. <https://doi.org/10.30845/jbep.v6n3a9>.
- Salmaa. 2023. "Studi Literatur: Pengertian, Ciri, Teknik Pengumpulan Datanya." Penerbitdeepublish. 2023. <https://penerbitdeepublish.com/studi-literatur/>.
- Sułkowski, Łukasz, Katarzyna Kolasińska-Morawska, Marta Brzozowska, Paweł Morawski, and Tomasz Schroeder. 2022. "Last Mile Logistics Innovations in the Courier-Express- Parcel Sector Due to the COVID-19 Pandemic." *Sustainability (Switzerland)* 14 (13). <https://doi.org/10.3390/su14138207>.
- Suryana, Hana. 2015. *Value Creation As A Strategy To Increase Business oleh: Panitia Disertasi : Kopromotor Merangkap Sekretaris*.
- Teoh, Teoh Yeon Kin, Suzanawati Abu Hasan, and Siti Nur Atikah Zahari. 2020. "Data Envelopment Analysis for Malaysia Courier Services Performance and Customer Satisfaction." *Journal of Computing Research and Innovation* 5 (3): 25–33. <https://doi.org/10.24191/jcrinn.v5i3.135>

From Farm to Fork: Leveraging Blockchain Technology to Improve Food Supply Chain Integrity in Indonesia

Syifa Salsabila¹ & Agus Purnomo²

^{1&2}*Department of Master of Logistics Management, Faculty of Logistics, Technology and Business, Universitas Logistik dan Bisnis Internasional, Bandung, Indonesia*

Abstract

This research aims to analyze the potential implementation of blockchain technology in improving the transparency and traceability of Indonesia's food supply chain and strengthening national food security and resilience. The problem identified is the need for more visibility in the food supply chain, leading to uncertainty regarding the origin and quality of food products. This research methodology uses a quantitative approach with data obtained through questionnaires to the public aged 20-27 years. This population was chosen because this age group is active in the use of technology. The questionnaire used a Likert scale model with 18 questions to measure attitudes, opinions, and perceptions of blockchain applications. Primary data was obtained directly from respondents, while secondary data was taken from literature studies and previous research. The results showed that blockchain can increase transparency and traceability in Indonesia's food supply chain. Blockchain can reduce the risk of fraud, make it easier to trace product origin and increase consumer confidence in food quality and safety. In addition, blockchain also provides economic benefits to producers and distributors by reducing operational costs and increasing efficiency. This study concludes that the adoption of blockchain technology in the food supply chain in Indonesia can have a significant positive impact on national food security and resilience. However, achieving these benefits requires collaboration between the government, private sector, and educational institutions to overcome technical, regulatory, and academic challenges. This research makes an essential contribution to understanding the potential of blockchain and offers recommendations for practical implementation in Indonesia.

Keywords: Blockchain, Transparency, Traceability & Food Supply Chain.

1. Introduction

The supply chain is a crucial component in various business sectors, facilitating the movement of goods and services in the context of globalization. In the Indonesian food industry, the supply chain plays a vital role in ensuring the availability of safe, high-quality, and affordable food for the community. However, the Indonesian food industry faces significant challenges in terms of transparency and traceability within its supply chain. Surayana points out that developing countries, including Indonesia, will face increasing challenges in the coming years. These challenges are related to achieving, maintaining, and improving food security and sustainability from 2015 to 2025, a timeframe that aligns with global conditions (FAO, 2011a; Food Security Agency, 2013). The graph below illustrates that Indonesia's average Food Security Index is lower than the global average of 62.2. Furthermore, the 2023 report from the Food and Agriculture Organization (FAO) states that Indonesia ranks 63 out of 113 countries in terms of food security in 2022.

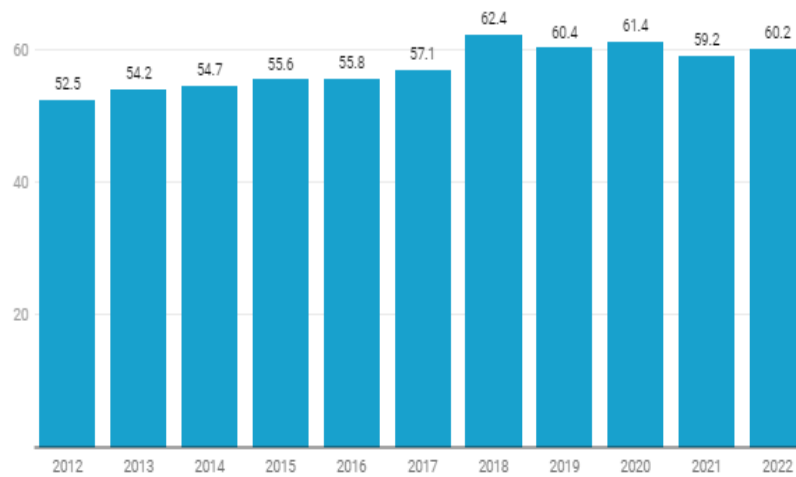


Fig 1: Indonesian Food Security Index
Sources: (GFSI, Economist Impact)

Two critical concerns often faced by stakeholders in the food supply chain are the absence of clarity and transparency in traceability. Transparency refers to the capacity to monitor and comprehend the movement of food and information from its source to the final destination, while traceability pertains to the ability to determine the origin, journey, and condition of food throughout the distribution process. The lack of traceability and transparency presents significant challenges in overseeing and managing the entire food supply chain. For instance, the inability to accurately trace the source of products can lead to the dissemination of potentially fatal diseases, harm to brand image, and financial losses.

The need for solutions to enhance transparency and traceability in the food supply chain is apparent due to concerns surrounding the safety of products and consumers. The utilization of blockchain technology to address this matter signifies a substantial shift in approach, transitioning from a centralized to a decentralized model. This is accomplished through the establishment of network consensus among servers operating blockchain software, which replicates and verifies transaction data. Consequently, if one server is compromised, the impact is mitigated by the fact that the majority of other servers maintain accurate data (Darmawan, 2017). Blockchain enables the prompt authentication and integrity verification of information by providing transparent evidence at each stage of the food supply chain, from production to distribution.

Blockchain technology, known for its decentralized nature, offers several advantages in the context of the food supply chain. These include enhanced transparency, robust data security, immutability of data, and real-time tracking capabilities. In comparison, traditional approaches like barcodes, RFID, and centralized supply chain management systems have been found to have limitations when it comes to the food supply chain. This is primarily because these systems rely on centralized operational software, which raises concerns about their susceptibility to attacks (Darmawan, 2017).

The aforementioned analysis demonstrates that this research provides a deeper understanding of the challenges faced by the Indonesian food supply chain. Additionally, it proposes innovative solutions that can be implemented to improve transparency and traceability within the industry. The aim of this research is to evaluate the utilization of blockchain technology, transparency, and traceability in ensuring food product safety and minimizing risks to society within the Indonesian food supply chain. The objective of this study is to assess the impact of

blockchain technology, transparency, and traceability on food product safety. Furthermore, this study seeks to investigate the influence of blockchain technology, transparency, and traceability on societal risk.

This research makes a substantial contribution to the integration of blockchain technology for enhancing food safety in Indonesia. This aspect has not been thoroughly investigated within the local context. The main novelty of this study lies in its comprehensive approach, which combines three pivotal elements: blockchain technology, transparency, and traceability. The analysis of these elements seeks to examine their influence not only on the safety of food products but also on the mitigation of risks faced by Indonesians. By exploring the interplay between technological innovation and food safety in the context of a developing country with intricate supply chain dynamics, this study addresses a notable gap in knowledge.

The remaining portion of this article will be structured into discrete sections. The second section will analyze the literature that substantiates the research hypotheses. The third section will explicate the methodology employed to attain the research objectives. The fourth section will present the findings that address the research hypotheses. The fifth section will discuss the interpretation and reaffirmation of the research findings within the framework of existing theory or research. Lastly, the conclusion will be further developed by incorporating implications and potential avenues for future research.

2. Literature Review

The Impact of Blockchain Technology on Mitigating Risks to Society

A comprehensive investigation conducted by Shivangin Viral. T, Snatosh B. Rane, and Vaibhav S. Narwane (2024) and published in the esteemed Journal of Modern Supply Chain Research and Applications sheds light on the immense potential of incorporating blockchain technology and the Internet of Things (IoT) into integrated architectures and eco-friendly supply chains. The study highlights the crucial role that blockchain technology plays in enhancing transparency and traceability, thereby effectively reducing risks to society. By enabling precise tracking of product origins and journeys, blockchain technology serves as a preventive measure against the dissemination of potentially life-threatening diseases and safeguards consumers from the perils of unsafe products.

H1: The Utilization of Blockchain Technology Positively Impacts Risk Reduction in Society.

Blockchain Technology in Ensuring Food Product Safety

The potential application of blockchain technology in port management in Indonesia was explored by Indraprakoso and Haripin (2023) in their study published in the Sanskara Journal of Management and Business. Their findings revealed that blockchain technology has the capability to enhance real-time tracking, consequently leading to an improvement in food product safety. Given that blockchain technology allows for the verification of information authenticity and integrity throughout the entire food supply chain from production to distribution, it plays a crucial role in ensuring food product safety.

H2: *The Implementation of Blockchain Technology Positively Impacts Food Product Safety.*

Application and Preparedness of the Food Industry in Embracing Blockchain Technology

In their study published in the Imagine Journal, Renaldo Fajar Nugraha Susilo and Sya'ban Fauzan Athallah (2023) investigated the utilization of artificial intelligence (AI) across different stages of the food system in Indonesia. These stages include production, distribution, quality control, and resource management. While the primary emphasis of this research is on AI, it also highlights the

readiness of the food industry to adopt advanced technologies like blockchain in order to improve the sustainability of the food system.

H3: *Blockchain technology has the potential to significantly improve food product safety and effectively mitigate risks to the general public*

The Role of Traceability in Risk Reduction for Society

Studies conducted by Bailey (2005) and Golan (2004) demonstrate that the implementation of a comprehensive traceability system can effectively reduce risk for society. This is achieved through the facilitation of efficient product recall processes during emergency situations, as well as by providing consumers with transparent information regarding the products they consume. The traceability system enables the identification of potential issues and helps prevent the distribution of unsafe products.

H4: *The implementation of traceability measures has the potential to mitigate the risks to society.*

Transparency in Enhancing Food Product Safety

In a publication titled "Consumer Trust in Food Safety Requires Information Transparency" in the Australasian Journal of Information Systems, Tri Lam et al. (2018) highlight the significance of transparency in the food supply chain in facilitating a comprehensive comprehension of production and distribution processes. This, in turn, fosters consumer trust in the safety of food products. The authors emphasize the essentiality of such transparency to guarantee that consumers receive products that are both of superior quality and safety.

H5: *The disclosure of information regarding food products has a significant positive effect on their safety*

Transparency in Enhancing Food Product Safety

In the Journal of Innovations: Technology, Governance, Globalization, Frank Yannias (2018) introduces "A new era of food transparency powered by blockchain," wherein he posits that transparency within the supply chain can contribute to mitigating risks to society by offering pertinent and easily accessible data regarding the conditions and manufacturing procedures of food products. Consequently, this empowers consumers to make judicious and well-informed choices about the products they choose to consume.

H6: *The level of transparency significantly influences the societal risk in a positive manner.*

In consideration of the earlier presented hypothesis, it becomes apparent that numerous factors contribute to the absence of lucidity and openness within the Indonesian food supply chain. The utilization of blockchain technology presents a viable resolution to these predicaments, as attested by the triumphs of prior research studies in showcasing the efficacy of this technology in surmounting these obstacles. The hypothesis can be broadly articulated as follows: the indirect impact of blockchain technology, transparency, and traceability on the safety of food products and the ensuing risk to society. Drawing from this elucidation, the ensuing conceptual framework can be derived:

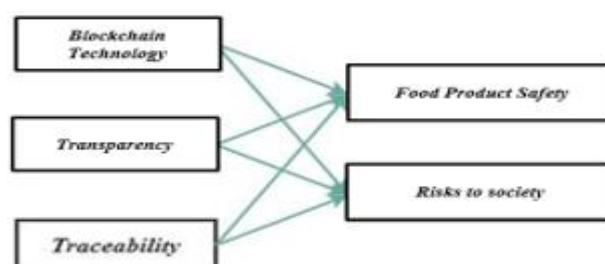


Figure 2: Theoretical Framework

3. Methodology

Research Design

The current investigation utilizes a cross-sectional methodology as its temporal framework. Specifically, data is gathered from a subset of the population in the form of a sample of respondents to assess their viewpoints on the subject being studied. The data collection process occurs only once, without any subsequent repetitions (Sekaran & Bougie, 2013).

Data Source and Sampling Techniques

The data utilized in this study consist of quantitative data, specifically numerical values that will be derived through data analysis. The data were collected from questionnaires distributed to the research population. The data sources in this study are divided into two categories: primary data and secondary data. Primary data were directly obtained from respondents through the questionnaires. The questionnaire was constructed using a Likert scale to facilitate the measurement of attitudes, opinions, and perceptions pertaining to the research topics.

The questionnaire consists of 18 questions, each with five response options. Secondary data refers to information obtained indirectly, such as from relevant literature and previous research related to the current study. As defined by Sugiyono (2015:119), the term "population" refers to a broad category encompassing objects or subjects that possess distinct qualities and characteristics, which researchers utilize for study and eventual conclusion drawing. For the purposes of this research, the chosen population consists of individuals from the general public, aged between 20 and 27 years, representing diverse social circles. This specific population was selected due to their active engagement with new technology and digital innovation within this age range, as well as to encompass a wide range of perspectives from different groups, thus enriching the analysis.

4. Result

The PLS-SEM methodology is utilized to evaluate the research model, which consists of two distinct components: the inner model and the outer model. The examination of the outer model is conducted to validate and ensure the reliability of the variables used. In order to establish convergent validity, it is necessary to achieve a factor loading value of at least 0.7 and an average variance extracted (AVE) value of at least 0.5. Moreover, discriminant validity was assessed by confirming that the correlation between latent constructs exceeds the square root of the AVE (Fornell-Larcker criterion). The reliability of the model was assessed using composite reliability (≥ 0.70) and Cronbach's alpha (≥ 0.70).

Outer Structural Model Results

The findings presented in Table 1 demonstrate that each indicator fulfills the criteria for convergent validity, as the AVE values are higher than 0.5 and the factor loadings are higher than 0.7. Moreover, the results indicate that discriminant validity has been established based on the Fornell-Larcker Criterion. Additionally, the values of Cronbach's alpha and composite reliability (ρ_a and ρ_c) for all variables were above 0.7, indicating a high level of internal consistency and reliability. These analysis results suggest that all tested variables possess satisfactory validity and reliability. Consequently, the outer structural model of this study is suitable for further analysis without requiring the distribution of any additional questionnaires.

Table 1: Validity and Reliability of the variabels

	Cronbach's alpha	Keandalan komposit (rho_a)	Keandalan komposit (rho_c)	Rata-rata varians diekstraksi (AVE)
Keamanan Produk Pangan	0.903	0.906	0.932	0.775
Risiko Terhadap Masyarakat	0.723	0.728	0.844	0.644
Teknologi Blockchain	0.765	0.819	0.841	0.574
Traceability	0.848	0.894	0.908	0.767
Transparansi	0.733	0.784	0.836	0.572

Table 2: Fornell-Larcker Criteria (Diskriminant Validity)

	Food Product Safety	Risk to Society	Blockchain Technology	Traceability	Transparency
Food Product Safety					
Risk to Society	1.001				
Blockchain Technology	1.022	0,933			
Traceability	0,633	0,693	1.066		
Transparency	0,959	1.020	1.113	0,861	

Inner Structural Model Results

The evaluation of the model is grounded in the utilization of the R-squared value (coefficient of determination), T-statistic value, and P-value. As depicted in Table 3, the R-Squared value of the food product safety variable is 0.892, while the R-Squared value of the risk variable to the community is 0.604. Additionally, the adjusted R-squared value of the food product safety variable is 0.882, while the adjusted R-squared value of the risk variable to the community is 0.568. A higher R-Squared value denotes that exogenous variable exert a significant influence on endogenous variables.

Table 3: R-Squares (Determinant Coefficient)

	R-square	Adjusted R-square
Keamanan Produk Pangan	0.892	0.882
Risiko Terhadap Masyarakat	0.604	0.568

$$R_Sq = R \text{ Square}; R_Sq_A = R \text{ Square Adjusted}$$

To establish the significance of the relationship between variables at the 5% significance level, two criteria must be met: the t value should exceed 1.65, and the P value should be less than 0.05. The marginally lower adjusted R-squared value suggests that the model has been adjusted to accommodate the number of variables used. In summary, the analysis of this research model demonstrates that the exogenous variables have a significant impact on the endogenous variables, both directly and indirectly. The high R-Squared values indicate that the model can explain a substantial amount of variation in the endogenous variables, thus lending strong validity to the structural model in this study. Upon comparing Table 4 and Figure 3, it becomes evident that all accepted hypotheses indicate a direct or mediated positive relationship between the variables. For example, the noteworthy associations between Blockchain Technology and Food Product Safety, as well as between Transparency and Risk to Society, demonstrate a pronounced influence of exogenous variables on endogenous variables.

Table 4: The Conclusions of the Hypothesis Testing for all Research Hypotheses.

	Sampel asli (O)	Rata-rata sampel (M)	Standar deviasi (STDEV)	T statistik (O/STDEV)	Nilai P (P values)
Teknologi Blockchain -> Keamanan Produk Pangan	1.112	1.128	0.151	7.377	0.000
Teknologi Blockchain -> Risiko Terhadap Masyarakat	0.331	0.302	0.260	1.270	0.204
Traceability -> Keamanan Produk Pangan	-0.319	-0.310	0.146	2.191	0.028
Traceability -> Risiko Terhadap Masyarakat	-0.008	0.040	0.173	0.046	0.964
Transparansi -> Keamanan Produk Pangan	0.061	0.063	0.102	0.596	0.551
Transparansi -> Risiko Terhadap Masyarakat	0.483	0.486	0.227	2.132	0.033

Hypo = Hypothesis; β = Path Coefficients O = Original Sample; SDD = Standard Deviation; T_Sta = T Statistics; P_Va = P Value; Hy_TC = Hypothesis Testing Conclusion; Acp = Accepted

Table 4 demonstrates that the green value signifies the hypothesis that has been accepted, whereas the red value signifies the hypothesis that has been rejected. This analysis suggests that blockchain technology has an impact on the safety of food products, but it does not have an effect on the risks to society. The variables associated with traceability have a significant influence on product safety, but they do not have an impact on the risks to society. On the other hand, the transparency variable has no effect on product safety, but it does affect the risks to society.

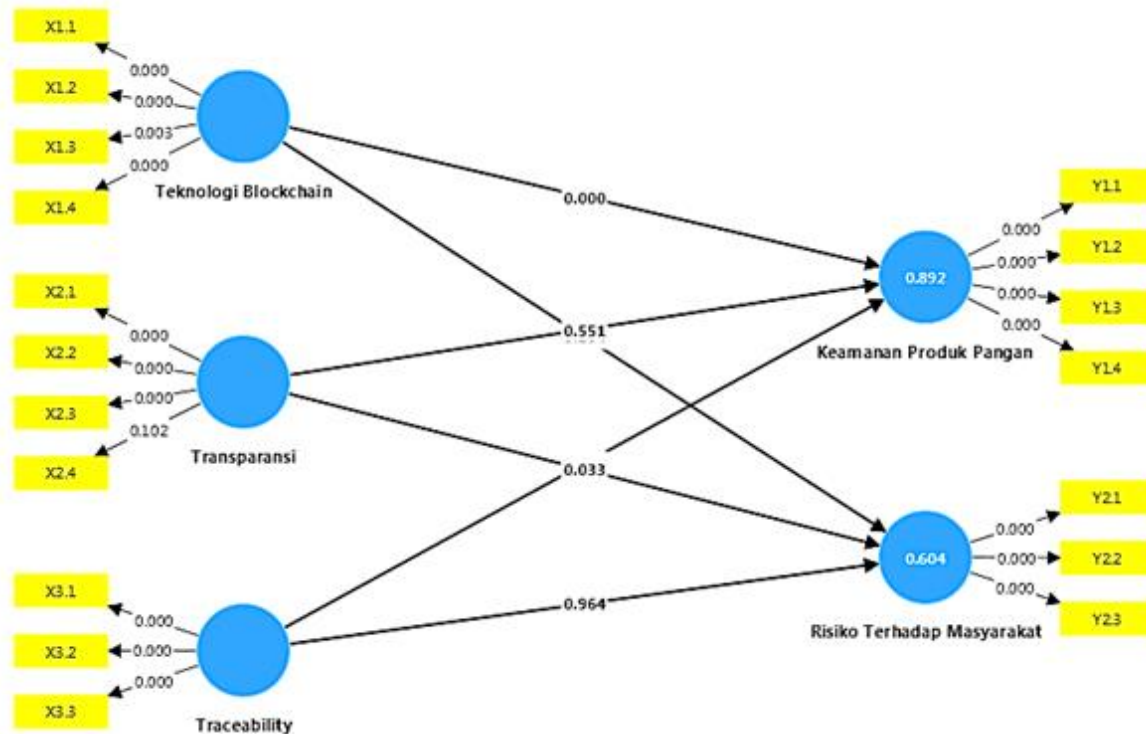


Fig 3: The Summary of the model from Bootstrapping result: Path coefficient, Factor Loading, and T-Values

5. Discussion

This study aims to explore the potential of blockchain technology in enhancing transparency and traceability in the Indonesian food supply chain. This, in turn, can contribute to improving the safety of food products and mitigating societal risks. The independent variables considered in this study consist of blockchain technology, transparency, and traceability. On the other hand, the dependent variables are food product safety and risk to society.

The findings of the previous analysis provide evidence supporting Hypothesis 1 (H1), which suggests that blockchain technology has a positive and direct impact on the safety of food products. The utilization of blockchain technology in ensuring food product safety offers numerous advantages. These benefits include streamlining each stage of the supply chain, effectively tracking the movement of products from one point to another, enhancing food safety by eliminating counterfeit items, reducing financial risk and promoting trade, and facilitating business progress in financial services.

By implementing blockchain technology in food product safety, consumers are empowered to gain a comprehensive understanding of the entire production and distribution process. Consequently, consumers can evaluate the quality of ingredients utilized in production, ensuring they meet the required standards. Moreover, consumers can also determine if inferior quality ingredients are used. The merits of employing blockchain technology in food product safety

encompass improved safety and reliability in assuring product quality. Nevertheless, in addition to the aforementioned advantages, integrating blockchain technology with existing systems poses certain drawbacks, namely high costs and complexity. Nonetheless, through ongoing development of optimal solutions, blockchain technology possesses the potential to become an integral component of the food industry in the future (Permana, 2024).

Blockchain, being a decentralized peer-to-peer platform, holds great potential for application in complex food supply chains. A blockchain technology model called Deep Improving Commute Experience (DeepICE) demonstrates the superior performance of the proposed model when compared to existing approaches. Unlike many other industries, the food production sector is characterized by a complex value chain that requires careful attention to handling and storage. The use of blockchain technology has the capacity to improve the trustworthiness, efficiency, and security of shared data among participants in the supply chain network.

Transportation and temperature are two factors that can significantly impact the quality and freshness of food products. The unique attributes of blockchain technology, such as instantaneous information exchange, robust cybersecurity, transparency, reliability, traceability, and increased visibility, contribute to the optimization of supply chain operations. Blockchain technology is a distributed database and an innovative tool in the supply chain, particularly in processes such as production, distribution, and marketing. Based on the preceding discussion, it can be concluded that integrating blockchain technology with the traceability process in the supply chain is of significant importance. This integration allows for the authorization of information relevant to consumers, thereby enhancing transparency and accountability within the sector.

The findings of Hypothesis 3 (H3) suggest that traceability has a positive and direct impact on the safety of food products. In recent years, there have been numerous instances of harmful substances being found in food items, which has raised awareness about the importance of implementing traceability systems in the food industry's production processes. Traceability systems play a crucial role in ensuring the safety and quality of food products. By implementing a traceability system, the production and distribution of unsafe and low-quality products can be minimized.

Moreover, a traceability system can aid in reducing the production and distribution of unsafe and low-quality items. In the food industry, traceability systems can be categorized into six main elements: product traceability, process traceability, genetic traceability, input traceability, disease and pest traceability, and traceability measurement, which focuses on agriculture and the food supply chain. Thus, traceability can enhance consumer confidence in the safety of food products. The implementation of a traceability system enables continuous process improvement and mitigates potential safety hazards. Considering these factors, it can be argued that traceability systems are crucial for ensuring the safety of food products (Handayani et al., 2019). The implementation of a traceability system holds significant importance for food product safety, as well as for ensuring quality and accurate labeling of food items. The implementation of such a system offers various benefits for food producers, consumers, and the government.

According to Moe (1998), CIES-The Food Business Forum (2005), and GSI (2007) as cited in Sudibyo (2012), the benefits for food producers are as follows:

1. It facilitates the food industry or company in adhering to the regulatory stipulations of the respective country.

2. The company demonstrates its ability and willingness to promptly take action to withdraw the product from the market and safeguard the established brand reputation in cases where there is non-compliance with product quality or food safety standards.
3. One approach to mitigating the expenses linked to product recalls involves prioritizing the recovery, disposition, and reconditioning of products that are still accessible in the market.
4. The objective of this study is to identify and mitigate potential issues that may arise during the production process, while ensuring that the corresponding responsibilities are appropriately assigned to the individuals capable of addressing them.
5. The aim of this study is to identify and resolve any potential issues that may arise throughout the production process, while ensuring that the appropriate accountability is assigned to individuals capable of addressing them.
6. It is crucial to establish a transparent framework that encompasses all the necessary elements, including a clear provision for identity.
7. The aim of this study is to minimize the occurrence of infectious disease outbreaks in livestock populations.
8. It is crucial to protect the entire food chain from the adverse impacts of animal and livestock diseases.
9. The objective of this study is to ensure the availability of food products to consumers and to preserve established product markets and consumer confidence.
10. It is recommended to create products that are either unique in the market or aligned with consumer preferences.

As previously discussed by Bailey (2005), FSA (2002), and Golan (2004) in Sudibyo (2012), traceability offers numerous advantages for consumers, which are as follows:

1. In the event of an emergency, the implementation of product recalls will prove to be a more effective method for ensuring food safety.
2. The system enables consumers to easily avoid particular food products and ingredients, such as those that trigger allergies or intolerances to specific foods, or those that are incongruous with their chosen lifestyle preferences.
3. The system enables consumers to make more informed decisions about food products based on objective data about the nutritional and other attributes of a range of food items produced by different companies.

As previously discussed by Bailey (2005), FSA (2002), and Golan (2004) in Sudibyo (2012), traceability offers numerous advantages for consumers, which are as follows:

1. In the event of an emergency, the implementation of product recalls will prove to be a more effective method for ensuring food safety.
2. The system enables consumers to easily avoid particular food products and ingredients, such as those that trigger allergies or intolerances to specific foods, or those that are incongruous with their chosen lifestyle preferences.

The system enables consumers to make more informed decisions about food products based on objective data about the nutritional and other attributes of a range of food items produced by different companies. A well-designed traceability system will facilitate the following:

1. The objective of this study is to minimize the financial burden associated with product recalls in the market. (Product Recall).
2. It is crucial to undertake corrective actions in order to prevent the recurrence of a product recall in the future.

3. It is vital to identify potential concerns and establish measures aimed at averting penalties arising from production errors.
4. It is of utmost significance to bolster consumer trust in the brands manufactured.

It is imperative to improve the effectiveness of the production process and quality control, specifically concerning the utilization of production raw materials, product attributes, and data on the quantity of raw material inventory.

The results of Hypothesis 6 (H6) demonstrate that transparency has a positive and direct impact on societal risk. Transparency within the supply chain allows businesses and consumers to understand the various processes involved in the production and distribution of goods. Supply chain transparency encompasses knowledge of the geographical location, manufacturing processes, labor practices, product journey, and environmental impacts. The aim of supply chain transparency is to provide consumers with comprehensive access to information regarding the production and distribution processes of goods. This is advantageous for both manufacturers and consumers as it allows consumers to assess whether the product, they are purchasing poses any potential risks to their health and safety. Supply chain transparency also promotes responsible actions among businesses and consumers, enabling them to align their decisions with their values and goals. For consumers, supply chain transparency offers relevant information for their purchasing and consumption choices.

Transparency plays a crucial role in fostering the development of sustainable supply chains. With more companies embracing environmental and social initiatives, transparency becomes a valuable instrument for attaining their objectives and reassuring their consumers. On one hand, heightened transparency in supply chains can facilitate the transition towards more sustainable commodity production systems. By shedding light on the intricacies of supply chains, transparency empowers various stakeholders to identify and address risks, improve conditions on the ground, and evaluate progress made thus far. The complex nature of global supply chains undeniably contributes to concealing questionable and unsustainable production practices (Gardner et al., 2019). To mitigate the societal risks associated with food supply chains, food chain suppliers should prioritize increasing transparency through the following measures:

1. **Mapping the Supply Chain**
The attainment of transparency commences with a comprehension of the different constituents and stakeholders implicated. A thorough comprehension of each participant can foster the establishment of more resilient supply chains, characterized by heightened visibility and diminished societal hazards related to supply chains. The adoption of supply chain management systems, capable of precisely tracing and governing the complexities inherent in contemporary, globalized supply networks, serves to expedite the achievement of transparency.
2. **It is advisable for the company to establish partnerships with suppliers.**
Collaborating with suppliers plays a crucial role in fostering the integration of ethical and environmental standards. Moreover, it serves as a preventive measure against information gaps that hinder sustainability and transparency endeavors. One effective approach for validating practices is the implementation of periodic audits, which can be carried out internally or by an external entity. These audits encompass various domains, such as labor standards, environmental impacts, emissions levels, quality control, and other relevant factors. Audits are an integral part of risk management as they provide a mechanism for ensuring that operations and activities align with predetermined expectations.

3. **Implementing Technology Solutions**
 Several companies are currently exploring methods to enhance transparency by utilizing blockchain technology, which employs digital ledgers to securely and openly record transactions. Implementing this technology can effectively mitigate the occurrence of fraudulent activities and guarantee the ethical sourcing and production of goods and services.
4. **Using Data**
 Supply chain data collected from diverse sources can yield valuable insights into operational efficiencies, potential risks, and areas that require improvement. Real-time data plays a crucial role in enabling companies to promptly adjust and respond to supply chain challenges. Supply chain control towers serve as a nexus for multiple data-driven information sources, enhancing overall visibility and decision-making capabilities.
5. **Publicizing Information to Society**
 Supply chain transparency is contingent upon both internal and external information availability. Companies employ a range of strategies to enhance consumers' and stakeholders' comprehension of various aspects of the supply chain. Notably, product labeling and packaging can be devised to emphasize details regarding product origin, ingredients, and manufacturing procedures. Moreover, company websites and other online platforms facilitate the disclosure of supply chain information, such as audit summaries and sustainability or corporate responsibility reports, thereby enabling individuals to gauge the associated risks when consuming food products provided by the company.

6. Conclusion and Implications

This study investigates the utilization of blockchain technology in enhancing the transparency and traceability of the food supply chain in Indonesia. The findings of the conducted analysis demonstrate that blockchain technology yields a favorable impact on transparency and traceability by enhancing the safety of food products and mitigating risks to the public. This outcome is substantiated by the standardized beta (B) coefficient values of 0.719 and 0.652, indicating a positive influence, as well as a significance value below 0.005, suggesting a significant effect in the implementation of blockchain technology. Furthermore, the calculated T-values, exceeding the T-table values, provide further confirmation of the statistical significance of these findings.

The research findings presented in this study have significant implications for the future. The adoption of blockchain technology can enhance transparency and traceability, leading to increased consumer confidence in the safety and quality of food products. Moreover, this technology can bolster the brand image by reinforcing trust. Additionally, the implementation of blockchain can yield cost reductions for companies involved in the food supply chain by minimizing the need for manual audits and diminishing the risk of errors or data manipulation. Furthermore, the outcomes of this research can serve as a foundation for policymakers to devise regulatory frameworks that facilitate the integration of blockchain technology in the food industry, thereby enhancing food safety standards.

Further research is required to investigate the integration of blockchain with other technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), to enhance the efficiency and transparency of the food supply chain. Examining the economic and social ramifications of blockchain implementation, including conducting cost-benefit analysis for various stakeholders, also presents an essential and captivating area for future investigation.

However, it is important to acknowledge the limitations of this study. One notable limitation is the restricted sample size, which only includes individuals from the general public within the age range of 20-27 years. As such, the findings may not fully represent the perceptions of the wider population. Additionally, given the fast-paced advancements in blockchain technology, it is crucial to consider that the results of this research might need to be reviewed or reevaluated in light of evolving times and the specific technological developments within the food supply chain.

Acknowledgments

We wish to extend our gratitude to the University of Logistics and International Business for their support in facilitating this research. Furthermore, we would like to express our sincere appreciation to the local individuals who graciously took part in the random completion of the questionnaire, as their contributions were instrumental in the accomplishment of this study.

References

- Beck, K., & Ralph, J. (1994). *Pola Menghasilkan Arsitektur. dalam Prosiding Konferensi Eropa tentang Pemrograman Berorientasi Objek* (hlm. 139-149). Bologna, Italia.
- Chen, S., Mulgrew, B., & Grant, PM (1993). *Teknik Clustering untuk Pemerataan Saluran Komunikasi Digital Menggunakan Jaringan Fungsi Basis Radial. Transaksi IEEE di Jaringan Neural*, 4(2), 570-578.
- Chen, WK (1993). *Jaringan dan Sistem Linier*. Belmont, CA: Wadsworth. (hlm. 123-135)
- Cichocki, A., & Tidak Berperilaku, R. (1993). *Jaringan Neural untuk Optimasi dan Pemrosesan Sinyal (Edisi ke-1st)*. Chichester, Inggris: Wiley.
- Darmawan, O., Indonesia, A. A. F., dari Bitcoin, C. E. O., & Indonesia, B. (2017). *Teknologi Blockchain, Teknologi Masa Depan*. Fintech Talk-Opinion editorial.
- FAO. (2011a). *FAO di Abad 21, Menjamin Ketahanan Pangan di Dunia yang Berubah*. Roma.
- Ghozali, I. (2018). *Aplikasi Analisis Multivariate dengan Program IBM SPSS*. Yogyakarta: Universitas Diponegoro
- Hill, RM (1997). Model Produksi-persediaan yang Terintegrasi dengan Vendor Tunggal Pembeli Tunggal dengan Kebijakan Umum. *Jurnal Riset Operasional Eropa*, 97(3), 493-499.
- Indraprakoso, D. (2023). *Eksplorasi Potensi Penggunaan Blockchain dalam Optimalisasi Manajemen Pelabuhan di Indonesia: Tinjauan Literatur. Sanskara Manajemen dan Bisnis*, 1(03), 140-160.
- Lam, TK, Heales, J., Hartley, N., & Hodgkinson, C. (2020). Kepercayaan Konsumen terhadap Keamanan Pangan Memerlukan Transparansi Informasi. *Jurnal Sistem Informasi Australasia*, 24.
- Sugiyono. (2013). *Metode Penelitian Kuantitatif, Kualitatif, dan R & D*. Bandung: Alfabeta.
- Sugiyono. (2015). *Metode Penelitian Kuantitatif, Kualitatif, dan Kombinasi (Mixed Methods)*. Bandung: Alfabeta.
- Susilo, R. F. N. (2023). Penggunaan Artificial Intelligence (AI) dalam Membangun Sistem Pangan Berkelanjutan di Indonesia. *Jurnal Imagine*, 3(2), 104-116.
- Thakker, SV, Rane, SB, & Narwane, VS (2024). *Implementasi Arsitektur Terintegrasi Berbasis Blockchain-IoT dalam Rantai Pasokan Ramah Lingkungan. Penelitian dan Aplikasi Rantai Pasokan Modern*.
- Vidmar, RJ (1992, Agustus). Tentang Penggunaan Plasma Atmosfer sebagai Reflektor Elektromagnetik. *Transaksi IEEE pada Ilmu Plasma*, 21(3), 876-880. <http://www.halcyon.com/pub/journals/21ps03-vidmar>
- Yiannas, F. (2018). Era Baru Transparansi Pangan yang Didukung oleh Blockchain. *Inovasi: Teknologi, Tata Kelola, Globalisasi*, 12(1-2), 46-56.

Integrating Advance Technology and Logistics Customer Service for Optimal Logistics Performance: A Study at Shopee Express Pangalengan Branch

Muhamad Faisal Nasrudin^{1*} & Agus Purnomo¹

¹Department of Logistics Management, Faculty of Logistics, Technology and Business,
Universitas Logistik dan Bisnis Internasional, Bandung, Indonesia

*211230015@std.ulbi.ac.id

Abstract

The expansion of e-commerce has elevated the importance of package tracking and delivery for logistics companies, which now combined with cutting-edge technology with customer-focused services. This study examines the integration of Advance Technology (AT) and Logistics Customer Service (LCS) to optimize Logistics Performance (LP) at Shopee Express Pangalengan Branch. This research employed an explanatory cross-sectional survey approach, gathering data through questionnaires administered to 96 Shopee Express users located in Pangalengan. The study utilized Partial Least Squares Structural Equation Modeling (PLS-SEM) for data analysis. Findings revealed that both Advanced Technology and Logistics Customer Service significantly and positively impact logistics performance. Advance technology contributes through improved operational efficiency and shipment visibility, while Logistics Customer Service improves customer satisfaction and loyalty. The findings confirm the importance of integrating advanced technology and superior customer service in e-commerce logistics strategies. Practical implications include recommendations for continued investment in technology and improved customer service quality that enable e-commerce logistics companies to optimize their performance in the digital age.

Keywords: Advance Technology, Logistics Customer Service, Logistics Performance, E-commerce Logistics, PLS-SEM.

1. Introduction

The era of globalization has increased competition in various sectors, including the logistics industry. Companies continue to look for strategies to improve their logistics performance by utilizing Advance Technology (AT) and improving customer service (Lisawanto et al., 2023). Effective logistics operations are crucial for managing supply chains and have emerged as a critical factor in determining an organization's success (L. Zhang, 2018). This includes various aspects, such as on-time delivery, cost effectiveness, and customer satisfaction, all of which contribute to operational efficiency and overall competitiveness.

The logistics industry has witnessed a significant transformation in recent years, driven by the growing demand for efficient and customer-centric services (Perenc, 2018). Along with the growth of the e-commerce sector, long-distance delivery has become a critical component in the supply chain, thus posing a challenge for logistics service providers to meet evolving customer expectations (Vakulenko et al., 2019). Logistics firms are now prioritizing the combination of Advanced Technology and enhanced customer service approaches to overcome these obstacles and boost their overall logistics performance (LP).

Advance technology has emerged as a significant driver for improving logistics performance. The application of technologies such as the Internet of Things (IoT), big data

analytics, and automation has revolutionized supply chain operations (Hercegová et al., 2021). These technologies facilitate real-time tracking, predictive maintenance, and optimized routing, leading to increased efficiency, reduced costs, and better decision-making (Scherbakov & Silkina, 2019). In addition, the integration of Advance Technology can streamline the flow of information, enabling smooth coordination among supply chain partners (Duan, 2020). In addition to technological advancements, Logistics Customer Service (LCS) has gained prominence as an important factor affecting logistics performance (LP). Meeting customer expectations and providing exceptional service has become imperative to maintain a competitive advantage (Ghoumrassi & Tigu, 2017). Effective communication, responsiveness to customer queries, and personalized solutions can increase customer satisfaction and loyalty, ultimately driving logistics performance.

This research examines the integration of Advance Technology (AT) and Logistics Customer Service (LCS) at Shopee Express, one of the leading logistics service providers in Indonesia. This research investigates the impact of digitalization on customer satisfaction, as well as the strategies used by Shopee Express to improve its logistics performance (LP) through technological innovation and a customer experience-centered approach. Shopee Express currently utilizes AT, especially the real-time tracking system. This unique feature allows customers to see the live location of the vehicle distributing their packages. Additionally, the system seamlessly transitions from showing delivery trucks to motorcycles during the long-distance delivery phase, all within the same Shopee app. This level of detailed tracking surpasses the capabilities of many other logistics providers in Indonesia, which usually rely on descriptive text updates to show the location of the package.

In addition, Shopee Express has integrated customer service features powered by AI. One notable application is the AI's ability to accurately estimate package arrival time. In addition, Shopee Express offers a customer-centric guarantee: if the parcel arrives later than the promised delivery time (as determined by Shopee and Shopee Express), customers automatically receive compensation in the form of Shopee Pay credit added to their account balance. These technological advancements and LCS innovations put Shopee Express at the forefront of e-commerce logistics in Indonesia, offering a level of transparency and reliability that enhances the overall customer experience. The integration of real-time tracking, AI-powered forecasting, and customer assurance demonstrates Shopee Express' commitment in utilizing AT to improve LP and customer satisfaction.

The integration of AT and customer-centric strategies has emerged as an important approach for logistics providers to meet the growing demands of the e-commerce industry. By leveraging technological innovations and focusing on improving customer experience, Shopee Express Branch Pangalengan aims to optimize LP and maintain a competitive edge in the market. Despite an expanding field of research, there remains a gap in fully comprehending how Advanced Technology (AT) and Logistics Customer Service (LCS) can be effectively combined to maximize Logistics Performance (LP). Previous research has mostly focused on these factors individually or examined their effects within a specific context or industry (Cano et al., 2021). This research seeks to examine how Advanced Technology (AT) and Logistics Customer Service (LCS) impact Logistics Performance (LP), with the goal of offering useful findings for both industry professionals and academic researchers.

This research offers novelty in exploring the integration of AT and LCS to optimize LP from the customer perspective in the context of e-commerce in Pangalengan. This research is

unique in that it locates customer experiences and perceptions focusing on non-urban settlements. By focusing on Shopee Express in Pangalengan, this study provides valuable insights into how customers perceive and evaluate the implementation of advanced logistics technology in their daily e-commerce services. In addition, this study contributes to the development of a conceptual model that describes the relationship between AT, LCS and LP based on customers' perspectives in an e-commerce context. This approach enables a deeper understanding of how AT and LCS directly affect LP in the e-commerce logistics process.

2. Literature Review

The Role of Advance Technology in Achieving Logistics Performance

A country's level of digitization plays an important role in the formation and development of its logistics performance. Advance technology, especially with regard to digital connectivity and the integration of digital technology into business processes, significantly improves various aspects of logistics performance at the country level. It was found that specific indicators such as fixed broadband coverage, 4G coverage, broadband price index, ICT specialists, professional social media usage, big data, and cross-border e-commerce have a significant influence on various aspects of LP (Moldabekova et al., 2021). Based on the findings of this study, the application of technology in logistics management provides several significant benefits. These technologies contribute to lower overall costs, improved cooperation between suppliers and customers, and increased visibility and traceability of products and information. In addition, technology also plays an important role in supporting the decision-making process throughout the supply chain, including for the end consumer (Cano et al., 2021).

Internet of Things (IoT) technology and Blockchain technology (BCT) have a positive impact on the level of transparency in humanitarian logistics operations. This research provides a new understanding of how AT such as IoT and BCT can improve Humanitarian LP by increasing the level of transparency, public trust, and coordination between all parties involved in humanitarian aid operations (Khan et al., 2021). Several key technologies from Industry 4.0 such as Internet of Things (IoT), Cyber-Physical Systems (CPS), Big Data Analytics, Artificial Intelligence (AI), Cloud Technologies, Blockchain, and Autonomous Robots act as key factors in improving sustainable LP through increased digitization, connectivity, intelligence, integration, and operational responsiveness. However, the application of these technologies requires careful consideration of trade-offs between various aspects of economic, environmental, and social sustainability in order to achieve an optimal balance in their implementation (Sun et al., 2022).

The technologies discussed in this section are useful for updating logistics education materials, improving teacher performance, showing the balance between traditional and disruptive technologies, and illustrating the relationship between the two (Cano et al., 2021).

1) Global Positioning System and General Packet Radio Service

GPS is a positioning technology that is effective in all weather conditions. This technology provides high accuracy and fast response to determine the location of vehicles or goods in the supply chain (Hussien et al., 2023). Meanwhile, GPRS is a GSM network-based communication technology that offers the advantage of higher data transmission speeds. The combination of GPS and GPRS is often applied in alarm systems and position monitoring of cargo vehicles (Cano et al., 2021). When combined with technologies such as RFID, these technologies enable smarter and more dynamic logistics systems for product collection and delivery, as RFID records product information. These technologies are key

enablers of IoT and enable real-time tracking of the location of each transportation unit (Naumova et al., 2020).

2) Internet of Things

This technology connects everyday objects and products to the internet, allowing them to send and receive data. IoT is based on self-configuring infrastructure using standardized and interoperable communication protocols, where physical and virtual objects have identities as well as physical attributes, and are integrated into information networks through intelligent interfaces. In logistics, IoT technology connects various assets throughout the supply chain. The data generated from these connections provides real-time visibility of operations and creates new sources of value. IoT solutions for logistics integrate sensors with RFID and GPS to provide real-time monitoring of products, ensuring that products arrive in the condition expected by customers (Chuang et al., 2017).

3) Artificial Intelligence

According to this study, Artificial Intelligence (AI) is crucial in enhancing last-mile delivery logistics. AI is implemented in various critical areas to boost efficiency and cut delivery expenses. One key application is Vehicle Routing Optimization (VRO), which employs AI algorithms to determine the most efficient delivery paths, thereby reducing travel distances and transportation costs. Last Mile Platform (LaMP) utilizes AI to automate courier routes by considering various factors such as delivery destination, traffic conditions, and weather in real-time (Jucha, 2021). In the research (Shaklab et al., 2023) mentioned that this Journal describes the comprehensive application of AI in last mile delivery logistics, focusing on robot-based autonomous delivery systems. AI is leveraged to optimize routes and delivery schedules through sophisticated Vehicle Routing Problem (VRP) models, considering travel time uncertainty and customer time preferences. Safety is top of mind with the use of recurrent neural networks to predict pedestrian movements, vibration monitoring systems for package security, and automated loading and unloading mechanisms for contactless delivery. Delivery robots are equipped with intelligent navigation capabilities, allowing them to operate autonomously in complex urban environments. This multifaceted approach demonstrates how AI can improve efficiency, safety, and customer satisfaction in last mile logistics, while addressing real-world operational challenges.

The application of AI in logistics, especially last mile delivery (LMD), has brought significant changes to the industry. AI enables more accurate data-driven decision-making, by analyzing various factors such as consumer patterns, traffic conditions, and driver performance. AI systems can dynamically optimize delivery routes and scheduling, improving overall operational efficiency. AI integration in logistics systems enables real-time data sharing across the supply chain, improving coordination and responsiveness. AI-powered digital services, such as real-time tracking and intelligent scheduling, improve customer experience. AI also plays an important role in demand forecasting and predictive maintenance, helping companies anticipate future needs and reduce downtime. The implementation of AI in Last Mile Delivery (LMD) enhances the overall delivery process, making it more efficient, adaptable, and focused on customer needs. This provides a competitive edge for businesses that embrace AI technology, helping them tackle the increasing challenges posed by the expanding e-commerce sector (Sorooshian et al., 2022).

H1: Advance Technology has a positive and direct effect on Logistics Performance

The Role of Logistics Customer Service in Achieving Logistics Performance

The role of LCS plays vital part in Logistics Performance. This research shows that a focus on written shipping policies, organizational structure, order cycle time, inventory availability, and customer complaint handling significantly contribute to improved LP. The new findings from this research highlight the importance of tailoring LCS elements to industry-specific needs, especially in the context of freight forwarding, and emphasize the importance of after-sales service in achieving customer satisfaction and optimal LP (Purwoko et al., 2022).

The main factors of LCS that affect LP include delivery speed, flexibility of delivery time/place, clarity of return procedures, and delivery price. The higher the quality of LCS, the better LP can be achieved. The main findings of the study (Majchrzak-Lepczyk & Łupicka, 2019) are:

1. Non-price factors in LCS, such as speed and flexibility of delivery and clarity of return procedures, are now favored by consumers over price.
2. The increased use of mobile devices for online shopping has driven consumer expectations of faster delivery.
3. Consumer awareness of the right to return goods is increasing, making clarity of return procedures an important factor.
4. In some European countries, such as Poland, consumers are willing to pay more for faster delivery services.

This research reveals that non-price factors in Logistics Customer Service play an increasingly important role in determining the LP of e-commerce companies, with preferences varying across different European countries. These findings provide new insights into the importance of adapting LCS strategies according to the specific needs of each country's market to improve the competitiveness of e-commerce companies (Majchrzak-Lepczyk & Łupicka, 2019).

H2: Logistics Customer Service has a positive and direct effect on Logistics Performance

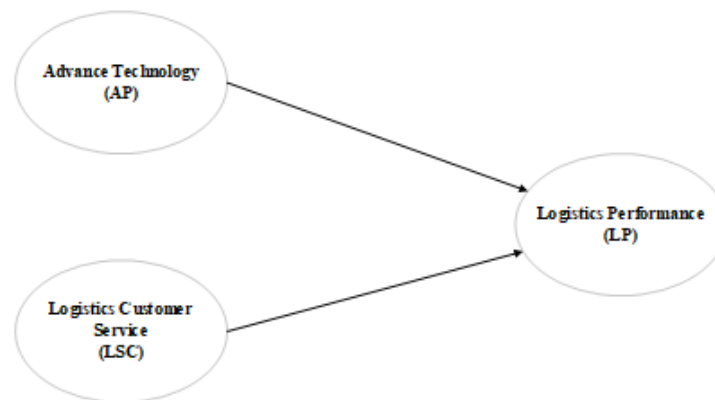


Figure 1: Theoretical Framework

3. Methodology

Research Design

Explanatory research methods, also known as causal or verification research, aim to uncover cause-and-effect relationships between variables. This approach seeks to identify and verify how a phenomenon changes or varies in relation to other variables. In addition, explanatory research also serves to test theories or hypotheses, which may strengthen or refute pre-existing theories. The explanatory survey method is specifically used to analyze the effect of independent variables on dependent variables. This research design involves hypothesis testing through relevant statistical analysis techniques. The choice of this method is based on its ability to explain the causal relationship and test the effect of the independent variable (X) on the dependent variable (Y) (Sari et al., 2022).

Cross-sectional research design is a method that studies the relationship between risk factors and their effects through observation at a single point in time. Unlike longitudinal research which requires a long period of time, cross-sectional aims to collect data simultaneously or in one short period of time. In the context of this research, the cross-sectional survey method was applied to collect data from customers of Shopee Express Pangalengan branch. Data collection is carried out through distributing questionnaires to respondents in a relatively short period of time and simultaneously (Abduh et al., 2022).

Data Source and Sampling Techniques

Prior to initiating the survey, researchers developed a 25-item questionnaire. This survey instrument employed a five-point semantic differential scale and was structured around the three variables outlined in the conceptual research model. To ensure respondents' comprehension, the questionnaire was translated into Indonesian. An online survey was conducted with 100 Shopee Express customers in Pangalengan, Bandung Regency, West Java, Indonesia. This region was chosen due to the high activity of Shopee Express in non-urban areas. The respondents were users of the Shopee Express service, selected based on their experience regarding the variables under study. From the 100 surveys sent out, 96 responses were considered valid and suitable for inclusion in the subsequent analysis.

The research employed Variance-based Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the data and investigate relationships among variables. SmartPLS 3.0 software was utilized to assess the measurement model, confirming the construct variables' validity and reliability. Despite the non-normal distribution of data, the conceptual model was validated through PLS-SEM application (Hair et al., 2021).

4. Results

The PLS-SEM method was applied to evaluate the research model, which consists of two aspects: internal and external models. In the external model assessment, validity and reliability are the main focus. Convergent validity using a factor loading threshold of 0.7 and an average variance extracted (AVE) value of at least 0.5. The Fornell-Lacker criterion was employed to test discriminant validity, requiring the correlation between latent constructs to surpass the square root of the AVE.

Model reliability was assessed through composite reliability and Cronbach's alpha, both needing to meet a minimum value of 0.70. The internal model evaluation, aimed at predicting relationships between latent variables, utilized T-statistic values, P-values, and R-squared. According to Hair et al. (2021), R-squared values of 0.75, 0.5, and 0.25 denote strong, moderate, and weak influences of exogenous factors on endogenous variables, respectively. The significance of variable relationships at the 5% level was determined by a t-value exceeding 1.65 and a P-value below 0.05.

Outer Structural Model Result

Table 1 data indicates that all indicators satisfy convergent validity requirements, with factor loading values of 0.7 or higher and AVE values of 0.5 or above. These findings are crucial in assessing the outer model. Table 2 demonstrates compliance with discriminant validity criteria, as the square root of AVE (Fornell-Lacker Criterion) exceeds the correlation between latent constructs. Additionally, the model exhibits Composite Reliability and Cronbach's Alpha values of 0.70 or greater, verifying that it meets the necessary reliability standards.

Table 1: Assessment of Variable Validity and Reliability

Var	Ind	FL	Crb α	Cps Re	AV E
Advance Technology (AT)			.922	.938	.685
T1	location tracking accuracy	.809			
T2	speed of information	.898			
T3	real-time monitoring	.761			
T4	efficiency improvement	.735			
T5	predicted delivery time	.864			
T6	delivery route optimization	.758			
T7	customer satisfaction	.947			
Logistics Customer Service (LCS)			.962	.968	.732
S1	policy clarity	.966			
S2	policy transparency	.783			
S3	warranty availability	.817			
S4	ease of warranty claims	.771			
S5	speed of warranty claim settlement	.869			
S6	packaging quality	.769			
S7	packaging safety	.773			
S8	ease of claim process	.965			
S9	speed of claims handling	.969			
S10	ease of return process	.843			
S11	Return processing speed	.851			
Logistics Performance (LP)			.911	.929	.652
P1	Delivery time	.796			
P2	Shipping cost	.807			
P3	Speed of delivery time	.753			
P4	Customer satisfaction	.859			
P5	Problem solving	.841			
P6	Service uniqueness	.744			
P7	Service flexibility	.843			

Var = Variables, Ind = Indicators; FL = Factor Loading; Crb_ α = Cronbach's alpha; Cps_Re = Composite Reliability; AV_E = AVE

Table 2: Fornell-Larcker Criterion (Discriminant Validity)

	AT	LCS	LP
AT	.828		
LCS	.483	.856	
LP	.710	.687	.807

Inner Structural Model Result

Internal model assessment involves examining three parameters: R-squared (coefficient of determination), T-statistic value, and P-value. Data presented in Table 3 shows an R-Squared value greater than 0.5. This suggests that the exogenous variables, AT and LCS, exert a moderately significant influence on the endogenous variable, LP.

Table 3: R-Square (Determinant Coefficient)

	R. Squ	R. Sq Ad
LP	.658	.651

R_Squ = R Square; R_Sq_Ad = R Square Adjusted

Significance of variable relationships at the 5% level is determined using the criteria of T-value exceeding 1.65 and P-value less than 0.05. Comparing Table 4 and Figure 2 reveals that all hypotheses are supported, demonstrating positive direct relationships.

Table 4: Summary of Hypothesis Test Results for All Proposed Research Hypotheses

Hypothesis	β . Pc	O. S	SD	T Stc	P_VL	Hy T.Co
Hpt1:AT \rightarrow LP	.493	.493	.093	5.273	.000	Accepted
Hyp2: LCS \rightarrow LP	.449	.449	.084	5.336	.000	Accepted

Hpt = Hypothesis; β . Pc = Path Coefficients O. S = Original Sample; SD = Standard Deviation; T_Stc = T Statistics; P_VL = P Value; Hy.T.Co = Hypothesis Testing Conclusion

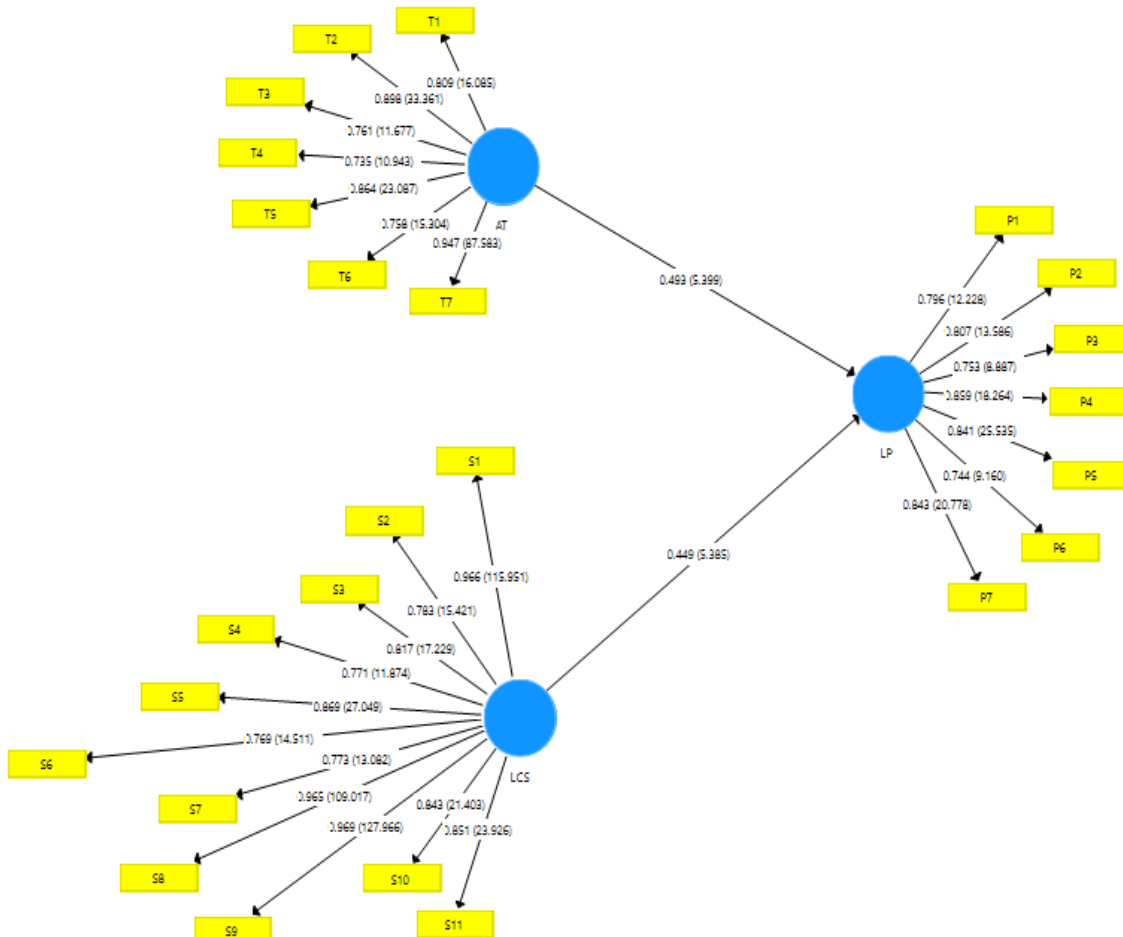


Figure 2: Overview of the Model Based on Bootstrap Analysis: Path Coefficients, Factor Loadings, and T-Statistics

5. Discussion

This study explores how Advanced Technology (AT) and Logistics Customer Service (LCS) combined to optimize Logistics Performance at Shopee Express Pangalengan Branch. In addition, this research also analyzes the impact that AT and LCS have on LP.

Findings from H1 indicate that Advanced Technology (AT) directly and positively influences Logistics Performance (LP). Advanced Technology encompasses cutting-edge tools used in logistics operations, such as warehouse management systems, real-time tracking capabilities, and predictive analytics. This in turn enables companies to achieve optimal LP (Y. Zhang et al., 2017). Practically speaking, companies that adopt AT tend to achieve higher operational efficiency, reduce errors, and increase delivery speed. This improves their productivity, strengthens service reliability, and meets customer expectations for fast and accurate delivery, thereby creating a significant competitive advantage (Wang et al., 2019). In this context, AT value stems from its capacity to enhance real-time tracking systems and increase the transparency of

item-specific tracking data. Consequently, the impact of AT on LP is both practically significant and well-supported by theoretical frameworks in operations and logistics management research.

The findings from H2 corroborate the notion that Logistics Customer Service directly and positively influences Logistics Performance. Organizations that implement superior LCS practices demonstrate a higher ability to meet customer needs, handle complaints effectively, and increase overall customer satisfaction (Gligor et al., 2019). This customer-focused approach not only helps build customer loyalty but also contributes to improved operational efficiency through constructive customer feedback (Yu et al., 2017). From a strategic point of view, excellence in LCS allows companies to differentiate themselves from competitors and build a strong reputation in a highly competitive market (Purnama et al., 2024). In addition, organizations that successfully integrate superior customer service into their logistics operations often experience increased market share, higher customer retention, and sustained revenue growth (Lestari & Harto, 2024). As a result, superior LCS drives improvements in overall LP, including reduced delivery times, increased order accuracy, and decreased return rates (Burity, 2021). Therefore, by placing customer satisfaction as a top priority in logistics operations, companies can build a strong foundation for optimal and sustainable LP.

The recommendations from this study are as follows: First, it is recommended that Shopee Express Pangalengan Branch maintain its investment in Advanced Technology. This should be done not only to enhance operational efficiency but also as a strategic approach to gain a competitive edge and establish market dominance in the e-commerce logistics sector. Secondly, the company is advised to enhance the quality of their Logistics Customer Service, as empirical evidence shows it directly boosts Logistics Performance. By striking a balance between technological innovation and exceptional customer service, the company can reinforce its market standing while fostering long-term growth. This strategy also enables quick adaptation to evolving customer needs and market trends, ultimately leading to stronger customer loyalty and business growth. Third, seamless integration between AT and LCS is highly recommended, as this not only improves overall LP, but also drives innovation in logistics business models. This strategy enables companies to create more personalized and responsive logistics solutions, exceeding customer expectations in terms of service speed, accuracy and convenience. Fourth, to further strengthen LP, it is recommended to periodically analyze customer data and operational feedback to identify areas of improvement and opportunities for innovation. Finally, cultivating an organizational culture that emphasizes both technological advancement and outstanding customer service across all hierarchical levels can substantially enhance LP and nurture enduring customer relationships.

6. Conclusion and Implications

This research reveals the direct impact of Advanced Technology (AT) and Logistics Customer Service (LCS) on Logistics Performance (LP) at Shopee Express Pangalengan Branch. Advance Technology, which includes GPS, AI, and IoT, not only improves operational efficiency directly but also contributes to the overall improvement of Logistics Performance. In addition, superior Logistics Customer Service also plays an important role in improving customer satisfaction and operational effectiveness, thus improving logistics performance. The integration of Advance Technology and quality customer service into the logistics strategy is essential to achieve long-term operational excellence and gain a competitive edge in the highly dynamic e-commerce market.

The practical implications of this study's findings for e-commerce logistics management are as follows: First, organizations can enhance their ability to respond to market demands and

meet customer expectations by prioritizing the implementation of Advanced Technology such as GPS for real-time tracking, AI for route optimization, and IoT for real-time customer feedback system. Second, by understanding the importance of excellent Logistics Customer Service in achieving optimal Logistics Performance, companies can develop comprehensive training programs for customer service staff and implement more sophisticated customer relationship management systems. This includes activities ranging from order handling to customer complaint resolution. By integrating Advance Technology and superior customer service, companies can improve operational efficiency, reduce shipping errors, and strengthen customer loyalty.

However, it should be noted that this research has some limitations. For example, this research focuses on Shopee Express Pangalengan branch, which does not fully represent the dynamics of e-commerce logistics in other regions or a larger scale. Future research could broaden the geographical scope to explore regional differences in technology adoption and customer service approaches. Additionally, they should consider variables such as logistics competitive advantages, organizational culture, and other factors that may impact logistics performance, which were not addressed in this study. Moreover, upcoming research should take into account external factors that could influence technological advancements in last-mile delivery, shifts in government policies, and competitive dynamics within the e-commerce sector. Incorporating additional variables and indicators into the analysis would provide a more comprehensive understanding of the factors affecting logistics performance in the broader e-commerce landscape.

References

- Abduh, M., Alawiyah, T., Apriansyah, G., Sirodj, R. A., & Afgani, M. W. (2022). Survey Design: Cross Sectional dalam Penelitian Kualitatif. *Jurnal Pendidikan Sains dan Komputer*, 3(01), 31–39. <https://doi.org/10.47709/jpsk.v3i01.1955>
- Burity, J. (2021). The Importance of Logistics Efficiency on Customer Satisfaction. *Journal of Marketing Development and Competitiveness*, 15(3), 2021. <https://articlearchives.co/index.php/JMDC/article/view/4684>
- Cano, J. A., Salazar, F., Gómez-Montoya, R. A., & Cortés, P. (2021). Disruptive and Conventional Technologies for the Support of Logistics Processes: A Literature Review. *International Journal of Technology*, 12(3), 448–460. <https://doi.org/10.14716/ijtech.v12i3.4280>
- Chuang, C.-H., Lee, D.-H., Chang, W.-J., Weng, W.-C., Shaikh, M. O., & Huang, C.-L. (2017). Real-Time Monitoring via Patch-Type Piezoelectric Force Sensors for Internet of Things Based Logistics. *IEEE Sensors Journal*, 17(8), 2498–2506. <https://doi.org/10.1109/jsen.2017.2665653>
- Duan, C. (2020). 5G Promotes the Intelligent Development of the Logistics Industry. *Clausius Scientific Press - Journal Books Proceedings*. <https://doi.org/https://dx.doi.org/10.23977/ICCIA2020054>
- Ghoumrassi, A., & Tigu, G. (2017). The Impact of the Logistics Management in Customer Satisfaction. *Proceedings of the International Conference on Business Excellence*, 11(1), 292–301. <https://doi.org/10.1515/picbe-2017-0031>
- Gligor, D., Bozkurt, S., Russo, I., & Omar, A. (2019). A Look into the Past and Future: Theories within Supply Chain Management, Marketing and Management. In *Supply Chain Management* (Vol. 24, Issue 1, pp. 170–186). Emerald Group Holdings Ltd. <https://doi.org/10.1108/SCM-03-2018-0124>
- Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). *Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R A Workbook*. Springer, Cham. https://doi.org/https://doi.org/10.1007/978-3-030-80519-7_1

- Hercegová, K., Pyanov, A., & Mukhoryanova, O. (2021). Personnel Management in the Sustainable Transport and Logistics Industry. *SHS Web of Conferences*, 128, 04022. <https://doi.org/10.1051/shsconf/202112804022>
- Hussien, N. M., Mohialden, Y. M., Abbas, B. K., & Mohammed, I. S. (2023). Review of an Accurate System Utilizing GPS Technology. *Journal La Multiapp*, 3(6), 266–269. <https://doi.org/10.37899/journallamultiapp.v3i6.746>
- Jucha, P. (2021). Use of Artificial Intelligence in Last Mile Delivery. *SHS Web of Conferences*, 92, 04011. <https://doi.org/10.1051/shsconf/20219204011>
- Khan, M., Imtiaz, S., Parvaiz, G. S., Hussain, A., & Bae, J. (2021). Integration of Internet-of-Things with Blockchain Technology to Enhance Humanitarian Logistics Performance. *IEEE Access*, 9, 25422–25436. <https://doi.org/10.1109/ACCESS.2021.3054771>
- Lestari, I. K., & Harto, B. (2024). Integrasi Omnichannel Marketing dan Content Marketing: Kajian Kualitatif Tentang Dampaknya pada Loyalitas Pelanggan Sektor Ritel Kuliner di Bandung. *Jurnal Review Pendidikan dan Pengajaran*, 7. <https://doi.org/https://doi.org/10.31004/jrpp.v7i2.25967>
- Lisawanto, L., Mantri, Y. M., Yusuf, R., & Mohdari, M. (2023). Digitalisasi PT Pos dalam Meningkatkan Kepuasan Pelanggan PT Pos Indonesia. *Ekonomis: Journal of Economics and Business*, 7(1), 667. <https://doi.org/10.33087/ekonomis.v7i1.1072>
- Majchrzak-Lepczyk*, J., & Lupicka, A. (2019). Factors Shaping Logistic Customer Service of E-Commerce in Selected European Countries. *ISMIC 2019 15th International Strategic Management Conference*, 61–68. <https://doi.org/10.15405/epsbs.2019.10.02.6>
- Moldabekova, A., Philipp, R., Reimers, H. E., & Alikozhayev, B. (2021). Digital Technologies for Improving Logistics Performance of Countries. *Transport and Telecommunication*, 22(2), 207–216. <https://doi.org/10.2478/tjt-2021-0016>
- Naumova, O. N., Ivanova, E. A., Prischepa, A. S., Soshnev, A. N., & Fedyukovsky, A. A. (2020). Analysis of the Influence of Information and Communication Technologies on the Development of Transport and Logistics Activities in the Regions of the Arctic Zone of the RF. *IOP Conference Series: Earth and Environmental Science*, 434(1). <https://doi.org/10.1088/1755-1315/434/1/012015>
- Perenc, J. (2018). Logistics as a Tool to Improve the Competitiveness of DHL Services. *European Journal of Service Management*, 27, 339–346. <https://doi.org/10.18276/ejsm.2018.27/2-41>
- Purnama, D. A., Yanuar, T., Syah, R., Sunaryanto, K., & Dhafi Iskandar, M. (2024). Strategi Pemasaran Digital dalam Industri Logistik Pada Warelogi. *Manajemen Strategis Terkini*, 6. <https://journalpedia.com/1/index.php/mst>
- Purwoko, H., Thamrin, H. M., Yuliyanto, A., Akira, H., & D4, S. (2022). Analysis of The Elements of Logistics Customer Service in Freight Forwarding. *Jurnal Manajemen Bisnis Transportasi dan Logistik*, 8(2). <https://journal.itltrisakti.ac.id/index.php/jmtbtl>
- Sari, M., Rachman, H., Juli Astuti, N., Win Afgani, M., & Abdullah Siroj, R. (2022). Explanatory Survey dalam Metode Penelitian Deskriptif Kuantitatif. *Jurnal Pendidikan Sains dan Komputer*, 3(01), 10–16. <https://doi.org/10.47709/jpsk.v3i01.1953>
- Scherbakov, V., & Silkina, G. (2019). Logistics of Smart Supply Chains. *Atlantis Press - Proceedings of the International Conference on Digital Technologies in Logistics and Infrastructure (ICDTLI 2019)*. <https://doi.org/https://doi.org/10.2991/icdtli-19.2019.15>
- Shaklab, E., Karapetyan, A., Sharma, A., Mebrahtu, M., Basri, M., Nagy, M., Khonji, M., & Dias, J. (2023). Towards Autonomous and Safe Last-mile Deliveries with AI-augmented Self-driving Delivery Robots. *Cornel University*. <https://doi.org/https://doi.org/10.48550/arXiv.2305.17705>

- Sorooshian, S., Khademi Sharifabad, S., Parsaee, M., & Afshari, A. R. (2022). Toward a Modern Last-Mile Delivery: Consequences and Obstacles of Intelligent Technology. In *Applied System Innovation* (Vol. 5, Issue 4). MDPI. <https://doi.org/10.3390/asi5040082>
- Sun, X., Yu, H., Solvang, W. D., Wang, Y., & Wang, K. (2022). The Application of Industry 4.0 Technologies in Sustainable Logistics: a Systematic Literature Review (2012–2020) to Explore Future Research Opportunities. In *Environmental Science and Pollution Research* (Vol. 29, Issue 7, pp. 9560–9591). Springer Science and Business Media Deutschland GmbH. <https://doi.org/10.1007/s11356-021-17693-y>
- Vakulenko, Y., Shams, P., Hellström, D., & Hjort, K. (2019). Service Innovation in e-Commerce Last Mile Delivery: Mapping the e-Customer Journey. *Journal of Business Research*, 101, 461–468. <https://doi.org/10.1016/j.jbusres.2019.01.016>
- Wang, Y., Han, J. H., & Beynon-Davies, P. (2019). Understanding Blockchain Technology for Future Supply Chains: a Systematic Literature Review and Research Agenda. In *Supply Chain Management* (Vol. 24, Issue 1, pp. 62–84). Emerald Group Holdings Ltd. <https://doi.org/10.1108/SCM-03-2018-0148>
- Yu, Y., Wang, X., Zhong, R. Y., & Huang, G. Q. (2017). E-commerce Logistics in Supply Chain Management Implementations and Future Perspective in Furniture Industry. *Industrial Management and Data Systems*, 117(10), 2263–2286. <https://doi.org/10.1108/IMDS-09-2016-0398>
- Zhang, L. (2018). Research on Logistics Industry Transformation and Upgrading based on Resource Integration and Sharing. *IOP Conference Series: Earth and Environmental Science*, 186(6). <https://doi.org/10.1088/1755-1315/186/6/012046>
- Zhang, Y., Zhao, L., & Qian, C. (2017). Modeling of an IoT-enabled supply chain for perishable food with two-echelon supply hubs. *Industrial Management and Data Systems*, 117(9), 1890–1905. <https://doi.org/10.1108/IMDS-10-2016-0456>

The Impact of Ambidextrous Leadership, Logistics Organizational Culture, Logistics Organizational Structure, On Logistics Innovation and Its Implications for Company Performance PT Pos Indonesia Bangkalan Branch Office

AhmadRosadi¹ & Saptono Kusdanu Waskito²

^{1&2}Program Studi S2 Manajemen Logistik, Fakultas Logistik, Teknologi, & Bisnis
Universitas Logistik dan Bisnis Internasional, Jl. Sariasih No.54 Sarijadi, Sukasari Bandung
40151

¹Gomeed84@gmail.com & ²Saptono@ulbi.ac.id

Abstract

The author conducted a study on the performance of PT Pos Indonesia Bangkalan branch Office 69100, focusing on parcel revenue in 2023. The parcel revenue recorded was IDR 3,015,510,283 from a target of IDR 3,666,031,000, which means only 82.26% of the target was achieved. The failure to meet the target indicates a performance issue at PT Pos Indonesia Bangkalan Branch Office 69100. The author conducted the study titled "The Impact of Ambidextrous Leadership, Logistics Organizational Culture, and Logistics Organizational Structure on Logistics Innovation and Its Implications for the Performance of PT Pos Indonesia Bangkalan Branch Office." The population was 229 customers, with a sample size of 146 respondents determined based on the Slovin formula. All indicators had values greater than 0.7 and were declared valid. All dimensions had Cronbach's Alpha values above 0.7 and were declared reliable. There was a positive and significant influence of ambidextrous leadership on logistics innovation with a path coefficient value and a p-value of 0.001. There was a positive and significant influence of logistics organizational culture on logistics innovation with a path coefficient value of 0.207 and a p-value of 0.010. There was a positive and significant influence of logistics organizational structure on logistics innovation with a path coefficient value of 0.253 and a p-value of 0.034. There was a positive and significant simultaneous influence of ambidextrous leadership, logistics organizational culture, and logistics organizational structure on logistics innovation with an R Square value of 0.577. There was a positive and significant influence of logistics innovation on the performance of PT Pos Indonesia Bangkalan branch office with a path coefficient value of 0.762 and a p-value of 0.000. PT Pos Indonesia Bangkalan branch office should continue to innovate to increase revenue

Keywords: Ambidextrous Leadership, Logistics Organizational Culture, Logistics Organizational Structure, Logistics Innovation, Company Performance

1. Introduction

The revenue realization of PT Pos Indonesia in 2023 was only 82.26% of the target. This information indicates performance issues within PT Pos Indonesia. According to Utarayana (2021), company performance is the result of an organization's work over a specific period (one month, one quarter, one semester, one year) in line with organizational goals. The dimensions of company performance, according to Utarayana (2021), consist of financial performance, marketing performance, and operational performance. Company performance, as stated by Kyunga na (2019), Faturachman (2023), Kiragu (2020), Sibuea (2020), and Fathona (2020), is influenced by logistics innovation. Fathona (2024) describes logistics innovation as a mental process leading to the creation of new phenomena, new products, and new services in the logistics field. Fathona

(2020) explains that the dimensions of logistics innovation consist of logistics process, logistics value, and various logistics services.

According to Oluwafemi (2019), Mascareno (2021), Fadilah (2021), Schlosser (2023), Zhang (2024), Mascareno (2021), and Fadilah (2021), logistics innovation is influenced by ambidextrous leadership. Zhang (2024) explains that ambidextrous leadership can be defined as the ability to foster both explorative and exploitative behaviors in followers by increasing or reducing variance in their behavior and flexibly switching between those behaviors. The dimensions of ambidextrous leadership are opening leadership behaviors, closing leadership behaviors, and temporal flexibility.

Logistics innovation, according to Vinh The (2019), Siswanti (2022), Fraihat (2023), Anggraini (2023), and Alateeg (2024), is influenced by logistics organizational culture. Alateeg (2024) explains that organizational culture encompasses the shared values, beliefs, and norms that shape the way employees think, act, and interact within the organization. The dimensions of logistics organizational culture are knowledge sharing, risk-taking, and openness to new ideas. Logistics organizational structure, according to Lestari (2022), Anggraini (2023), Fraihat (2023), Ananda (2023), and Asbari (2024), influences logistics innovation. Fraihat (2023) explains that logistics organizational structure is a system that outlines how specific activities are handled to fulfill a strategic mission; rules, roles, and obligations are all part of all activities.

The organizational structure also determines the flow of information between divisions within the corporation. The dimensions of logistics organizational structure are centralization, formalization, and departmentalization.

The unique factors that distinguish the current researcher from the articles mentioned above are:

1. There is a positive but not significant influence of digital transformation on business model innovation.
2. There is a positive but not significant influence of logistics competence on business model innovation.
3. There has been no quantitative research examining the influence of business model innovation on company performance.

2. Body of Paper

Research Methods

This study employs a quantitative, descriptive, and verificative research. It uses quantitative, descriptive, and analytical methods. According to Sugiyono (2021), the quantitative research method is a research method used to study the behavior of a population or a sample (a part of the population). The author conducts research using the descriptive method. According to Sugiyono (2021), descriptive research is research aimed at obtaining a description or overview of certain characteristics of the variables being studied, usually depicted in the form of average variable values.

The author also conducts research using the verificative method. According to Siregar (2023), verificative research is used to test the validity of existing knowledge in a particular field. Verificative research is used to prove experts' opinions regarding the influence of independent variables on intervening variables, and the influence of intervening variables on dependent variables.

Research Model

The research model in this study is presented in Figure 2.1

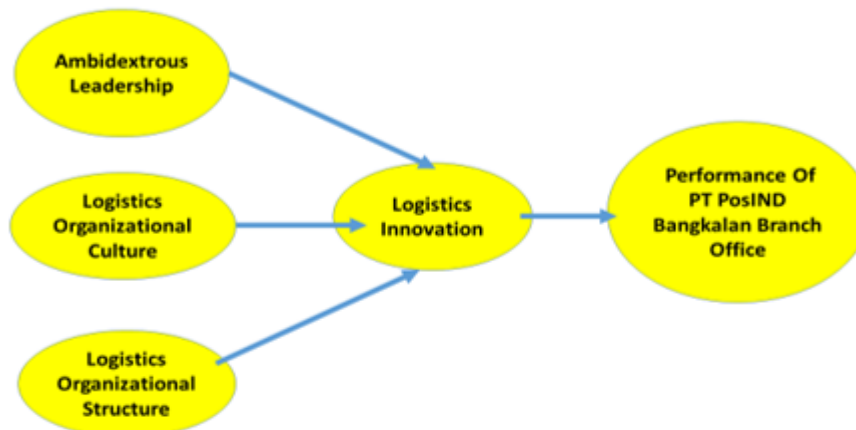


Figure 1: Research Model

The population consists of 235 customers of PT Pos Indonesia Bangkalan branch office. The sample size was determined using the Slovin formula, resulting in 146.

Hypotheses

The author proposes the following:

No Hypotheses

1. H₁ : There is a positive and significant influence of ambidextrous leadership on logistics
2. H₂ : There is a positive and significant influence of logistics organizational culture on logistics innovation
3. H₃ : There is a positive and significant influence of logistics organizational structure on logistics innovation
4. H₄ : There is a positive and significant simultaneous influence of ambidextrous leadership, logistics organizational culture, and logistics organizational structure on logistics innovation
5. H₅ : There is a positive and significant influence of logistics innovation on company performance

3. Results

The research results indicate that the mean values of each indicator range from 2.753 to 3.425, classifying them as fairly good to good, but not yet optimal. Therefore, the variables in this study are deemed suitable for further research. Hasnita (2021) states that research results are considered valid if each indicator has a factor loading value above 0.7. The research results show that the factor loading values of all indicators for the variables range from 0.756 to 0.892. These values are higher than 0.700. Hence, according to Hasnita (2021), all indicators in this study are declared valid since all factor loading values exceed 0.700. Hasnita (2021) also explains that a variable is considered reliable if each variable has a Cronbach's Alpha value greater than 0.700. All variables have Cronbach's Alpha values ranging from 0.801 to 0.903, which are above 0.70, therefore, all variables are declared reliable for research.

The research results show that the path coefficient value of ambidextrous leadership on logistics innovation is 0.363 with a p-value of 0.001. This means there is a positive and significant influence of ambidextrous leadership on logistics innovation. There is a positive and significant

influence of logistics organizational culture on logistics innovation with a path coefficient value of 0.207 and a p-value of 0.010. There is a positive and significant influence of logistics organizational structure on logistics innovation with a path coefficient value of 0.253 and a p-value of 0.034. There is a positive and significant simultaneous influence of ambidextrous leadership, logistics organizational culture, and logistics organizational structure on logistics innovation with a determination coefficient value of 0.577. The path coefficient value of the influence of logistics innovation on company performance is 0.762 with a p-value of 0.000. This means there is a positive and significant influence of logistics innovation on company performance.

The overall research results using the Structural Equation Model (SEM) with the PLS application are presented in Figure 2.1 below:

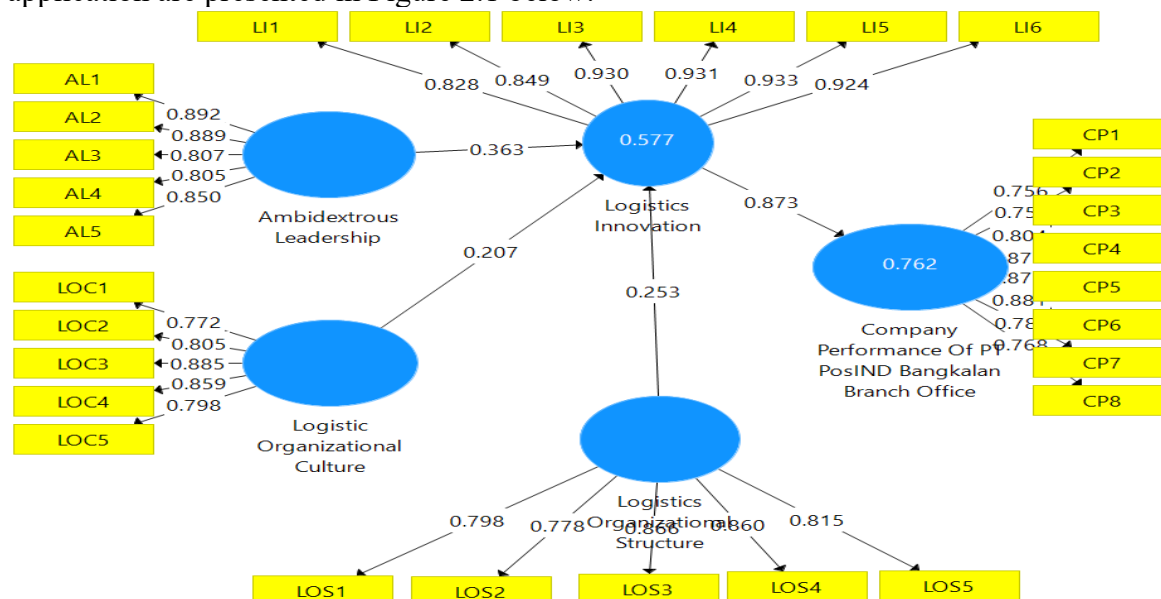


Figure 2.1. Result Research

4. Implication and Direction for Future Research

Implication

Considering that the path coefficient value of the logistics organizational culture variable is the smallest compared to the other two independent variables, the author recommends that the implementation of logistics organizational culture, specifically ethical culture (*budaya akhlak*), should be further enhanced in daily operations. This enhancement aims to improve the implementation of ethical culture, thereby fostering logistics innovation in the Bangkalan Branch Office environment.

Direction

The author has successfully demonstrated that logistics innovation influences the corporate company PT Pos Indonesia, with a contribution of only 0.762 or 76.20%. This information suggests that there are still opportunities for other researchers to investigate other variables that may affect the company. For example, variables like green logistics, agility, and lean logistics could be explored.

References

Al-Khawaldah, R. A., Al-Zoubi, W. K., Alshaer, S. A., Almarshad, M. N., Alshalabi, F. S., Altharawi, M. H., & Al-Hawary, S. I. (2022). Green Supply Chain Management and Competitive Advantage: The Mediating Role of Organizational Ambidexterity. *Uncertain*

- Supply Chain Management*, 10(3), 961–972. <https://doi.org/10.5267/j.uscm.2022.2.017>
- Andrini, D., & Susanto, P. (2022). Peran Ambidextrous Leadership Memediasi Hubungan Antara Orientasi Kewirausahaan, Budaya Inovasi dan Kinerja Sekolah di Kota Payakumbuh. *Jurnal Ekonomika dan Bisnis (JEBS)*, 2(1), 334–342. <https://doi.org/10.47233/jebbs.v2i1.106>
- Arikunto. (2021). *Prosedur Penelitian*. Rineka Cipta, Jakarta
- Cherchata, A., Popovychenko, I., Andrusiv, U., Gryn, V., Shevchenko, N., & Shkuropatskyi, O. (2022). Innovations in Logistics Management as a Direction for Improving the Logistics Activities of Enterprises. *Management Systems in Production Engineering*, 30(1), 9–17. <https://doi.org/10.2478/mspe-2022-0002>
- Cho, Y., & Lee, C. (n.d.). *The Effects of Process Innovation and Partnership in SCM: Focusing on the Mediating Roles*. 21(2), 453–472.
- Csedő, Z. (2023). Sustainability change management in inter-organizational innovation networks. *Society and Economy*, 45(4), 355–371. <https://doi.org/10.1556/204.2023.00011>
- Daugherty, P. J., Chen, H., & Ferrin, B. G. (2011). Organizational structure and logistics service innovation. *International Journal of Logistics Management*, 22(1), 26–51. <https://doi.org/10.1108/09574091111127543>
- Elvi, M. (2013). *Research Paper Organizational Structure and Logistics Service Innovation*. 31(September), 14–31.
- Feng, T., Si, Z., Jiang, W., & Tan, J. (2024). Supply chain transformational leadership and resilience: the mediating role of ambidextrous business model. *Humanities and Social Sciences Communications*, 11(1), 1–12. <https://doi.org/10.1057/s41599-024-03099-x>
- Grawe, S. J. (2009). Logistics innovation: A literature-based conceptual framework. *The International Journal of Logistics Management*, 20(3), 360–377. <https://doi.org/10.1108/09574090911002823>
- Hasnita. (2021). *Model Praktek PLS*. Padang, Universitas Padang
- Karagöz, İ. B., & Akgün, A. E. (2015). The Roles of its Capability and Organizational Culture on Logistics Capability and Firm Performance. *Journal of Business Studies Quarterly*, 7(2), 23. <http://eserv.uum.edu.my/docview/304876413?accountid=42599>
- Kusdanu Waskito, Saptono.(2023).*Terampil Mengolah Data Regresi, Path Analysis, Structural Equation Model Menggunakan SPSS, AMOS*. Alfabeta, Bandung
- Ližbetinová, L., Lorincová, S., & Caha, Z. (2016). Primjena Instrumenta Procjene Organizacije Kulture (OCAI) na logističke tvrtke. *Nase More*, 63(3), 170–176. <https://doi.org/10.17818/NM/2016/SI17>
- Ramdan, M. R., Abdullah, N. L., Isa, R. M., & Hanafiah, M. H. (2021). Organizational Ambidexterity within Supply Chain Management: A scoping Review. *Logforum*, 17(4), 531–546. <https://doi.org/10.17270/J.LOG.2021.618>
- Saputra, N. (2022). Menakar Pengaruh dari Ambidextrous Leadership terhadap Business Agility dari Perusahaan Publik di Masa Krisis. *Ideas: Jurnal Pendidikan, Sosial, Dan Budaya*, 8(4), 1435. <https://doi.org/10.32884/ideas.v8i4.845>
- Sudaryono, D. (2015). *Metodologi Riset di Bidang TI*. Yogyakarta: Andi.
- Sunyoto, Danang. (2013). *Metodologi penelitian akuntansi*.
- Yudha Pratama, T., & Kistyanto, A. (2024). Ambidextrous Leadership on Innovation Performance: The Mediating Role of Employee Creativity at PT Pertamina Patra Niaga Jatimbalinus. *Journal of Business and Management Review*, 5(5), 360–375. <https://doi.org/10.47153/jbmr55.9762024>.

Risk Management Design in Optimizing Employee Performance with The Approach of Enterprise Risk Management (ERM)

Ramadani Al Mantinu^{1*}

Magister Logistik & Supply Chain Management, Universitas Logistik & Bisnis Internasional, Jl. Sari Asih no 54, Sukasari, Bandung, Jawa Barat 40151, Indonesia

Abstract

In running a company will definitely face risks. Risks that arise come from the external environment and the internal environment of the company that makes the company suffer losses. The research method used is a descriptive qualitative research method with journal literature study data collection techniques. This study uses the Enterprise Risk Management (ERM) method. In applying this method, it starts by identifying risks, conducting performance assessments and controlling risks. With the application of the Enterprise Risk Management (ERM) method, the company can find the risks that occur in the company based on the categories of low, medium, or high. The purpose of this study is to identify the risks that may occur in the company and then, create a risk matrix to determine the risk constraints that occur based on the lowest to heaviest order for control prioritisation. The results show that the dominant risks that occurred in the company were delayed delivery of nuggets, stale nuggets when the freezer died, work accidents occurred during work, and damage to vehicles transporting nuggets.

Keywords: Risk Management, Enterprise Risk Management

1. Introduction

Companies that exist today have supply chains both as suppliers, and as customers that operate within the scope of the Indonesian region and the global scope. The company is currently facing the development of a fairly developed and increasingly complex supply chain that is certain. Every company must be aware of changes in operating the supply chain in order to adjust to the company's demand. Risk control design is part of the company's strategic plan in achieving its goals. If risk control is not well organised, this can lead to weak risk management (Safitri & Rufaedah, 2020). Another thing that companies must also know are the factors that affect the smooth running of the supply chain and all the obstacles that can occur as well as risk management strategies that can be applied to anticipate the risks that occur. In terms of implementing risk management, it can make a better influence on the company. Risk management is a set of policies, procedures that an organisation has to manage, monitor, and control the organisation against risk (Pagestuti, 2019) in (Lubis & Imsar, 2022).

The risks that occur within the company have their own challenges. This challenge makes the company must be able to minimise existing risks. A good company is a company that is able to manage risks, so that risks can be minimised or eliminated (Mellisa & Andono, 2013). shipping optimisation in fulfilling this inventory must be designed risk management so that all conditions that occur can be minimised especially in the company, this inventory is vital, which must be coordinated to fulfil its needs at all times. According to Ahmad, Tuli and Mahmud (2022), inventory is a number of finished goods, raw materials, and process in goods that the company owns with the aim of reselling or further processing.

Inventory is also part of the company's assets which are generally quite high material in value and prone to theft or misuse. Every company implements in minimising the risks that occur.

In minimising these risks, the company does not only carry out risk management, but the company conducts research within the company in finding solutions, namely by using the Enterprise Risk Management (ERM) method. This method is very helpful for company leaders in estimating, managing risks that occur or before they occur in the company. The right way to manage the risks that occur in the company is by implementing Enterprise Risk Management (ERM). With the application in controlling Enterprise Risk Management (ERM), the company is helped in understanding how to handle and control risks in order to minimise the impact of risks that occur, so that the company's goals are achieved in handling the risks that occur.

Implementation of Enterprise Risk Management (ERM) can be done by identifying events that occur within the company, assessing and responding to risks. The company can assess management performance to avoid risks that can affect employee performance in the company. In implementing Enterprise Risk Management (ERM), the possibility of companies finding risks that have occurred or that have not been identified which are divided into low (Low), medium (Medium), High (High) groups (Nugroho, 2013) in (Hasan et al., 2021).

PT XYZ company is engaged in frozen food retail which has been established from 2015. The products produced by this company are nuggets and have distributed to large and small retail stores. Retail stores that have subscribed to this company are around 180 stores spread from crowded areas to remote areas. Travel time in the distribution of nugget products is divided into several working areas including 60 retail stores with a travel time of 2-4 hours, 60 retail stores with a travel time of 3-6 hours, 60 retail stores with a travel time of 1-2 hours. The number of requests from customers indicate that the company must make an appropriate and fast production system in order to meet customer demand in fulfilling customer satisfaction. The system is made to achieve the company's goals to become a trusted and responsible company. PT XYZ company is engaged in frozen food retail which has been established since 2015. In carrying out business activities, PT XYZ faces several operational risk constraints.

The risks are human resource risk, technological process risk, and environmental risk. For human resources risk, there is an ineffective employee development strategy and frequent work accidents. The technology risk experienced by this company is in the form of a virus disruption in the company's computer system which causes the company's data to be lost. As for the process risks that occur in this company are in the form of damage to transportation and distributors are late in delivering goods and environmental risks in the form of stale nuggets and freezers that died due to power outages.

The problems that occur in the company are part of an indication of poor internal control. Based on the results of the literature study of this problem, it occurs because the company has not identified and analysed certain things that often occur from the internal and external environment. Seeing from these problems PT XYZ needs to identify and analyse the risks that may occur from the company to minimise losses that may occur with the Enterprise Risk Management (ERM) approach. From the identification and analysis of risks being studied, the company focuses on the company's operational field. In identifying and analysing risks with the Enterprise Risk Management (ERM) approach, the company only focuses on the problem identification stage to the risk treatment stage.

This research does not continue to the monitoring and review stage and the documentation stage of the risk management system. This is because it takes a long time to supervise the implementation. This research is closely related to operational management. It is known that

operational management is a form of comprehensive and optimal management based on work problems, goods, machinery, equipment, raw materials that can be used as a service product for sale. In the implementation of the company's production operational activities, it is necessary to have a manager that can make decisions in efforts to regulate and coordinate the use of production activity resources known as operational management (Wijaya et al., 2020).

Rohimmah et al (2022) states that from the results of data processing, the priority risk plan is obtained, namely the mismatch between the production plan and the implementation of production with the strategy of optimising machinery and equipment, source risk. Mirzania (2021) states that examining the application of Enterprise Risk Management (ERM) is to minimise credit risk, interest rate risk, and liquidity risk in banking companies. The implementation of Enterprise Risk Management (ERM) also affects the value of a company. The effect of the value of Enterprise Risk Management (ERM) on a company has an impact on the efficiency of the company.

Previous research became the author's reference in conducting research. Besides that, the author also took a literature study in fulfilling the research data in this journal. From the references that the authors take can enrich the theory used in this study. From previous research, the author found similarities in the theoretical aspects of research studies but with different aspects of objects, time and place. This research was conducted by the author at PT XYZ in 2024. The similarities between the current research and previous research lie in the aspect of theoretical studies related to company risk and the Enterprise Risk Management (ERM) approach method.

The purpose of this research is to identify the risks that occur in the operations of PT XYZ Company by assessing the risks. This risk research analysis is based on the severity or impact of the risk and the level of likelihood of risk occurrence and identification of risk handling that occurs and provides recommendations for improvement suggestions made by the company to deal with risks. Based on the background, the author identifies the problems like the percentage of the risk occurrence rate and the level of probability of occurrence by identifying risk handling and providing input for recommendations for improvements that can be made by the company to deal with.

2. Theoretical Review

Definition of Risk

The definition of risk is a possibility that occurs or an event that can harm the company's business, the event cannot be predicted (Latifiana, D. ,2017). The possibility of causing risks that occur to the business is fundamental to identifying and measuring the level of concern. According to SNI ISO 31000 in (Wiryono & Suharto, 2018), risk is an uncertainty that causes the company to have an impact on conditions that are negative or positive. This impact needs to be followed up because it will be an obstacle to achieving a goal or goal in the company in the short and long term. From the above definition, it can be concluded that risk is an event or event that has a dangerous impact on an organisation or company that causes future losses.

Operational Risk

According to Bambang Rianto Rustam (2017) in Trianto et al. (2021), operational risk is the malfunction of an internal process, human error, system failure and external events that affect company operations. This operational risk can occur at two levels, namely technical and organisational. In the implementation category, operational risk can occur when information systems, errors in recording, inadequate information and inaccurate risk measurement. In the organizational category, operational risk can arise because the monitoring system, reporting

system, procedure system and a policy are not running properly. Operational risk arises from losses or failures in internal processes, people, systems and external events. In general, operational risk is related to a number of problems that stem from a failure of a procedure or process. From this incident, the risk is not something new and cannot be faced. All companies will definitely experience the name of failure and must have the potential and process in anticipating the problem.

Enterprise Risk Management (ERM)

According to COSO (The Committee of Sponsoring Organizations of the Treadway Commission) in (Legawa, 2021) the definition of ERM (Enterprise Risk Management) is a process that is influenced by the intensity of the board of directors, management and other personal. In implementing the strategy, the entire company is designed to identify potential events that affect the entity in managing risks to stay on risk appetite in providing full confidence in the achievement of the entity's goals. The definition of Enterprise Risk Management (ERM) according to COSO in Makikui et al., (2017) is a series of processes that affect the entire entity, the board of directors, management and other forces whose implementation is through the determination of the company's strategy, which is made to identify potential events and can affect the entity in managing acceptable risks and providing security guarantees in achieving company goals.

Enterprise Risk Management (ERM) has an important role in describing the approach and identification, analysis, response and monitoring of risks and opportunities in the internal and external environment faced by the company. According to Darmawi (2016), Enterprise Risk Management (ERM) is an organisational management that requires efficient and effective administrative systems and procedures in its implementation. For example, a risk related to legal issues faced by the company has an impact on the company's reputation. This impact will affect the increase in the company's share price on the stock exchange (Soetedjo & Sugianto, 2018).

3. Research Method

In this study, the object of research is PT XYZ. It is a company that produces nuggets whose production market covers large and remote areas. The scope of this research is a variable related to operational risk. The research method used is qualitative research based on literature studies in data collection such as journal studies and publications that are in accordance with the topic under study. The data collection technique in this research is a literature study of several journal sources as data references. The following is the flow of research in the research article as follows:

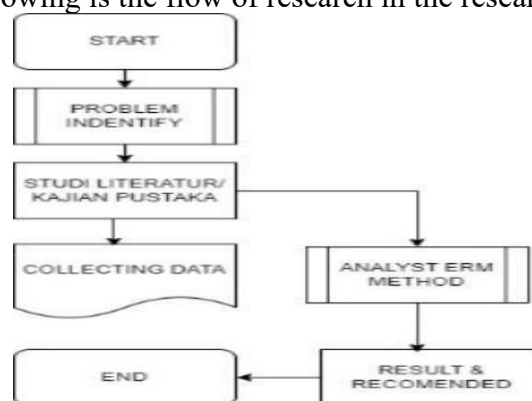


Figure 1: Author's Analysis (2024)

This research uses the Enterprise Risk Management (ERM) method approach. The application of the ERM method is carried out from identifying events that arise in business activities, assessing and managing risks. By applying Enterprise Risk Management (ERM), the company can find existing and unidentified risks and can classify risks based on groups, from low, medium, and high.

4. Results and Discussion

Risk Identification

The identification of risks that occur at PT XYZ is based on business processes that do not run according to the desired company targets. This research is focused on operational risks that occur. There are several problems that occur from the company's operations. This risk consists of human resource risk, productivity risk, and process risk.

Table 1: Risk Identification

Risk Type	Code	Risk	Cause/ Source of Risk
Human Capital Risks	A1	Ineffective employee skill development strategy	Lack of skill training for self- development of company employees
	A2	Occupational accidents occur during work	Lack of insight into work safety. As well as not complying with work safety provisions
Technology Risks	B1	A virus interfered with the computer, causing data loss.	Lack of database to data storage, resulting in data loss or viruses.
Process Risk	C1	Damage to vehicle transporting nuggets	Lack of vehicle maintenance and often late monthly late services
	C2	Delay in nugget delivery	Unscheduled deliveries resulting in a build- up of goods
Environmental Risks	D1	Stale nuggets when the freezer goes out of power	Frequent blackouts in the neighbourhood
	D2	Freezer defrosting due to blackout	Frequent blackouts in the neighbourhood

Source: Author's Process (2024) Risk Assessment

Company management can be measured and can be assessed from the size or scale of the risks faced. The company can also know the impact of the risk on the company's operations. According to Arta et al., (2021), by measuring this risk scale, the company can prioritise the most relevant risks that occur. In risk assessment, the author uses a frequency taken from numbers 1-5 which can be seen as follows:

Table 2. Frequency of Occurrence Scale

Level	Event
1	Never
2	Rarely
3	Quite often
4	Frequently
5	Very Often

Source: Author's Process (2024)

Table 3. Impact Level

Level	Event
1	Very Small
2	Small
3	Medium
4	Large
5	Very Large

Source: Author's Process (2024)

Based on the frequency table and impact table made by the author, the following is the identification of risks based on the frequency and impact caused below:

Table 4. Risk Assessment

Type Risk	Code	Risk	Frequency	Impat	Cause/ Source of Risk
Human Capital Risks	A1	Ineffe ctive employee skill developme nt strategy	1	2	Low
	A2	Occu patio nal accidents occur during work	2	3	Medium
Technology Risk	B1	Avirus interf ered with the computer, causi ng data loss.	3	2	Low
Process Risk	C1	Damage to vehicle transporting nuggets	2	4	Medium
	C2	Delaying nugget delivery	4	4	High
Environment Risk	D1	Freezer defrosting due to balck out	2	2	Low

Based on the results of risk identification from frequency and impact, the author determines the severity of low, medium, and high by using a likelihood impact matrix by dividing the frequency and impact into x and y axes.

5			D1		
4				C2	
3		B1			
2	D2		A2	C1	
1		A1			
Frequency	1	2	3	4	5

Impact descriptions:

1. Green boxes have little risk (Low Risk)
2. Yellow boxes have a medium level of risk.
3. Red box has high risk

Based on the risk map above, the risk grouping based on severity can be seen as follows:

1. Low risk
Risks included in the low-risk group are freezer melting due to a power outage (D2), ineffective employee skill development strategy (A1), and virus interference on the computer causing data loss (B1).
2. Medium Risk
Risks included in the medium risk category are work accidents occur at work (A2) and vehicle damage transporting nuggets (C1).
3. High risk
4. Risks that occur in the high-risk category are stale nuggets when the freezer dies (D1) and delayed delivery of nuggets (C2).

Risk Control

Based on the risk assessment, the company's management can determine whether the risk is acceptable (acceptable risk) or not (unacceptable risk). If the risk is unacceptable, the company must determine how to handle the risk, so that the risk can decrease. If the risk is acceptable or tolerated, the company needs to monitor the risk. (Ahmad, 2020).

Table 5. Risk Control

Level	Kod	Resiko	Pengendalian
High	C2	Delay in nugget delivery	Organised the nugget departure schedule to avoid delays.
	D1	Stale nuggets when the freezer is off	Provide UPS or Genset to minimize when there is a blackout.
Medium	A2	Occupational accidents occur during work	Conduct OSH socialisation to all employees of the Company so that they can be careful at work.
	C1	Damage to vehicle transporting nuggets	Carry out periodic vehicle maintenance by Conditioning vehicle eligibility

The results of the risk management analysis using the Enterprise Risk Management (ERM) method that has been carried out in the production area of PT XYZ show that there are 7 risks that occur. These risks include (1) human resource risk, (2) technology risk, (3) process risk and (4) environmental risk. Each process can be categorised into 3 levels, namely, low, medium and high. In the process of data processing based on analysis, it was agreed to carry out risk control only at the medium and high-risk levels. From the discussion during the dissemination, it has been discussed that the low level can be accepted by PT XYZ. Risk control is expected to prevent and minimise the risks that may occur during the production process, so that productivity can be effective and efficient.

5. Conclusions

From the results of research at PT XYZ Company, there are several conclusions that can be drawn, namely in risk analysis with Enterprise Risk Management (ERM) focusing on company operations and it is known that there are 7 risks that may occur within the company. Operational risks include human resources, process risk, technology risk, environmental risk. Risk assessment is carried out based on the severity of the impact which can be divided into several levels of probability and class. Risk scoring is obtained by multiplying the likelihood (occurrence) and impact (severity). From the risk scoring calculation, the highest risk is risk D1, which is stale nuggets when the freezer dies.

In the risk matrix, each risk is divided into 5 levels, namely very high, high, medium, low, very low levels. In responding to risks that occur, there are several ways to avoid risk, reduce risk and accept risk. At high and medium levels, risks are focused on avoiding and reducing. At the low level, the risk is focused on being reduced if possible. While the very low level of risk response is to accept risk by means of routine monitoring. From the results of research and risk analysis conducted by the author at the company, it is highly recommended that PT XYZ implements Enterprise Risk Management (ERM) because ERM risk analysis can help the company in assessing and managing risks that occur both large and small risks properly so that it can help the company in achieving company goals and can increase the company's profitability and not harm the company. The application of ERM can assist the company in identifying problems that occur both internally and externally, especially the company's operational risks. For further research, it is hoped that it will be able to examine other aspects of risk such as financial risk, strategic risk and others.

Bibliography

- Ahmad, R.S., Tuli, H. and Mahmud, M. (2022). Penerapan Pengelolaan Persediaan Berdasarkan Sak Emkm Bagi Kelangsungan Usaha Mikro di Kota Gorontalo, *Jurnal Ilmiah Manajemen dan Bisnis*, 5(1), pp. 217–229. Available at: <https://ejurnal.ung.ac.id/index.php/JIMB/article/view/14732%0Ahttps://ejurnal.ung.ac.id/index.php/JIMB/article/viewFile/14732/4473>.
- Dwiasnati, S. and Hidayat, R. R. (2022). Penerapan Manajemen Risiko Menggunakan COSO: Enterprise Risk Management Framework Integrated Pada PT ALPHANET', *Jurnal Tata Kelola dan Kerangka Kerja Teknologi Informasi*, 8(2), pp. 66–72. Available at: <https://doi.org/10.34010/jtk3ti.v8i2.7845>.
- Hasan, N.N., Rahmadini, F. and Dariyah, D. (2021) 'Application of Enterprise Risk Management to Banking Risk', *MIZANIA: Jurnal Ekonomi dan Akuntansi*, 1(2), pp. 67–84. Available at: <https://doi.org/10.47776/mizania.v1i2.245>.
- Lubis, M. D. S. and Imsar (2022) 'Analisis Manajemen Risiko Operasional Berdasarkan Pendekatan Enterprise Risk Management (Erm) Pada Ud. Anugrah Cabang Rantau Prapat, JMBIUNSRAT (*Jurnal Ilmiah Manajemen Bisnis dan Inovasi Universitas Sam Ratulangi*).', 9(3), pp. 1492–1504. Available at: <https://doi.org/10.35794/jmbi.v9i3.44457>.
- Mellisa & Andono (2013) 'Penerapan Enterprise Risk Management dalam Rangka Meningkatkan Efektifitas Kegiatan Operasional, *Jurnal Ilmiah Mahasiswa Universitas Surabaya*, 2(1), pp. 1–15.
- Safitri, S.A. and Rufaedah, Y. (2020). Perancangan Enterprise Risk Management pada Perusahaan Peternakan (Studi Kasus pada PT Aretha Nusantara Farm)', *Industrial Research Workshop and National Seminar*, pp. 26–27

Proposed Logistics Distribution Pattern for Regional Head Election in Bulukumba Regency (Case Study of the 2024 Regional Head Election)

Mirza Azzahra Damayanti¹ & Melia Eka Lestiani²

¹University of Logistics and International Business, Jakarta 11480, Indonesia

²Lecturer, University of Logistics and International Business, Bandung 40151, Indonesia

Abstract

The General Election Commission (KPU) of Bulukumba Regency is an institution that organizes general elections as stipulated by law governing the conduct of general elections in Bulukumba Regency. One of the crucial stages for the successful organization of elections is the accurate and efficient distribution of election logistics. The KPU of Bulukumba Regency needs to conduct mapping and understand the characteristics of the area to facilitate the determination of distribution patterns, distribution scheduling, mode of transportation, budget preparation, and collaboration with relevant agencies. PT. Pos Indonesia Bulukumba branch, as a state-owned enterprise engaged in courier and logistics services, can provide solutions for the KPU Bulukumba in selecting transportation modes, scheduling distributions, and determining optimal logistic distribution routes for the 2024 Regional Head Election in Bulukumba Regency using the capacitated vehicle routing problem approach by considering distances from Google Maps and using the nearest neighbor algorithm to determine the shortest distance between points. The proposed distribution pattern provided by PT. Pos Indonesia Bulukumba branch includes using 4 units of CDD box, 3 units of CDD long box, and 1 unit of CDE engkel. The route used is 6 routes with a total of 3 trips, and the distribution schedule is carried out in 1 day starting in the morning with an estimated completion of distribution and all transportation modes returning to the KPU warehouse in the evening.

Keywords: Election Logistics Distribution, Distribution Pattern, Capacitated Vehicle Routing Problem, Nearest Neighbor

1. Introduction

Background

Logistics is a series of activities from the initial point, which is the supplier, to the endpoint, which is the consumer. According to Donald J. Bowersox, translated by Hasyim Ali (2002), logistics is the strategic process of managing the movement and storage of goods, spare parts, and finished goods from suppliers, among company facilities, and to customers. The General Election Commission (KPU) is a general election organizing agency as referred to in the law governing general election organizers who are given the duties and authorities in organizing elections based on the provisions stipulated in the law governing elections. In organizing the election, there are logistics distribution activities for election equipment which of course must be managed with proper and effective logistics management in accordance with the Technical Guidelines for Election Logistics Management.

Election logistics is the organizing equipment used in the election of Governors and Deputy Governors, Regents and Deputy Regents and/or Mayors and Deputy Mayors, which consists of voting equipment, other equipment support, as well as socialization and campaign materials. Effective and efficient management of general election logistics is one of the important aspects/keys in realizing the implementation of elections with integrity, professionalism and accountability. The management of election logistics consists of several stages, namely planning

537

needs and budgets, procurement, distribution, maintenance and inventory, and destruction of ballots. These stages are a cycle whose implementation is carried out continuously as a cycle of Election Logistics Governance.

One of the stages that is an important factor in measuring the success of organizing elections is the distribution of election logistics that is appropriate and effectively efficient. This is the main focus of the Bulukumba Regency KPU to ensure that the distribution of election logistics can be carried out properly so that the election can run smoothly. The year 2024 is a political year because in this year simultaneous elections will be held for the Election of President and Vice President, House of Representatives (DPR), Regional Representative Council (DPD), Provincial and Regency / City People's Representative Council (DPRD) which will be held on February 14, 2024 and the implementation of Regional Head Elections (Pilkada) for the Election of Governors & Deputy Governors and the Election of Regents & Deputy Regents or the Election of Mayors & Deputy Mayors which will be held on November 27, 2024.

There are several studies related to election logistics researched by Zainal Ilham Barkati (2014) on Distribution Management of 2014 Legislative Election Logistics in Malinau Regency, Dewi Safitri & Hawignyo (2024) on Logistics Distribution Planning Strategies for Efficient and Successful 2024 Elections at the General Election Commission Kab. Karawang, Eka Wisnu Wardhana & Oki Anita Candra Dewi (2021) on Optimizing the Number of Vehicles and Distribution Routes for Election Logistics in Kediri Regency during the Pandemic.

Based on historical data for the February 14, 2024 elections in Bulukumba Regency, there are 1241 polling stations (TPS) spread across 10 sub-districts and 147 villages. Logistics distribution for the 2024 elections in Bulukumba Regency is estimated to have 4964 voting booths (4 booths / TPS) and 2482 ballot boxes (2 ballot boxes / TPS) which will be distributed to all polling stations. In the implementation of the distribution of election logistics, the KPU of Bulukumba Regency feels the need to map the farthest areas that are not easy to reach, Bulukumba Regency has several islands but there is only 1 inhabited island, Liukang Loe Island. By paying attention to the existing topology and geography, the Bulukumba Regency KPU also needs to take into account the obstacles that may arise in the process of distributing election logistics such as the distance of the TPS location, the travel time required, geographical and weather conditions, the number of voters, security and vulnerability of the area, and the means of transportation needed to reach all existing TPS. By mapping and knowing the characteristics of the area, it can facilitate the determination of distribution patterns, distribution scheduling, determination of transportation modes, budget preparation and cooperation with related agencies.

Departing from the problems experienced by the Bulukumba Regency KPU during the February 2024 elections reported on the metrotvnews.com news portal website, namely the shortage of ballots due to ballots that were found damaged during the sorting and folding process, causing the election logistics distribution process to be delayed for several days. The distribution of election logistics that must be postponed can affect the distribution scheduling that has been determined. To avoid delays in the distribution process to the polling stations (TPS), it is necessary to plan the right distribution pattern by considering the various risks that may occur. Therefore, it is necessary to carry out careful planning so that logistics distribution can run on time, in the right amount, in the right location, and remain in good condition in accordance with the Technical Guidelines for General Election Logistics Management until it reaches the location of the Polling Station (TPS).

PT Pos Indonesia is one of the companies engaged in the first goods delivery service in Indonesia. PT Pos Indonesia has the task of implementing and supporting government program policies in the economic field as well as development which generally provides delivery services for all Indonesian people. PT Pos Indonesia as a state-owned enterprise engaged in courier and logistics services has collaborated with KPU RI in the context of distributing election logistics in 2024. PT Pos Indonesia has more than 4,800 post offices with networks spread throughout Indonesia even to the 3T (foremost, remote, disadvantaged) areas. For the Bulukumba Regency area, PT Pos Indonesia has 1 Branch Office and 3 Sub-Branch Offices spread across the Bulukumba Regency area. The distribution of Post Offices in Bulukumba Regency by having 4 locations that can cover services to all areas of Bulukumba Regency even to border areas with other districts and areas that are difficult to reach. By having 4 Post Offices spread across the Bulukumba Regency area, PT Pos Indonesia Bulukumba Branch Office in carrying out the distribution of election logistics in collaboration with the KPU Bulukumba Regency, supported by human resources (HR) who already understand the geographical conditions and characteristics of the region in Bulukumba Regency. So that the election logistics distribution process can be carried out effectively and efficiently from the planning process to implementation.



*Figure 1: Distribution of Sub-districts and Post Offices in Bulukumba Regency Source: Google Maps June 2024
Processed by the author*

This research focuses on the selection of transportation modes, distribution scheduling, and determination of optimal logistics distribution routes in the 2024 Pilkada in Bulukumba Regency using the capacitated vehicle routing problem approach by taking into account the distance from Google maps and using the nearest neighbor algorithm in determining the closest distance between points. The results of this study are expected to be a template for the Bulukumba Branch Post Office in handling the distribution of election logistics which can be a reference if in the future it handles the distribution of election logistics again.

2. Problem Formulation

Based on the background of the problems described above, the problem formulations that will be discussed in this study are as follows:

1. How is the selection of transport mode for logistics distribution of Bulukumba regency election in 2024?
2. How to determine the optimal route for logistics distribution for the Bulukumba regency

election in 2024?

3. How is the scheduling of logistics distribution for the 2024 Bulukumba regency election?

3. Research Objectives

The objectives of this research are:

1. Knowing the appropriate mode of transportation for the logistics distribution of the 2024 Bulukumba Regency Pilkada.
2. Determining the optimal route for logistics distribution for the 2024 Bulukumba regency election.
3. Scheduling the distribution of logistics for the 2024 Bulukumba regency election.

4. Body of Paper

Method

Capacitated Vehicle Routing Problem

This research uses the capacitated vehicle routing problem (CVRP) method to get the shortest and optimal route by considering the capacity of the transportation mode. The distribution of election logistics is carried out with an origin point from the Bulukumba Regency KPU warehouse to each sub-district office then back to the Bulukumba Regency KPU warehouse. By using the CVRP method, it is possible for trucks to do multi-dropping and more than one route in one day. The basic concept of CVRP is:

- Each vehicle departs from the depot and terminates at the same depot
- The route form starts from the depot (origin) and the customer is the destination to be visited.
- Each customer is visited by exactly one vehicle
- The demand for each customer is equal to q_i ($i = 1, 2, \dots, N$) and Q is the maximum capacity of the vehicle
- CPRV is a method that considers the routes formed are customer requests and each route is not allowed to exceed the capacity of the vehicle used Q .

Nearest Neighbor

The Nearest Neighbor algorithm is a simple method that was first introduced in 1983. (Anita et al., 2017). Each iteration, the nearest neighbor algorithm method looks for the closest distance from each customer or from one sub-district to another in this study. A new route will be formed if there is a possible position for the next destination. The nearest neighbor algorithm inserts one sub-district after another that is adjacent to another sub-district that has not met its demand until all capacities are met then returns to the origin point or KPU warehouse. This is done repeatedly until all points are fulfilled.

Based on previous research conducted by Pop (2011), the following is a description of the nearest neighbor algorithm for the logistics distribution of the Bulukumba Regency KPU election.

1. The starting point (origin) is the Bulukumba Regency KPU warehouse as the location of the Bulukumba Regency election logistics storage. Then from the KPU warehouse looking for the location of the nearest sub-district office from the warehouse as the initial route visited.
2. Next, find the location of another sub-district office that is closest to the first sub-district office visited if the capacity of the transportation mode still allows for the delivery of the next sub-district.

- a. If the selected sub-district has a demand that exceeds the remaining capacity, then go back to step (2) to find another sub-district with sufficient demand for the remaining capacity.
- b. If none of the sub-districts have a demand that matches the remaining capacity of the transportation mode, then return to step (1), namely the route starts again from the origin point of the KPU warehouse and looks for other sub-district destination points that have not been visited.
3. If all sub-districts have been visited and their demand has been met then this algorithm is complete.

Another alternative that can be done is to choose a mode of transportation that is adjusted to the demand of adjacent sub-districts so as to maximize the capacity of the mode of transportation and the delivery route becomes more effective and efficient vehicle.

The Nearest Neighbor algorithm searches for routes by considering the closest distance from one point to another. Table 1 shows the distance matrix from the KPU warehouse located at Jl. Jend Sudirman No.10, Bulukumba to each sub-district location in Bulukumba Regency. Distance data is obtained through Google Maps by collecting the distance of all 10 sub-districts and the KPU warehouse. The closest distance from the KPU warehouse is to Ujung Bulu sub-district as far as 1 km, while the farthest distance is Kajang sub-district with a distance of 39.5 km.

Table 1: Distance Matrix of KPU Warehouse and Sub-districts in Bulukumba Regency (km)

		TUJUAN										
		GUDANG KPU	BONTO BAHARI	BONTOTIRO	BULUKUMPA	GANTARANG	HERLANG	KAJANG	KINDANG	RILAU ALE	UJUNG BULU	UJUNG LOE
ASAL	GUDANG KPU	0	24,3	35,1	30,2	4,4	35,1	39,5	29,1	24,3	1	9,5
	BONTO BAHARI	24,3	0	13,1	45,8	28,7	20,8	27,1	52,5	39,9	24	14,8
	BONTOTIRO	35,1	13,1	0	46,1	39,5	18	25,1	64,2	41,5	34,2	24,5
	BULUKUMPA	30,2	45,8	46,1	0	33,1	35	30,8	47,4	6,8	30,4	31
	GANTARANG	4,4	28,7	39,5	33,1	0	39,5	43,9	30,8	27,2	5,1	13,8
	HERLANG	35,1	20,8	10,5	35	39,5	0	9,2	64,2	41,8	35,3	25,6
	KAJANG	39,5	27,1	25,7	30,8	45,8	9,2	0	61,8	37,8	41,6	32
	KINDANG	29,1	53,4	64,2	47,4	29,8	64,2	61,8	0	41,4	29,8	38,5
	RILAU ALE	24,3	34,9	42,2	7,1	26,4	42,1	37,8	41,4	0	23,7	24,3
	UJUNG BULU	1	24,4	34,8	30,4	5,1	34,8	39,2	23,7	29,8	0	9,6
	UJUNG LOE	9,5	14,8	25,6	31	13,8	25,6	30	24,3	37,7	9,6	0

Source: Google Maps June 2024

The distance matrix data in Table 1 is used to find routes by finding the closest point from the origin to the first destination. Then look for the next destination point by considering the closest distance and demand needs of the next destination point. If the next point demand cannot be met, then look for another destination point that can fulfill the demand.

5. Result and Discussion

Mode of Transportation Selection

Guided by the General Election Commission Decree Number 1395 of 2023 concerning Technical Guidelines for Election Logistics Management. Listed in Chapter II point C regarding the distribution stages. The distribution of Election Logistics is carried out in order to fulfill the needs of Election Logistics in the implementation of voting and recapitulation of vote counting that takes place in the country and abroad. The distribution of Election Logistics by KPU, Provincial KPU, Regency / City KPU, and PPLN must pay attention to the priority scale of the destination area, including:

1. Voter turnout
2. Number of polling stations/TPSLN/KSK/Post

3. Distance
4. Travel time;
5. Geographical location;
6. Climate/weather;
7. Operational schedule of transportation modes;
8. Regulating the licensing of transportation modes;
9. Local licensing regulations; and
10. The degree of insecurity of the destination.

The type of transportation used can be land transportation, water transportation, and/ or air transportation with the following considerations:

1. Situation and conditions;
2. Distribution speed;
3. Availability of transportation and existing infrastructure;
4. Origin and destination conditions;
5. Effectiveness and efficiency; and
6. Security and safety.

The selection of transportation modes for the distribution of election logistics in this case, namely for the election of the Bulukumba Regency KPU, is adjusted to the demand for ballot boxes and voting booths in each sub-district.

Table 2: Demand for Ballot Booths and Ballot Boxes per Sub-district

No	Kabupaten	Kecamatan	Jumlah TPS	Bilik Suara	Kotak Suara
1	Bulukumba	Bonto Bahari	80	320 pcs	160 pcs
2		Bontotiro	82	328 pcs	164 pcs
3		Bulukumpa	156	624 pcs	312 pcs
4		Gantarang	226	904 pcs	452 pcs
5		Herlang	80	320 pcs	160 pcs
6		Kajang	143	572 pcs	286 pcs
7		Kindang	97	388 pcs	194 pcs
8		Rilau Ale	123	492 pcs	246 pcs
9		Ujung Bulu	127	508 pcs	254 pcs
10		Ujung Loe	127	508 pcs	254 pcs
	Total		1241	4964 pcs	2482 pcs

Source: KPU Bulukumba Regency 2023

The main things that must be considered in choosing the mode of transportation are the load capacity of the mode of transportation, the dimensions of the mode of transportation, the size and dimensions of the KPU ballot box, the size and dimensions of the KPU voting booth. The condition of the voting booths at the time of distribution is in a folded condition and has not been assembled to form a booth. This is because the voting booths themselves will be assembled at each polling station (TPS) so that at the time of distribution the booths are folded so that they are flat. The following is an illustration of the size of ballot boxes and voting booths (Figure 2 and Figure 3) based on General Election Commission Regulation Number 14 of 2023.

Ballot Box

Table 3: Ballot Box Size (cm)

Ukuran Kotak Suara	
P	60
L	40
T	40

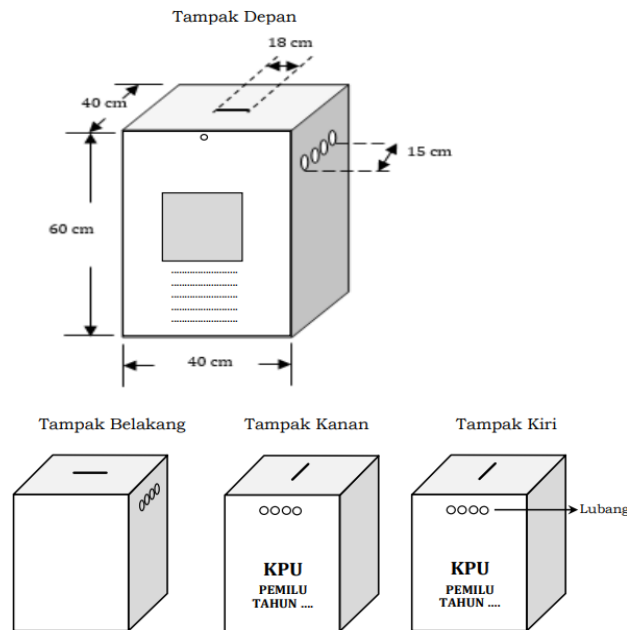


Figure 2: Ballot Box
Source: KPU Bulukumba Regency 2023

Folded Voting Booths

Table 4: Size of voting booth (cm)

Ukuran Bilik Suara	
P	160
L	60
T	3

Source: KPU Bulukumba Regency 2023



Figure 3: Folded voting booths
Source: KPU Bulukumba Regency 2023

The layout of ballot boxes and voting booths in the transportation mode during the distribution process is very important to consider as a reference in choosing the mode of transportation to maximize the available capacity. The provisions in the distribution are that the position of the ballot box must stand upright and must not be tilted or put to sleep. Meanwhile, voting booths can be inserted between ballot boxes by utilizing empty space or placed on top of the ballot box arrangement or on the side of the ballot box where there is still empty space. So, in determining the mode of transportation, the main thing that needs to be calculated is the size and dimensions of the ballot box.

The mode of transportation that can be an alternative that will be used in the distribution of logistics for the Bulukumba regional election by taking into account the road and geographical conditions can use the types of transportation modes *Colt Diesel Engkle (CDE)*, *Colt Diesel Double (CDD) Box*, *Colt Diesel Double Long (CDDL) Box*, *Blind Van*. The following is the capacity of the transportation mode for the distribution of ballot boxes and voting booths for the Bulukumba regional election.

Table 5: Alternative Modes of Transportation and their Capacities (pcs)

No	Moda Angkutan	Kapasitas Max	
		Kotak Suara	Bilik Suara
1	CDD Long Box	168	328
2	CDE Engkel	56	109
3	CDD Box	120	234
4	Blind Van	20	39

Source: KPU Bulukumba Regency 2023

The maximum capacity of the transportation mode is a reference in determining the distribution route using the capacitated vehicle routing problem (CVRP) method nearest neighbor algorithm. Determination of the number of transportation modes to be used is based on the number of routes and trips available.

Route Determination Using Nearest Neighbor Algorithm

An overview of the nearest neighbor algorithm for the distribution of election logistics of the Bulukumba Regency KPU can be illustrated as Figure 4 below.



Figure 4: Location Point of Bulukumba KPU Warehouse and Sub-district Source: Google Maps June 2024 processed by the author

Figure 4 is an overview of the location points of 10 sub-districts in Bulukumba Regency and the location of the KPU Warehouse. For route determination from the origin point, namely the KPU warehouse, looking for the location of the closest sub-district of all existing sub-districts the first route is to choose the sub-district closest to the KPU warehouse location as the first destination point (Figure 5).

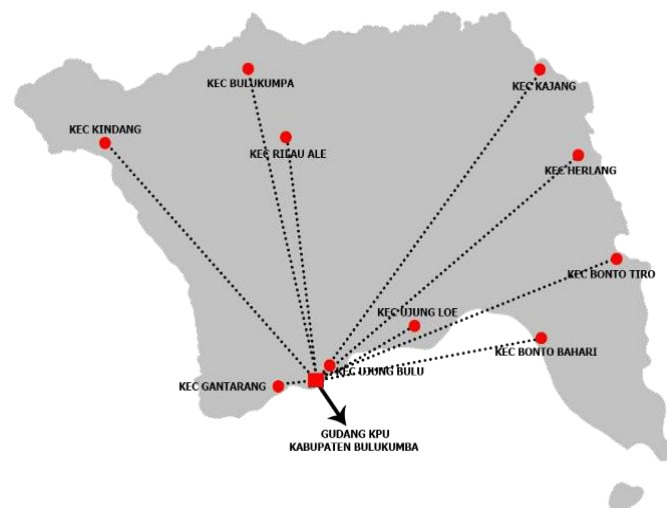


Figure 5: Nearest Neighbor Algorithm Finding the Nearest Point Source: Google Maps June 2024 processed by the author

The distance from the KPU warehouse to the nearest sub-district is Ujung Bulu sub-district with a distance of 1 km (table 1) so that Ujung Bulu sub-district is the first destination point. The nearest neighbor algorithm will pay attention to the capacity of the transportation mode and the demand needed by Ujung Bulu Sub-district, if using the CDD Box transportation mode with a capacity of 120 ballot boxes while the needs in Ujung Bulu Sub-district are 254 ballot boxes and 508 voting booths then to maximize capacity 3 CDD Box units are needed, there is a remaining capacity that will be used to transport the demand needed from other sub-districts or use 2 CDD Box units with a capacity shortage of 14 ballot boxes and 40 voting booths which can later be maximized to be transported by other transportation modes that route to Ujung Bulu Sub-district (Figure 6).

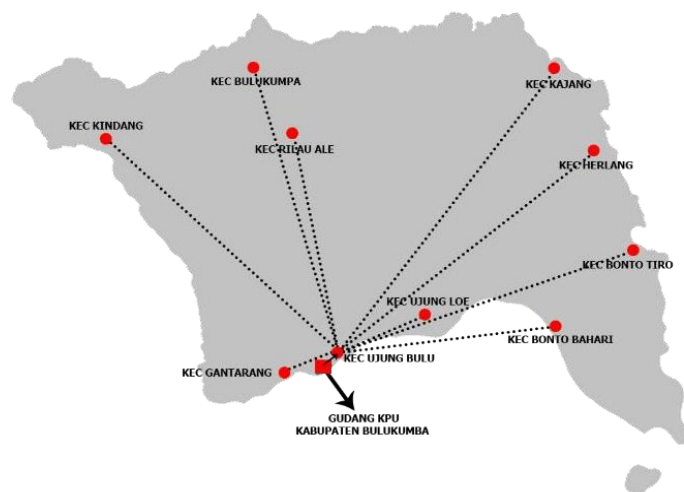


Figure 6: Nearest Neighbor Algorithm First Nearest Point Source: Google Maps June 2024 processed by the Author

After the first sub-district is selected, then look for the next sub-district location point closest to the first sub-district, namely Gantarang Sub-district. Demand needs from Gantarang District are 452 ballot boxes. Taking into account the very high demand and to maximize the capacity of the transportation mode, Gantarang District uses its own route with the transportation mode used as many as 1 unit CDD Box and 2 units CDD Long Box. Gantarang sub-district which

has its own route, then the Ujung Bulu sub-district route needs to find another sub-district location point while still considering demand and the closest distance.

The Ujung Bulu sub-district route then looks for the next sub-district location point with close proximity and by considering demand needs to maximize the capacity of the transport mode. So, for the route from Ujung Bulu Sub-district then to Rilau Ale Sub-district which is also adjacent to Bulukumpa Sub-district (Figure 7). So that the route formed starts from the origin point of the KPU Warehouse to Ujung Bulu Subdistrict then to Rilau Ale Subdistrict and the last point to Bulukumpa Subdistrict with a total distance of 31.8 km. The total demand transported was 812 ballot boxes and 1624 voting booths, the mode of transportation used was 2 units of CDD Long Box and 4 units of CDD Box.

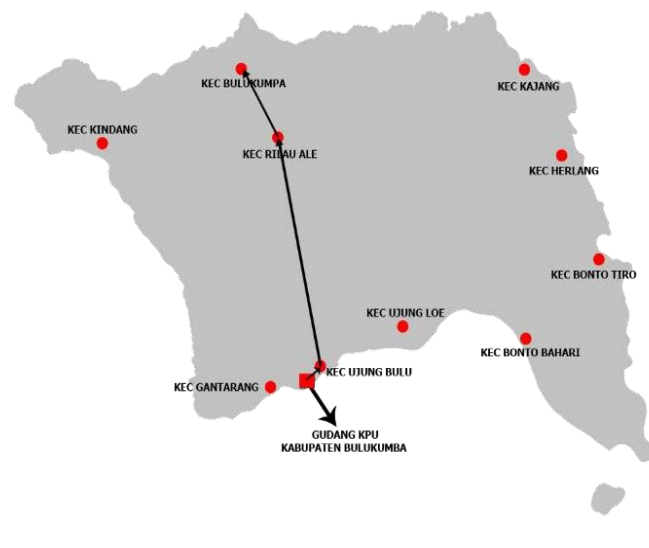


Figure 7: Nearest Neighbor Algorithm Route Determination Based on Demand and Distance Source: Google Maps June 2024 processed by the author

Then the next sub-district is Ujung Loe Sub-district, when viewed from its geographical location which is close to and in the same direction as Bontobahari Sub-district, it can be combined into the same route. The demand from Ujung Loe sub-district is 254 ballot boxes and 508 voting booths, while the demand from Bontobahari sub-district is 160 ballot boxes and 320 voting booths. The transportation modes used for this route are 3 units of CDD Box and 1 unit of CDE Engkel.

The next sub-district is Bontotiro sub-district which is also close and in the same direction with Herlang sub-district so that these two sub-districts can be combined into the same route. Bontotiro sub-district with demand of 164 ballot boxes and 328 voting booths and Herlang sub-district with demand of 160 ballot boxes and 320 voting booths. By considering the total demand needs of the two sub-districts, the transportation mode used is 2 units of CDD Long Box.

Determination of the next route for Kajang and Kindang sub-districts by considering the distance, geographical location, and demand needs, these two sub-districts use separate routes. Kajang sub-district with a demand requirement of 286 ballot boxes and 572 voting booths using the transportation mode of 2 units of CDD Box and 1 unit of CDE Engkel. Meanwhile, Kindang sub-district with a demand requirement of 194 ballot boxes and 388 voting booths uses the transportation mode of 1 unit CDD Long Box and 1 unit CDE Engkel.

Table 6: Results of Determination of Routes and Modes of Transportation

TRIP	ARMADA	ASAL	TUJUAN	RUTE	JARAK	BILIK SUARA	KOTAK SUARA	TOTAL	
								BILIK SUARA	KOTAK SUARA
1	A - CDD Box	GUDANG KPU	KECAMATAN UJUNG BULU	A	1 Km	508 pcs	254 pcs	1624 pcs	812 pcs
	B - CDD Box		KECAMATAN UJUNG BULU						
	C - CDD Box		KECAMATAN RILAU ALE		29,8 Km	492 pcs	246 pcs		
	D - CDD Box		KECAMATAN RILAU ALE						
	X - CDD Long Box		KECAMATAN BULUKUMPA	B	7,1 Km	624 pcs	312 pcs	388 pcs	194 pcs
	Y - CDD Long Box		KECAMATAN BULUKUMPA						
	Z - CDD Long Box		KECAMATAN KINDANG		29,1 Km	388 pcs	194 pcs		
	J - CDE Engkel		KECAMATAN KINDANG						
2	A - CDD Box	GUDANG KPU	KECAMATAN UJUNG LOE	A	9,5 Km	508 pcs	254 pcs	828 pcs	414 pcs
	B - CDD Box		KECAMATAN UJUNG LOE						
	C - CDD Box		KECAMATAN BONTO BAHARI		14,8 Km	320 pcs	160 pcs		
	J - CDE Engkel		KECAMATAN BONTO BAHARI						
	X - CDD Long Box		KECAMATAN BONTOTIRO	B	35,1 Km	328 pcs	164 pcs	648 pcs	324 pcs
	Y - CDD Long Box		KECAMATAN HERLANG		18 Km	320 pcs	160 pcs		
3	A - CDD Box	GUDANG KPU	KECAMATAN KAJANG	A	39,5 Km	572 pcs	286 pcs	572 pcs	286 pcs
	B - CDD Box		KECAMATAN KAJANG						
	J - CDE Engkel		KECAMATAN KAJANG						
	C - CDD Box		KECAMATAN GANTARANG						
	X - CDD Long Box		KECAMATAN GANTARANG	B	4,4 Km	904 pcs	452 pcs	904 pcs	452 pcs
	Y - CDD Long Box		KECAMATAN GANTARANG						

Source: Data Processing by the Author

The results of the analysis using the nearest neighbor algorithm method by considering the distance and capacity of the transportation mode, the results obtained 6 routes with a total of 3 trips. The first trip is route A from KPU Warehouse - Ujung Bulu Sub-district - Rilau Ale Sub-district - Bulukumpa Sub-district - KPU Warehouse, route B KPU Warehouse - Kindang- District - KPU Warehouse. The second trip is route A from KPU Warehouse - Ujung Loe sub- district - Bonto Bahari sub-district - KPU warehouse, route B is KPU Warehouse – Bontotiro sub-district - Herlang- KPU warehouse. The third trip is route A from KPU Warehouse - Kajang-District KPU Warehouse, route B is KPU Warehouse - Gantarang District KPU Warehouse.

Determination of the three trips is the result of calculations using the nearest neighbor algorithm by considering the demand needs of each sub-district and the capacity of the transportation mode, then looking for the closest distance between sub-district location points or looking for sub-district location points that can be passed by the same route so that they can be put together into one route with a multidrop system.

Scheduling Distribution to Sub-districts

In determining the scheduling of the distribution of logistics for the Bulukumba Regency elections, coordination with the KPU regarding the distribution plan to each sub-district and distribution is carried out by following the schedule determined by the Bulukumba Regency KPU. According to General Election Commission Decree Number 1395 of 2023 concerning Technical Guidelines for Election Logistics Management, the distribution of domestic election logistics is carried out using land, water and air transportation facilities with a distribution time schedule in accordance with the provisions set by the KPU.

The distribution of election logistics is carried out in accordance with the provisions of the KPU, distribution can be carried out starting from 4 days before the election by prioritizing the farthest locations. The election logistics needs must have been distributed to the polling stations (TPS) on 1 day before the election. For distribution from the KPU warehouse to the District Election Committee (PPK), it is carried out in 1 day.

Scheduling the distribution of election logistics from the KPU warehouse to the sub-district by considering the number of routes and trips that have been determined. Bulukumba Regency has 10 sub-districts so that the distribution process is carried out starting in the morning and finishing at night. This study designed 3 distribution trips, so the trips and routes became a reference for

making distribution schedules. Trip 1 uses the transportation mode of 4 units of CDD Box, 3 units of CDD Long Box, and 1 unit of CDE Engkel. Trip 2 uses the transportation mode 3 units CDD Box, 2 units CDD Long Box, and 1 unit CDE Engkel. Trip 3 uses transportation modes of 3 CDD Box units, 2 CDD Long Box units, and 1 CDE Engkel unit. The following is the logistics distribution schedule for the Bulukumba Regency election.

Table 7: Bulukumba Regency Pilkada Logistics Distribution Schedule

Trip	Armada	Asal	Tujuan	Rute	ETD	ETA
1	A - CDD Box	Gudang KPU	Kecamatan Ujung Bulu	A	06.00 WITA	11.45 WITA
	B - CDD Box		Kecamatan Ujung Bulu			
	C - CDD Box		Kecamatan Rilau Ale			
	D - CDD Box		Kecamatan Rilau Ale			
	X - CDD Long Box		Kecamatan Bulukumpa			
	Y - CDD Long Box		Kecamatan Bulukumpa			
	Z - CDD Long Box		Kecamatan Kindang	B	06.00 WITA	09.15 WITA
	J - CDE Engkel		Kecamatan Kindang			
2	A - CDD Box	Gudang KPU	Kecamatan Ujung Loe	A	12.30 WITA	16.30 WITA
	B - CDD Box		Kecamatan Ujung Loe			
	C - CDD Box		Kecamatan Bonto Bahari			
	J - CDE Engkel		Kecamatan Bonto Bahari			
	X - CDD Long Box		Kecamatan Bontotiro	B	12.30 WITA	17.15 WITA
	Y - CDD Long Box		Kecamatan Herlang			
3	A - CDD Box	Gudang KPU	Kecamatan Kajang	A	18.30 WITA	22.30 WITA
	B - CDD Box		Kecamatan Kajang			
	J - CDE Engkel		Kecamatan Kajang			
	C - CDD Box		Kecamatan Gantarang	B	18.30 WITA	21.15 WITA
	X - CDD Long Box		Kecamatan Gantarang			
	Y - CDD Long Box		Kecamatan Gantarang			

Source: Data Processing by the author

Trip 1 departed from the KPU warehouse at 06.00 WITA with route A to Ujung Bulu sub- district, Rilau Ale sub-district, and Bulukumpa sub-district, route B to Kindang sub-district. The estimated transportation mode of trip 1 returned to the KPU warehouse at 09.15 WITA for route B and at 11.45 WITA for route A. The transportation mode departs from the KPU warehouse at 12.30 WITA for the next trip. Trip 2 route A goes to Ujung Loe and Bonto Bahari sub-districts, route B goes to Bontotiro and Herlang sub-districts. The estimated trip 2 transportation mode returns to the KPU warehouse at 17.15 WITA for route B and at 16.30 WITA for route A. For trip 3, the transportation mode is departed again at 18.30 WITA with route A to Kajang sub-district and route B to Gantarang sub-district. The estimated trip 3 transportation mode returns to the KPU warehouse at 21.15 WITA for route B and 22.30 WITA for route A.

6. Conclusion

The distribution of election logistics that runs effectively and efficiently is one of the stages as a measure of the success of organizing elections. The distribution of election logistics starts from the Regency / City KPU to the District Organizing Committee (PPK), then to the Voting Committee (PPS) at the Kelurahan / Village level and then to the Polling Station. Distribution from the KPU warehouse to the sub-district is the initial distribution process so that it has a crucial role because it must be carried out effectively and efficiently and on time so that the forwarding of distribution to the polling stations is not hampered and on time according to planning.

The selection of transportation modes for the distribution of election logistics of the Bulukumba Regency KPU is adjusted to the demand for ballot boxes and voting booths in each sub-district. The mode of transportation that can be used in the distribution of logistics for the

Bulukumba Regency elections by taking into account road and geographical conditions is to use the *Colt Diesel Engkle* (CDE), *Colt Diesel Double* (CDD) *Box*, *Colt Diesel Double Long* (CDDL) *Box*. The number of transportation modes used is 4 units of CDD Box, 3 units of CDD Long Box, and 1 unit of CDE Engkle.

Determination of distribution routes after analysis using the nearest neighbor algorithm method by considering the distance and capacity of the transportation mode, the results obtained 6 routes with a total of 3 trips. The first trip is route A from KPU Warehouse - Ujung Bulu Sub-district - Rilau Ale Sub-district - Bulukumba Sub-district - KPU Warehouse, route B KPU Warehouse - Kindang-District - KPU Warehouse. The second trip is route A from KPU Warehouse - Ujung Loe sub-district - Bonto Bahari sub-district - KPU warehouse, route B is KPU Warehouse - Bontotiro sub-district - Herlang- KPU warehouse. The third trip is route A from KPU Warehouse - Kajang-District KPU Warehouse, route B is KPU Warehouse - Gantarang District KPU Warehouse.

Scheduling the distribution of election logistics from the KPU of Bulukumba Regency to the sub-district was carried out within 1 day. Distribution is carried out in accordance with the plan, namely 3 trips starting at 06.00 WITA with an estimated completion of distribution and all modes of transportation returning to the KPU warehouse at 22.30 WITA.

7. Implications and Direction for Future Research

This research is expected to be a consideration for logistics service provider companies, especially PT Pos Indonesia Bulukumba Branch Office in designing the operational pattern of the Bulukumba Regency election distribution. In addition, this research is also expected to be useful for the KPU of Bulukumba Regency so that it can carry out the 2024 election distribution process effectively and efficiently. This research is only limited to using one research method, namely the capacitated vehicle routing problem (CVRP) nearest neighbor algorithm. The nearest neighbor algorithm in this study in determining routes and modes of transportation only considers transportation capacity without considering costs. Suggestions for further research can be done using two or more research methods so that comparisons can be made in finding the best solution. Another suggestion is to add other variables as considerations in determining routes and modes of transportation such as direct and indirect costs, labor costs, overhead costs, and other costs.

References

- Anita, O., Dewi, C., & Trihardani, L. (2017). How Halal Transportation System Impact the Location Routing Problem. *Journal of Engineering and Management Industrial System*, 5(1). <https://doi.org/10.21776>
- Bowersox, Donald J. (2002), *Manajemen Logistik 2*, Terjemahan Drs. A. Hasyim Ali Jakarta: UP PT. Bumi Aksara.
- Ilham Barkati, Z. (n.d.). *Manajemen Distribusi Logistik Pemilu Legislatif Tahun 2014 di Kabupaten Malinau*. KPU RI. *Buku Pintar Pengelolaan Logistik Pemilu/Pemilihan*.
- Maps, Google. "Gudang KPU Kabupaten Bulukumba dan Kantor Kecamatan Kabupaten Bulukumba." <https://www.google.com/maps/@5.4490001,119.8960059,10z/data=!4m6!1m2!10m1!1e1!1m2!2swyRIVcpcQEOMgVI3BesO9g!3e3?entry=ttu>.
- Martono, S., & Warnars, H. L. H. S. (2020). Penentuan Rute Pengiriman Barang Dengan Metode Nearest Neighbor. *PETIR*, 13(1), 44–57. <https://doi.org/10.33322/petir.v13i1.869>
- Musdalifa, Ifa. 2024. Kekurangan Ribuan Surat Suara, KPU Bulukumba Tunda Distribusi. Diakses pada 26 Maret 2024 dari <https://www.metrotvnews.com/read/KRXC5Gvz-kekurangan-ribuan-surat-suara-kpu-bulukumba-tunda-distribusi>.

- Pop, P. C., Sitar, C. P., Zelina, I., Lupșe, V., Chira, C., Sitar, C. P., & Chira, C. (2011). Heuristic Algorithms for Solving the Generalized Vehicle Routing Problem. In *Communications & Control: Vol. VI* (Issue 1).
- Prasetyo, W., & Tamyiz, M. (2017). Vehicle Routing Problem dengan Aplikasi Metode Nearest Neighbor. In *Journal of Research and Technology* (Vol. 3, Issue 2).
- Peraturan Komisi Pemilihan Umum Nomor 2 Tahun 2024 Tentang Tahapan dan Jadwal Pemilihan Gubernur dan Wakil Gubernur, Bupati dan Wakil Bupati, serta Walikota Dan Wakil Walikota Tahun 2024
- Peraturan Komisi Pemilihan Umum Nomor 1395 Tahun 2023 Tentang Pedoman Teknis Tata Kelola Logistik Pemilihan Umum
- PT Pos Indonesia (PERSERO)
- Rizqi, F. (2023). Perancangan Model Capacitated Vehicle Routing Problem (C-VRP) Pada Distribusi Logistik Pemilu 2024 Kecamatan Bojong Dengan Metode Saving Matrix dan Nearest Neighbor. *Jurnal Science and Research Technology*, Vol. 1, 19–30
- Safitri, D., & Hawignyo. (2024). Strategi Perencanaan Pendistribusian Logistik Untuk Pemilu 2024 yang Efisien dan Sukses di Komisi Pemilihan Umum Kab. Karawang. *Jurnal Ilmiah Wahana Pendidikan*, 205–211.
- Sugiono, M. C. (2022). Model vehicle routing problem untuk penentuan rute distribusi unit sepeda motor dengan metode saving matrix. *Journal Industrial Servicess*, 7(2), 230. <https://doi.org/10.36055/jiss.v7i2.14018>
- Wisnu Wardhana, E., Anita Candra Dewi Komisi Pemilihan Umum Kabupaten Kediri, O., & Kediri, K. (n.d.). *Optimalisasi Jumlah Kendaraan dan Rute Distribusi Logistik Pemilihan di Kabupaten Kediri pada Masa Pandemi*. www.journal.kpu.go.id
- Zulkarnaen, W., Dewi Fitriani, I., Yuningsih, N., Muhammadiyah Bandung, S., & Tasikmalaya, S. (2020). *Pengembangan Supply Chain Management dalam Pengelolaan Distribusi Logistik Pemilu yang Lebih Tepat Jenis, Tepat Jumlah dan Tepat Waktu Berbasis Human Resources Competency Development Di KPU JAWA BARAT*. 4(2).

The Impact of Export Parcel Price, Parcel Service Quality, and Logistics Service Innovation on Purchasing Decisions and the Implications for Company Performance at PT PosIND KCU Denpasar

Depi Darpiyan¹ & Erna Mulyati²

^{1&2} Manajemen Logistik, Fakultas Logistik, Teknologi, dan Bisnis
 Universitas Logistik dan Bisnis Internasional
 Jl. Sariasih No.54 Sarijadi, Sukasari Bandung 40151
 Depi.darpiyan82@gmail.com & Ernamulyati@ulbi.ac.id.

Abstract

The author conducted a study on the export parcel revenue performance at PT PosIND KCU Denpasar, which has been continuously declining from 2022 to 2024. The ongoing decrease in revenue indicates an issue that will impact the performance of PT PosIND KCU Denpasar. This research aims to determine the effect of export parcel price, parcel service quality, and logistics service innovation on company performance with purchasing decision as an intervening variable. The method used in this causal research is PLS-SEM with data analysis using SmartPLS software. The population consists of 270 customers, and the sample size determined using the Slovin formula is 161 customers. The load factor and Cronbach's Alpha values for all variables are above 0.700, indicating that all data are valid and reliable. The research results show a positive influence of export parcel price on purchasing decision, with a T Statistics value of $3.348 > 1.96$ and a p-value of 0.001 . There is a positive influence of parcel service quality on purchasing decision, with a T Statistics value of $2.473 > 1.96$ and a p-value of $0.032 < 0.050$. There is a positive influence of logistics service innovation on purchasing decision, with a T Statistics value of 2.301 and a p-value of $0.032 < 0.05$. The study results indicate an R Square value of 0.553 , meaning there is a positive and significant effect of export parcel price and parcel service quality on purchasing decision. Additionally, there is a positive and significant effect of purchasing decision on company performance, with a T Statistics value of $12.987 > 1.96$ and a p-value of $0.000 < 0.05$. PosIND must continue to innovate its services to acquire customers from competitors and increase revenue.

Keywords: Export Parcel Price, Parcel Service Quality, Logistics Service Innovation, Purchasing Decision, Company Performance

1. Introduction

PosIND KCU Denpasar is one of the branches of PT PosIND that contributes the largest revenue from the courier and logistics business. PT PosIND's Courier and Logistics Business is divided into two categories: domestic shipments and international shipments. More than 80% of the courier and logistics revenue at PosIND KCU Denpasar comes from international shipments. However, the courier and logistics revenue at KCU Denpasar has been declining from 2022 to 2024, with the export parcel product experiencing the most significant decrease. The export parcel revenue at PT PosIND KCU Denpasar was IDR 67,147,000,000 in 2022, whereas in 2023, it was IDR 62,287,000,000, a decrease of IDR 5,060,000,000 (-7.24%). The export parcel revenue for the period January to May 2023 was IDR 28,287,395,584, whereas for the same period in 2024, it was IDR 21,998,937,528, a significant decrease of IDR 6,288,458,056 (-22.23%). The continuous decline in export parcel revenue at PosIND KCU Denpasar indicates an issue that has impacted the company performance.

According to Moerdiyanto (2024), company performance is the result of a series of business processes utilizing various resources. The dimensions/indicators of company performance according to Moerdiyanto (2024) consist of financial performance, operational performance, customer performance, market share, and innovation rate. According to S.K. Singh, et al. (2020), Yanto R (2020), M.A Khan, et al. (2020), J.M. Lee, et al. (2020), Seshadri (2001), and company performance is influenced by purchasing decision. According to Yanto R (2020), purchasing decision is a key aspect of consumer behavior that leads to the purchase of a product or service. The indicators of purchasing decision include: perceived quality, customer satisfaction, brand loyalty, purchase intention, perceived value for money.

According to Cagatay A (2021), Erika N (2024), Cyndi N (2021), Suci R (2024), Mulyadi (2024), price or tariff influences purchasing decision. According to Erika N (2024), price is the amount of money charged for a product or service and the amount of value that consumers exchange for the benefits of having or using the product and service. The dimensions of price consist of product affordability, price match with product quality, product price competitiveness, suitability of price, and product benefits. According to Octaviana A (2023), Fitrah A (2022), Novita D (2023), Zihan A (2023), Dwi R.A (2024), Mulyadi (2024), service quality influences purchasing decision. According to Fitrah Anggardin (2022), service quality is an activity carried out by the company in providing everything that consumers expect to fulfill consumer desires. The dimensions of service quality according to Fitrah A (2022) include five dimensions to determine the quality of service significantly felt by consumers, namely Tangible, reliability, responsiveness, assurance, and empathy.

According to Fifi M.S (2023), Fauzi R (2024), Alga T.R (2022), Brigita (2022), Joe E.A.S (2021), innovation influences purchasing decision. However, according to Afriyanti (2019), innovation has a negative and significant impact on purchase intention. According to Brigita (2022), innovation is a variety of products, services, or processes in an organization that use new resources and have an important impact on organizational success. The indicators of logistics service innovation include: technology integration, automation, sustainability initiatives, customer feedback utilization, flexibility, and customization.

Based on previous research, it is explained that there are still pros and cons regarding the influence of price, service quality, and innovation on purchasing decisions, so the research model cannot yet be generalized. The purpose of this study is to analyze the impact of export parcel price, parcel service quality, and logistics service innovation on purchasing decisions and the implications for company performance at PT PosIND KCU Denpasar.

2. Body of Paper

Research Methodology

This research employs a quantitative method. According to Herdarni et al. (2020), quantitative research aims to reveal phenomena holistically and contextually through data collection from natural settings, utilizing the researcher as the key instrument. Borg and Gall, as cited in Herdarni (2020), state that quantitative research is divided into exploratory and causal research. Causal research is designed to explain the relationships between variables, but causal conclusions cannot be based solely on simplicity. This means that researchers cannot draw causal conclusions between two or more variables based only on significant statistical calculations. Conclusions about the causal relationships between two or more variables are reached through four stages: (1) the conceptual stage, (2) the variable measurement stage, (3) the sample selection stage, and (4) the mathematical manipulation stage. The method used in this causal research is PLS-SEM with data

analysis using the smartPLS software. SmartPLS is chosen because it has several advantages over other statistical software. According to Harahap (2020), smartPLS offers the following advantages:

1. SmartPLS can be used to test complex relationships between variables. It is more powerful compared to other statistical software.
2. SmartPLS is more powerful because it uses an approach based on various assumptions.
3. The sample size required for analysis in smartPLS is relatively small.

SmartPLS is useful when there are limitations in population and sample size, while the model built is relatively complex and complicated. This capability is not found in other statistical software except for LISREL and AMOS, which require larger sample sizes.

Research Model

The research model in this study is presented in Figure 1.

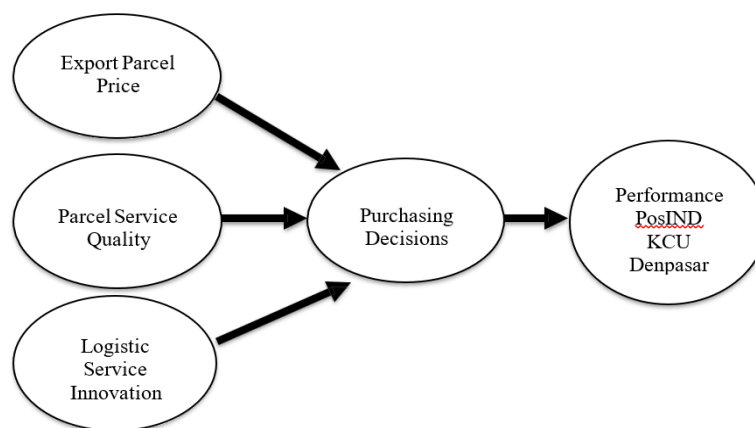


Figure 1: Research Model

The population consists of 270 customers of PT PosIND KCU Denpasar. With a margin of error of 5%, the sample size is determined using the Slovin formula, resulting in 161 participants.

Hypotheses:

The author establishes the hypotheses as follows:

- | No | Hypotheses |
|-------|--|
| 1. H1 | : There is a positive and significant influence of export parcel price on purchasing decision. |
| 2. H2 | : There is a positive and significant influence of parcel service quality on purchasing decision. |
| 3. H3 | : There is a positive and significant influence of logistics service innovation on purchasing decision. |
| 4. H4 | : There is a positive and significant influence of export parcel price, parcel service quality, and logistics service innovation on purchasing decision. |
| 5. H5 | : There is a positive and significant influence of purchasing decision on company performance. |

3. Results.

The results of the study indicate that the average value of each indicator ranges from 2.752 to 3.471, categorized as fairly good to good, but not yet excellent, making them suitable for research. Validity and reliability tests were conducted to measure the quality of the questionnaire. The validity test is a tool used to ensure that respondents are given the opportunity to express their

opinions by providing ratings of strongly agree, agree, somewhat agree, disagree, and strongly disagree to the questions in the questionnaire. It also ensures that respondents are correctly exercising their rights. The results show that the load factor values for all indicators of the variables studied are greater than 0.700. Since all indicators have load factor values greater than 0.700, referring to Hasnita (2021), all indicators in this study are declared valid. Hasnita (2021) explains that a variable is considered reliable if each variable has a Cronbach's Alpha value greater than 0.700. All variables in this study have Cronbach's Alpha values above 0.70, so all variables are declared reliable for research.

The study results indicate that the T Statistics value for the export parcel price variable is 3.348, where the T Statistics value > 1.96 , p value = 0.001, meaning there is a positive effect of export parcel price on purchasing decision. There is a positive effect of parcel service quality on purchasing decision with a T Statistics value of $2.473 > 1.96$ and a P value of $0.032 < 0.050$. There is a positive effect of logistics service innovation on purchasing decision with a T Statistics value of 2.301 and a P value of $0.032 < 0.05$. The study results show that the R Square value is 0.553, meaning there is a positive effect of export parcel price, parcel service quality on purchasing decision. And there is a positive and significant effect of purchasing decision on company performance with a T Statistics value of $12.987 > 1.96$ and a p value of $0.000 < 0.05$.

The overall research model is illustrated in Figure 2.1 below:

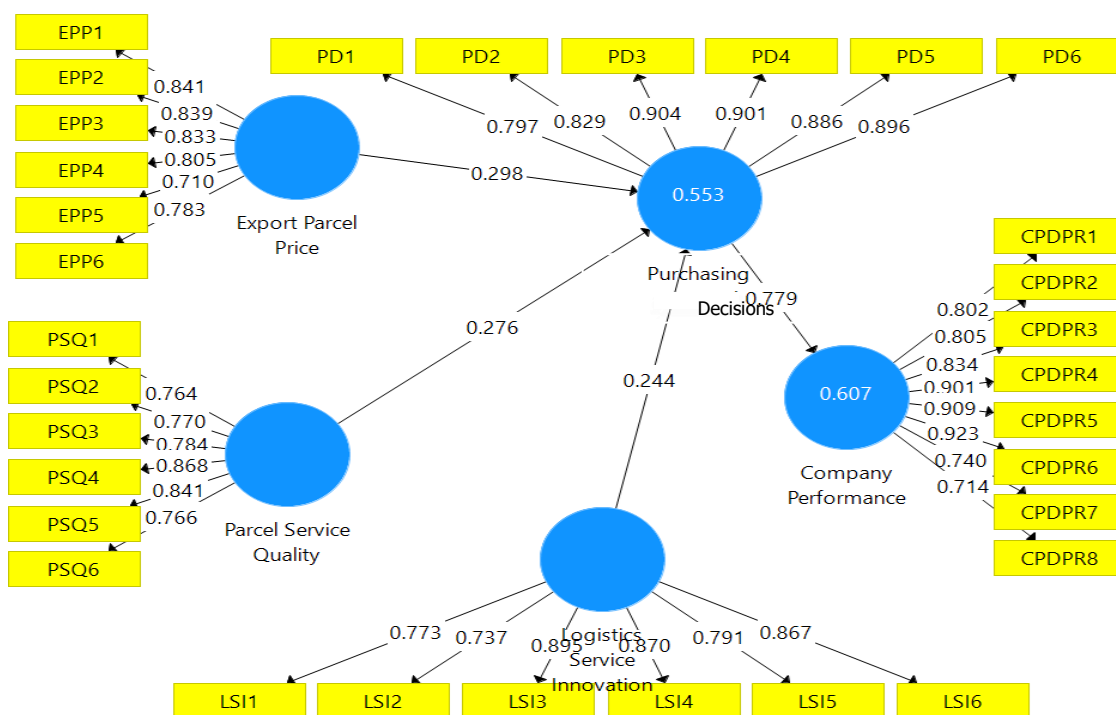


Figure 2.1. Result Research

Based on the results of the PLS-SEM analysis, it can be concluded that the variables export parcel price, parcel service quality, and logistics service innovation have a positive effect on purchasing decision, which then significantly affects company performance. The high R square values for purchasing decision and company performance indicate that this research model has strong predictive ability. Additionally, the findings align with real-world observations that price significantly impacts purchasing decisions, although some customers prioritize the quality of the products/services they receive over the price. Furthermore, some customers expect additional innovation in export parcel products, particularly in terms of reliability in tracking shipments.

4. Implication and Direction for Future Research

Implication

The research results indicate that all variables positively influence purchasing decisions, contradicting Afriyanti's (2019) findings, which stated that innovation negatively and significantly affects purchase intention. Given that the research indicates the path coefficient value for the logistics service innovation variable is the smallest compared to the other variables, the author recommends enhancing logistics service innovation. One recommendation is to create a single Air Way Bill (AWB) system to acquire B2C customers who sell goods on international marketplaces within the operational area of PosIND KCU Denpasar.

Future Research

The research conducted at PT PosIND KCU Denpasar has successfully demonstrated that export parcel price, parcel service quality, and logistics service innovation positively impact purchasing decision, although not very strongly. However, there is a very strong influence of purchasing decision on company performance. Based on the information presented in this study, there are still opportunities for other researchers to use different variables that may have a stronger influence on purchasing decisions, such as the marketing mix, customer reviews, etc. Additionally, researchers could explore other topics currently being developed at PT PosIND, such as the implementation of robotics for sorting activities, which has already been piloted at the Surabaya Postal Processing Center, digital transformation at PosIND, and PosIND's shift towards becoming a logistics company.

References

- Afriyanti, T., & Rahmidani, R. (2019). Pengaruh Inovasi Produk, Kemasan, Dan Variasi Produk Terhadap Minat Beli Ice Cream Aice di Kota Padang. *Jurnal Ecogen*, 2(3), 270. <https://doi.org/10.24036/jmpe.v2i3.7333>
- Akdoğan, Ç. (2021). A Study on The Effect of Price on Consumer Purchase Decision-Making. *BANESS Congress Series on Economics, Business and Management*, September, 285–293.
- Angelica, B. K. (2022). *Impact of CSR, Leader Image, And Innovation on Amazon Consumer Purchasing Decision*. 14(1), 28–41.
- Anggardini, F., & Ratnasari, S. D. (2022). *International Journal of Social Science and Human Research the Effect of Service Quality and Trust on Online Purchasing Decisions at Shopee*. 05(09), 4021–4028. <https://doi.org/10.47191/ijsshr/v5-i9-07>
- Arisinta, O., Ulu, R., & Bangkalan, S. P. (2023). *The Impact of Service Quality and Word of Mouth on Purchase Decision*. 5(1).
- Djafar, N., Yantu, I., Sudirman, S., & Hasiru, R. (2023). *Pengaruh Kualitas Pelayanan Terhadap Keputusan Pembelian di CV*. 1(1), 76–81.
- Eklesia, J., Sujarwo, A., Suseno, E., & Riyadi, H. (2021). *The Impact of Product Promotion and Innovation on Purchase Decisions at Prices as Intervening Variables*. 5(2), 200–206.
- Holiwono, M. R., & Putra, S. (2023). *The Influence of Innovation and Promotion on Consumer Purchase Decisions on Pangsit Mie Palu*. 111–129.
- Janda, S., & Seshadri, S. (2001). The influence of purchasing strategies on performance. *Journal of Business and Industrial Marketing*, 16(4), 294–308. <https://doi.org/10.1108/EUM00000000005502>
- Jinhui wu, S., & Closs, D. J. (2009). The impact of integrating return components planning with purchasing decisions on purchasing performance: A contingency perspective. *The International Journal of Logistics Management*, 20(1), 57–78. <https://doi.org/10.1108/09574090910954846>
- Lidya, V., & Pasaribu, D. (2024). *Pengaruh Kualitas Pelayanan dan Harga terhadap Keputusan Pembelian pada PT Lautan Berlian Utama Motor Jakarta Barat*. 4(1), 147–154.

- Merek, P. C., Pelayanan, K., & Harga, D. A. N. (2024). Pengaruh citra merek, kualitas pelayanan dan harga terhadap keputusan pembelian konsumen indomaret melalui keunggulan bersaing sebagai variabel. 10(1), 301–311.
- Natasha, C., & Subakti, A. G. (2021). The effect of pricing on purchase decisions in Koultoura coffee. IOP Conference Series: Earth and Environmental Science, 729(1). <https://doi.org/10.1088/1755-1315/729/1/012062>
- Nurmartiani, E. (2024). The Price Impact and Service Quality for Consumer Purchasing Decisions at Indomaret Surya Sumantri 82. Indonesian Journal of Economic & Management Sciences, 2(2), 339–356. <https://doi.org/10.55927/ijems.v2i2.9505>
- Ramadhani, S., Nasution, N. L., & Zebua, Y. (2024). Consumer Purchasing Decisions At Master Cash & Credit Kotapinang Pengaruh Kualitas Pelayanan , Kualitas Produk , Harga , Dan Kepuasan Konsumen. 5(2), 4850–4864.
- Razaq, A. T., & Hidayat, R. (n.d.). The Effect of Innovation, Promotion and Service Gojek on Purchasing Decisions. 2011. <https://doi.org/10.4108/eai.5-10-2022.2325862>
- Tiktok, P. A., Andriani, Z., Mirsyah, S., & Nasution, A. (2023). Bursa: Jurnal Ekonomi dan Bisnis Keputusan Pembelian Fashion di Tiktok Shop pada. 2(3)

The Impact of Dedicated Storage and Class-Based Storage Methods on the Warehouse Layout of KPK PosIND Jakarta Centrum on the Distance and Time of Item Movement

Hendri Lasmana¹ & Agus Purnomo²

^{1&2}Manajemen Logistik, Fakultas Logistik, Teknologi, dan Bisnis ULBI
hendriboilasmana@gmail.com

Abstract

The Directorate of Social Community of the Corruption Eradication Commission (KPK) collaborates with PosIND in the distribution of socialization materials to various regions in Indonesia. These materials are temporarily stored in the KPK PosIND warehouse at Jakarta Centrum before distribution. Observations of the warehouse conditions revealed several issues, including the lack of clear labeling and grouping of items, poor cleanliness, and an unstructured layout, which hinder workflow efficiency. This study aims to analyze the impact of the warehouse layout at KPK PosIND Jakarta Centrum using dedicated storage and class-based storage methods on the distance and time of item movement. The study results indicate that changes in the warehouse layout using dedicated storage and class-based storage methods led to a reduction in item movement distance by up to 59.38% and item movement time by up to 57.2%. Therefore, changes in the warehouse layout significantly reduce the distance and time of item movement.

Keywords: Warehouse Layout, Dedicated Storage, Warehouse Efficiency, Warehouse Management

1. Introduction

The Directorate of Social Community of the Corruption Eradication Commission (KPK) or *Komisi Pemberantasan Korupsi (KPK)* is a state institution in Indonesia with the primary duty of supervising, investigating, and following up on corruption crimes. The KPK was established based on Law Number 30 of 2002 concerning the Corruption Eradication Commission. The main goal of the KPK is to enhance the efficiency and effectiveness of corruption eradication efforts in Indonesia and to restore public trust in the government and other institutions (Corruption Eradication Commission, 2023).

The KPK's Directorate of Social Affairs collaborates with PosIND in the distribution of outreach materials to regions throughout Indonesia. These materials will be distributed to various parties in the regions, including local government agencies. Before distribution, the materials are temporarily stored at the KPK PosIND KCU Jakarta Centrum Warehouse. Based on observations at the KPK PosIND Jakarta Centrum Warehouse, several issues have been identified. First, there is no clear labeling and grouping of stored items, making identification and searching difficult. The disorganization of items ultimately creates an untidy environment, resulting in poor warehouse cleanliness. Second, poor warehouse management, coupled with a lack of structured layout, leads to inefficient workflow.

Warehouse layout management is a crucial aspect of operations for a logistics company like PosIND KCU Jakarta Centrum. A poorly organized warehouse can cause various problems, including difficulty in identifying and efficiently locating items by warehouse staff. Additionally, a lack of structure in the layout can impede workflow and reduce overall operational efficiency.

This research aims to analyze the impact of dedicated storage and class-based storage methods on the warehouse layout at PosIND Jakarta Centrum. Focusing on changes in travel distance and item retrieval time by warehouse staff, this study hopes to provide concrete solutions for improving warehouse management efficiency and effectiveness. The results of this research are expected to offer appropriate recommendations for improving the warehouse layout to meet the operational and working environment needs of PosIND Jakarta Centrum.

2. Literature Review

Warehouse

A warehouse is a storage facility used to accommodate materials, including raw materials, semi-finished goods, and finished products ready to be distributed to customers (Rosyada, 2023). Warehouses play a crucial role in inventory management and company logistics. For logistics and courier service companies, warehouses function as distribution centers where packages are received, sorted, temporarily stored, and then dispatched according to predetermined delivery schedules and routes. Warehouses also ensure a smooth and efficient flow of goods, enabling timely delivery to customers.

Warehouse Layout

A warehouse layout is a design aimed at reducing total costs by creating a balance between space utilization and goods management. The layout and design of a warehouse significantly affect a company's operational efficiency. An effective warehouse layout should minimize damage and loss of goods within it. Therefore, one important aspect of warehouse layout is the relationship between the receiving area (where goods are taken in) and the shipping area (where goods are sent out) (Ma'arif & Tanjung, 2006). In the operations of logistics and courier service companies, the warehouse layout is adjusted to the needs of document or goods movement and focuses on the physical arrangement of elements related to the courier service industry. Planning a warehouse layout involves designing or arranging various components, work centers, and equipment that manage the document or goods delivery process (Putro, 2022).

Dedicated Storage Method

In warehouse layout, the dedicated storage method, also known as fixed slot storage, assigns each item a fixed storage location so that when items need to be stored or retrieved, their locations can be easily identified (Purwantinah, 2021). The number of storage locations for an item must be sufficient to accommodate its maximum storage needs. The total storage space required is the combination of the maximum storage needs of each item, especially if more than one type of product is stored (Tompkins et al., 2010). The steps for arranging a warehouse layout using the dedicated storage method are as follows (Kulsum et al., 2020):

1. Calculating Space Requirements

Space requirements are calculated to place stored items in specific locations. The formula used to calculate space requirements is:

$$S_j = \frac{\text{Average receipts (inflow)}}{\text{Block capacity}}$$

2. Calculating Throughput

Throughput relates to the inflow and outflow of an item or product. The formula used to calculate throughput is:

$$T_j = \left(\frac{\text{Average inflow}}{\text{Max. Capacity per transport}} \right) + \left(\frac{\text{Average outflow}}{\text{Max. Capacity per transport}} \right)$$

3. Calculating T/S

T/S is essential as the main reference in determining product placement locations. Products are placed based on the ranking of T/S values from the largest to the smallest. The formula is as follows:

$$\frac{T}{S} = \frac{\text{Throughput}}{\text{Space Requirement}}$$

4. Calculating I/O

Calculation of item movement distance.

5. Items with the highest T/S are placed in areas with the shortest travel distance.

The predetermined distance is applied to place products according to the T/S ranking, ensuring smooth production and avoiding the accumulation of items in the process.

Class-based Storage Method

The Class-Based Storage method is a combination of the dedicated storage and randomized storage methods. In this method, products are grouped based on certain types or characteristics and placed in specific locations within the warehouse. These groups of items are based on similarities in the type of items or similarities in the consumer order list (Purwantinah, 2021). In class-based storage, products or components are divided into three, four, or five classes based on the comparison of throughput (T) and storage (S). Fast-moving products are categorized as class 1, followed by class 2, class 3, and so on, with placement adjusted according to their type or size (Johan & Suhada, 2018).

3. Research Method

In this study, data collection was conducted through observational approach involving direct observation of the research object, and through literature review encompassing examination and analysis of various relevant written sources. The methods used were dedicated storage and class-based storage methods involving calculations of space requirements, throughput, and T/S calculation and ranking, leading to recommendations for warehouse layout based on these methods. Each layout then influences changes in travel distance and picking time by warehouse personnel. The research flow is depicted in diagram form as follow:

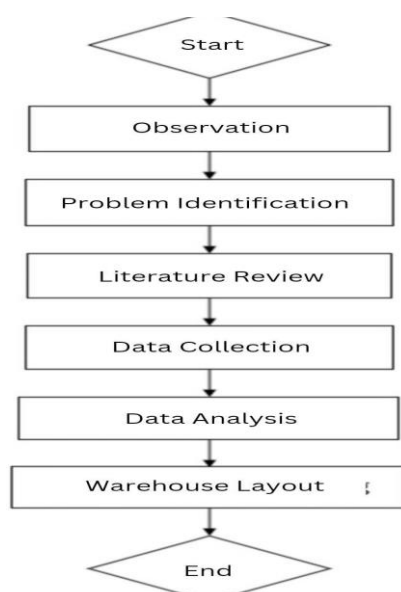


Figure 1: Research flow

4. Result and Discussion

Data on Types, Receipt, and Shipment of Goods

Activities at the KPK warehouse at PosIND KCU Jakarta Centrum include receiving, storing, and dispatching/shipping goods for the socialization activities of the Directorate of Social Community of the Corruption Eradication Commission (KPK) to various regions in Indonesia. Goods are received an average of twice a week, while shipments to the regions are also conducted an average of twice a week. The types of goods stored at the KPK warehouse at PosIND KCU Jakarta Centrum are presented in the following table:

Table 1. List of Names, Quantities of Receipt, and Shipment of Goods

No	Code	Types of Goods	Inflow	Outflow
1	2323	Card Holder BYB	1.000	0
2	2322	Mug Stainless BYB	1.000	0
3	2321	Umbrella BYB	1.000	77
4	2318	Tumbler Vacuum BYB	1.050	1
5	1856	Pencil Case BYB	1.000	990
6	1855	Piggybank BYB	1.000	980
7	1854	T-Shirt BYB	3.000	1.117
8	1852	Pouch BYB	5.000	3.143
9	1851	Totebag BYB	16.000	1.192
10	1850	Blocknotes BYB	4.060	2.958
11	1849	Tumbler BYB	6.000	3.015
12	1525	Boardgame PDKT	1.700	1.661
13	1512	Pocket Book on Understanding Corruption	2.500	2.495
14	1420	Spunbound Bag	40.000	32.202
15	1508	Wooden Plaque	350	250

Warehouse Information

The KPK warehouse at PosIND KCU Jakarta Centrum has an area of approximately 135 m². Inside the warehouse, there are 23 racks, each measuring 120 cm x 150 cm x 60 cm, and each rack has 3 slots/levels with a distance of 10 cm between them. Currently, the storage is still disorganized, and there is no naming or numbering on each rack. Some items are placed on the warehouse floor, even though there are still parts of the racks that are not filled. Among the total of 23 racks in the warehouse, only 6 racks are fully filled. Many items are stacked in the farthest part of the warehouse from the entrance, while the racks closest to the entrance still have a lot of empty space. The layout of the KPK warehouse at PosIND Jakarta Centrum can be illustrated as follows:

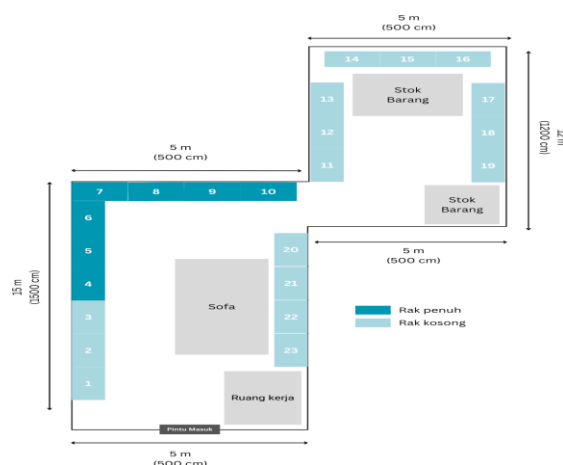


Figure 2. Warehouse Layout

Space Requirement, *Throughput*, and Activities

Socialization materials from the Directorate of Social Community of the KPK are placed on storage racks, each with 3 slots/levels. Each rack can accommodate between 240 to 43,000 items, depending on the type and size of the items. The flow of goods from receipt to shipment is manually handled by 2 warehouse staff members, each capable of carrying up to 200 items in one trip. The unit used for measuring both incoming and outgoing goods is "item". Furthermore, the placement of socialization materials can be ordered from the highest T/S value to the lowest. Items with the highest T/S value are placed on racks closest to the entrance, and items with the lowest T/S value are placed on racks farthest from the entrance.

Table 2: *Throughput, Space Requirements, Activities, And Sequence of Item Activities*

No	Code	Inflow	Outflow	Carrying Capacity	Throughput	Space Requirement			Activities (T/S)	Rank
						Slot/Rack Capacity	Theoretical SR	Actual SR		
1	2323	1.000	0	400	3	25.600	0,04	1	3	9
2	2322	1.000	0	400	3	396	2,5	3	1	12
3	2321	1.000	77	400	3	360	2,8	3	1	13
4	2318	1.050	1	400	3	540	1,9	2	1	14
5	1856	1.000	990	400	5	12.000	0,1	1	5	8
6	1855	1.000	980	400	5	240	4,2	5	1	15
7	1854	3.000	1.117	400	10	11.400	0,3	1	10	5
8	1852	5.000	3.143	400	20	6.000	0,8	1	20	2
9	1851	16.000	1.192	400	43	2.400	6,7	7	6	6
10	1850	4.060	2.958	400	18	7.200	0,6	1	18	3
11	1849	6.000	3.015	400	23	540	11,1	12	2	10
12	1525	1.700	1.661	400	8	43.200	0,04	1	8	6
13	1512	2.500	2.495	400	12	36.000	0,1	1	12	4
14	1420	40.000	32.202	400	181	34.200	1,2	2	90	1
15	1508	350	250	400	2	1.200	0,3	1	2	11

Classification of Goods

Using the class-based storage method, promotional items are grouped into 3 classes: Class A, Class B, and Class C. The classification is based on the durability of the materials of the promotional items stored in the warehouse.

Class A (green) = the most perishable materials, such as paper and fabric.

Class B (yellow) = moderately durable materials, such as wood and leather.

Class C (orange) = non-perishable materials, such as metal.

Calculation of Item Movement Distance in the Existing Warehouse

The following table presents the distance and time of item movement from each shelf in the KPK PosIND Jakarta Centrum Warehouse:

Table 5. Distance and Time of Item Transfer from Each Shelf

Rack	Distance (cm)	Time (s)	Rack	Distance (cm)	Time (s)
1	910	11,375	*13	-	-
2	1040	13	*14	-	-
3	1170	14,625	*15	-	-
4	1300	16,25	*16	-	-
5	1430	17,875	*17	-	-
6	1560	19,5	18	2560	32
7	1582	19,775	19	2430	30,375
8	1530	19,125	20	1610	20,125
9	1660	20,75	*21	-	-
10	1790	22,375	*22	-	-
11	2430	30,375	*23	-	-
12	2560	32			

**The shelf is not accessible because it is blocked by a sofa and a stack of stock items.*

Based on the table above, it is found that shelves 13, 14, 15, 16, 17, 21, 22, and 23 cannot be used because they are obstructed by a sofa and a stack of stock items placed on the floor. Among all shelves, only shelves 4, 5, 6, 7, 8, 9, and 10 are fully occupied. Some stock items are stored in the farthest part of the warehouse, requiring longer distances and more time for item transfers.

Warehouse Layout Changes

The arrangement of shelves in the KPK PosIND Jakarta Centrum warehouse remains unchanged. However, there is a need to reorganize the placement of stock items that are not properly arranged. Additionally, the sofa needs to be removed to prevent blocking available shelves and hindering the flow of item movement.

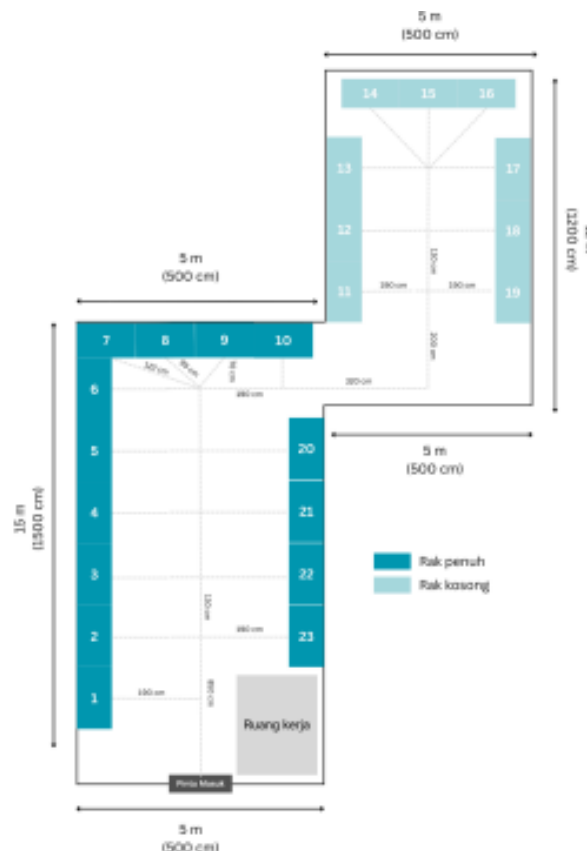


Figure 3. Warehouse Layout

Table 6: item Placement Based on Activity Sequende

No	Code	Placement	No	Code	Placement
1	1420	Rack 1 Slot 1-2	11	1508	Rack 8 Slot 2
2	1852	Rack 1 Slot 3	12	2322	Rack 8 Slot 3
3	1850	Rack 2 Slot 1	12	2322	Rack 9 Slot 1-2
4	1512	Rack 2 Slot 2	13	2321	Rack 9 Slot 3
5	1854	Rack 2 Slot 3	13	2321	Rack 7 Slot 1-2
6	1525	Rack 23 Slot 1	14	2318	Rack 7 Slot 3
7	1851	Rack 23 Slot 2-3	14	2318	Rack 6 Slot 1
		Rack 22 Slot 1-3	15	1855	Rack 6 Slot 2-3
		Rack 3 Slot 1-2	15	1855	Rack 10 Slot 1-3
8	1856	Rack 3 Slot 3			
9	2323	Rack 4 Slot 1			
		Rack 4 Slot 2-3			
10	1849	Rack 21 Slot 1-3			
		Rack 5 Slot 1-3			
		Rack 20 Slot 1-3			
		Rack 8 Slot 1			

Next, the warehouse layout changes based on the material durability classification can be described as follows:

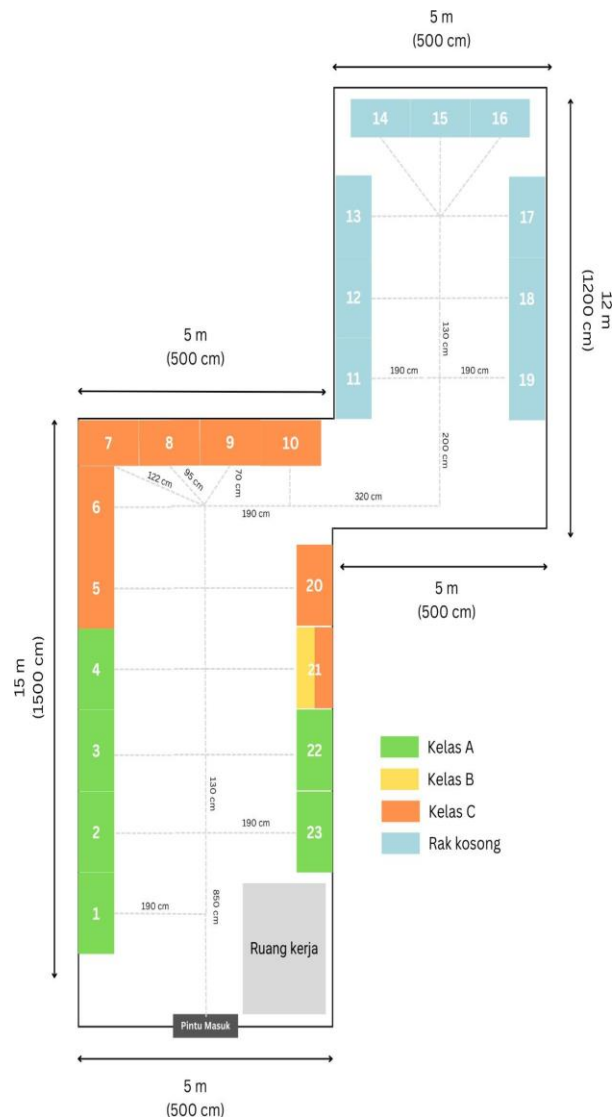


Figure 4. Warehouse Layout

Table 7. Item Placement Based on Classification

Classification	Code	Placement
Class A	2321	Rack 1 Slot 1-3
	1856	Rack 2 Slot 1
	1854	Rack 2 Slot 2
	1852	Rack 2 Slot 3
	1851	Rack 23 Slot 1-3
		Rack 3 Slot 1-3
		Rack 22 Slot 1
	1850	Rack 22 Slot 2
	1525	Rack 22 Slot 3
	1512	Rack 4 Slot 1
	1420	Rack 4 Slot 2-3

Classification	Code	Placement
Class B	2323	Rack 21 Slot 1
Class C	1508	Rack 21 Slot 2
	2322	Rack 21 Slot 3
	2318	Rack 5 Slot 1-2
		Rack 5 Slot 3
		Rack 20 Slot 1
	1855	Rack 8 Slot 1-3
		Rack 9 Slot 1-2
	1849	Rack 9 Slot 3
		Rack 7 Slot 1-3
		Rack 6 Slot 1-3
		Rack 10 Slot 1-3

Comparing Distance and Time of Item Transfer between Existing and New Layout

Changes in the warehouse layout, whether using the dedicated storage method or the class-based storage method, impact the distance and time of item transfers with the following details:

Table 8. Change in Distance and Time of Item Transfers

Rack	Existing Distance (cm)	Changed Distance (cm)	Percentage (%)	Existing Time (s)	Changed Time (s)	Percentage (%)
1	910	910	0	11,375	11,375	0
2	1040	1040	0	13	13	0
3	1170	1170	0	14,625	14,625	0
4	1300	1300	0	16,25	16,25	0
5	1430	1430	0	17,875	17,875	0
6	1560	1560	0	19,5	19,5	0
7	1582	1492	5.69	19,775	18,65	5.69
8	1530	1465	4.25	19,125	18,31	4.25
9	1660	1465	11.75	20,75	18,31	11.75
10	1790	1630	8.94	22,375	20,38	8.94
20	1610	1430	11.18	20,125	17,875	11.18

By removing the sofa, items that should be placed on shelves 11, 19, and 12 can be placed on shelves closer to the entrance, namely shelves 21, 22, and 23. This affects the change in distance and time of item transfers. The comparison is shown in the following table.

Table 10. Change in Distance and Time of Item Transfers

Rack	Existing Distance (cm)	Rack	Changed Distance (cm)	Percentage (%)
11	2430	21	1300	46,5
19	2430	22	1170	51,85
12	2560	23	1040	59,38

Rack	Existing Time (cm)	Rack	Changed Time (cm)	Percentage (%)
11	30,375	21	16,25	46,5
19	32	22	14,625	54,3
12	30,375	23	13	57,2

From the table above, it can be concluded that the percentage change in item transfer distance between the existing warehouse and the new layout ranges from 4.25% to 59.38%. The change in item transfer time ranges from 4.24% to 57.2%.

5. Conclusion

From this research, it can be concluded that the changes in the warehouse layout of KPK PosIND Jakarta Centrum using dedicated storage and class-based storage methods have influenced the distance and time of movement for promotional items. The transfer distances have become shorter and the transfer times have become quicker after the warehouse layout changes. Therefore, it is expected that the goals of improving work efficiency and cleanliness in the KPK PosIND Jakarta Centrum warehouse will be achieved.

References

- Isnaeni, N. S., & Susanto, N. (2022). Penerapan Metode Class Based Storage Untuk Perbaikan Tata Letak Gudang Barang Jadi (Studi Kasus Gudang Barang Jadi K PT Hartono Istana Teknologi). *Industrial Engineering Online Journal*, 10(3), 1-9.
- Johan, & Suhada, K. (2018). Usulan Perancangan Tata Letak Gudang dengan Menggunakan Metode Class-Based Storage (Studi Kasus di PT Heksatex Indah, Cimahi Selatan). *Journal Of Integrated System*, 1(1), 52-71. doi.org/10.28932/jis. v1i1.989
- Komisi Pemberantasan Korupsi. (2023, January 1). *Sekilas KPK*. Komisi Pemberantasan Korupsi (KPK). <https://www.kpk.go.id/id/tentang-kpk/sekilas-komisi-pemberantasan-korupsi>
- Kulsum, K., Muharni, Y., & Felayani, A.-A. A. (2020). Usulan pengoptimalan tata letak gudang W12 menggunakan kebijakan dedicated storage dengan penerapan simulasi (Studi kasus: PT. XYZ). *Teknika: Jurnal Sains dan Teknologi*, 16(2), 285–292.
- Ma'arif, M. S., & Tanjung, H. (2006). *Manajemen Operasi*. Jakarta: Grasindo.
- Purwantinah, A. (2021). *Pengelolaan Bisnis Ritel SMK/MAK Kelas XII*. Jakarta: Gramedia Widiasarana indonesia.
- Putro, A. E. (2022). *Manajemen Kurir dalam Perspektif Proses Bisnis*. Pekalongan: Penerbit NEM.
- Rosyada, M. (2023). *Manajemen Operasi*. Pekalongan: Penerbit NEM.
- Tompkins, J. A., White, J. A., Bozer, Y. A., & Tanchoco, J. M. A. (2010). *Facilities Planning*. Hoboken: Wiley

The Effect of Express Mail Service (EMS) Tariff, Direct Flight, and Logistics Competence on Service Quality and the Implications for Company Performance at PT PosIND KCU Denpasar

Yullia Ika Setyanhi¹ & Erna Mulyati²

^{1&2}Program Studi S2 Manajemen Logistik, Fakultas Logistik, Teknologi, dan Bisnis Universitas Logistik dan Bisnis Internasional Jl. Sariosih No.54 Sarijadi, Sukasari Bandung 40151
Liadufy12@gmail.com & Ernamulyati@ulbi.ac.id.

Abstract

The author conducted a study on the performance of the courier and logistics business at PosIND KCU Denpasar. The issue identified is the continuous decline in revenue from Express Mail Service (EMS), indicating a performance problem within PT PosIND KCU Denpasar. The research aims to analyze the impact of Express Mail Service (EMS) Tariff, direct flight, and logistics competence on company performance, with service quality as an intervening variable. The method used was quantitative, and data analysis was conducted using the smartPLS application. The study population consisted of 250 customers, with a sample size of 154 determined by the Slovin formula. The load factor and Cronbach's Alpha values for all variables were above 0.700, indicating that the data for all variables were valid and reliable. The T Statistics value for EMS Tariff was 3.434, where $T \text{ Statistics} > 1.96$ and $p\text{-value} = 0.001$, indicating a positive influence of EMS Tariff on Service Quality. There was a positive influence of Direct Flight on Service Quality, with a T Statistics value of $2.277 > 1.96$ and a $p\text{-value} of 0.023 < 0.050$. There was a positive influence of logistics competence on service quality, with a T Statistics value of 2.661 and a $p\text{-value} of 0.000 < 0.05$. The R Square value was 0.612, indicating a positive and significant influence of EMS Tariff, direct flight, and logistics competence on service quality. Additionally, there was a positive and significant influence of service quality on company performance, with a T Statistics value of 13.132 > 1.96 and a $p\text{-value} of 0.000 < 0.05$. PT PosIND should evaluate the implementation of direct flights for EMS services to enhance customer service quality and potentially increase company revenue.

Keywords: Express Mail Service (EMS) Tariff, Direct Flight, Logistics Competence, Service Quality, Company Performance

1. Introduction

One of the core businesses of PT PosIND is the courier and logistics business, which includes both domestic and international shipment services. Denpasar, being one of the most visited cities in Indonesia by international tourists, has a significant potential for international shipments. One of PosIND's products preferred by customers for international shipping is Express Mail Service (EMS). The revenue from EMS at PT PosIND KCU Denpasar has been declining from 2022 to 2024. In 2022, EMS revenue was IDR 11,560,000,000, which dropped to IDR 9,251,000,000 in 2023, experiencing a negative growth of -24.95%. For the period from January to May 2024, the revenue further decreased compared to 2023, amounting to IDR 5,050,574,042 in 2023 and IDR 4,874,648,720 in the same period of 2024, indicating a decline of -3.48%.

The declining EMS revenue at PosIND KCU Denpasar will undoubtedly affect the company's performance, one of which is a decrease in company profits. According to Yuen et al. (2022), company performance is a multidimensional outcome of an organization's operational and strategic activities. The indicators of company performance, according to Yuen et al. (2022), include operational efficiency, on-time delivery, customer satisfaction levels, market share, and profitability.

According to Apriyani (2023), Yulia (2023), Yusuf (2022), and Aprielia (2022), price or tariff affects service quality. Apriyani (2023) defines price/tariff as the amount of money charged for a product or service or the value exchanged by customers to gain the benefits of owning or using a product or service. The indicators of tariff include price competitiveness, affordability, transparency in pricing, flexibility in pricing, and value for money.

According to Rizki Fauzi (2020), direct flights affect service quality. Rizki Fauzi (2020) defines direct flights as flights that do not have any stops between the origin and destination, thus reaching the final destination more quickly and efficiently. The indicators of direct flights include reduced transit time, reliability, reduced handling, consistency, and network coverage. According to Kim (2020), Liu (2022), and Esterlinus (2023), logistics competence affects service quality. Kim et al. (2020) defines logistics competence as a set of capabilities and skills possessed by logistics companies to manage and optimize their logistics operations. The indicators of logistics competence include technological integration, staff competence, process innovation, customer feedback utilization, and sustainable practices.

Based on previous research, the influence of tariff, direct flight, and logistics competence on company performance is still debatable, with some researchers supporting and others opposing these influences. Hence, the model cannot be generalized yet. The purpose of this study is to analyze the influence of Express Mail Service (EMS) Tariff, direct flight, and logistic competency on the performance of PT PosIND KCU Denpasar, with service quality as an intervening variable.

2. Body of Paper Research Methodology

This study uses a quantitative research method to test the established hypotheses. According to Creswell (2014), quantitative research is a systematic approach to testing theories by examining the relationships between variables, expressed in numbers and analyzed using statistical techniques. Data were collected through the distribution of questionnaires to respondents who are customers of PT PosIND Denpasar Main Branch Office.

In determining the sample size, the researcher used the Slovin formula with a margin of error of 5%, resulting in a sample size of 154 respondents from a population of 250 customers. Data collection was carried out by distributing questionnaires both directly and through online platforms. The questionnaire used in this study consists of structured questions designed to measure variables such as EMS Tariffs, direct flights, logistics competence, and service quality. The collected data were then processed using the PLS-SEM (Partial Least Squares Structural Equation Modeling) application.

Previous research has indicated that company performance is influenced by service quality. According to Adeshina (2021), George K (2023), Hasan U (2020), Tomy F (2023), and Sayed E (2022), company performance is affected by service quality. Sayed E (2022) defines service quality as the capacity of a company to offer services that meet and exceed customer needs or expectations. The dimensions/indicators of service quality include tangibles, responsiveness, empathy, assurance, reliability, and access.

According to Hair et al. (2019), PLS-SEM is a structural equation modeling technique suitable for analyzing data with small sample sizes and non-normal data distributions. Furthermore, Ramayah et al. (2021) emphasized that PLS-SEM is particularly advantageous in exploratory research due to its flexibility in handling complex models with multiple indicators and constructs. The SmartPLS application was used to analyze the relationships between the variables in the research model, including testing the validity and reliability of the research instruments and hypothesis testing. This analysis allows researchers to identify direct and indirect effects between the independent and dependent variables in this study.

3. Research Model

The research model in this study is presented in Figure 1.

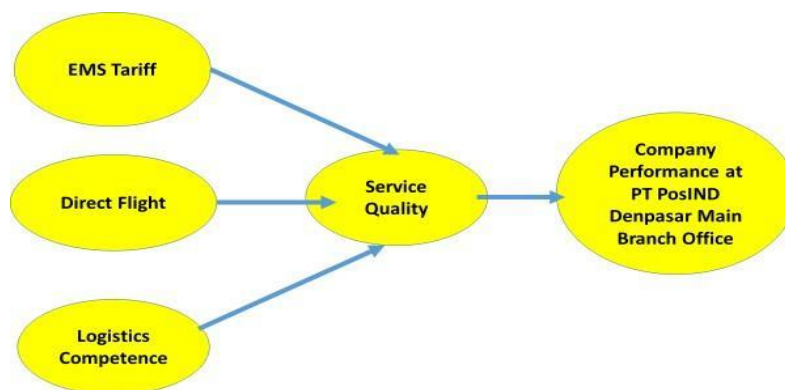


Figure 1: Research Model.

The total population is 250 customers of PT PosIND Denpasar branch with a margin of error of 5%, thus the sample size is determined using the Slovin's formula, totaling 154 people.

4. Hypotheses

The author formulates the hypotheses as follows:

No Hypotheses

1. H₁ : There is a positive and significant influence of EMS Tariff on service quality.
2. H₂ : There is a positive and significant influence of direct flight on service quality.
3. H₃ : There is a positive and significant influence of logistics on service quality.
4. H₄ : There is a positive and significant influence of EMS Tariff, direct flight, and logistics competence on service quality.
5. H₅ : There is a positive and significant influence of service quality on company performance.

5. Results

The results of the study indicate that the average value for each indicator ranges from 2.760 to 3.448, which are categorized as fairly good to good variables. Since the variables have average values that are not yet very good, it can be explained that the variables in this study meet the criteria for further investigation.

The tools used to test the quality of the questionnaire are validity and reliability tests. The validity test ensures that respondents are given the opportunity to express their opinions by rating each statement in the questionnaire on a scale from strongly agree to strongly disagree. The validity test also verifies that respondents correctly exercise their right to provide opinions ranging from strongly agree to strongly disagree. The study results indicate that the load factor values of all indicators in the examined variables are greater than 0.700. Therefore, according to Hasnita (2021), all indicators in this study are considered valid. Hasnita (2021) explains that a variable is deemed reliable if each variable has a Cronbach's Alpha value greater than 0.700. All variables have Cronbach's Alpha values above 0.700, making them reliable for this research.

The study results show that the T-Statistic value for the EMS Tariff variable is 3.434, where the T-Statistic > 1.96 , p-value = 0.001. This means there is a positive and significant influence of EMS Tariff on service quality. There is a positive and significant influence of direct flight on service quality with a T-Statistic value of $2.277 > 1.96$ and a p-value of $0.023 < 0.050$. There is a positive and significant influence of logistics competence on service quality with a T-Statistic value of 2.661 and a p-value of $0.000 < 0.05$. The study results indicate that the R-Square value is 0.612, meaning there is a positive and significant influence of EMS Tariff, direct flight, and logistics competence on service quality. There is also a positive influence of service quality on company performance with a T-Statistic value of $13.132 > 1.96$ and a p-value of $0.000 < 0.05$.

The overall research model can be explained in Figure 2.1 below:

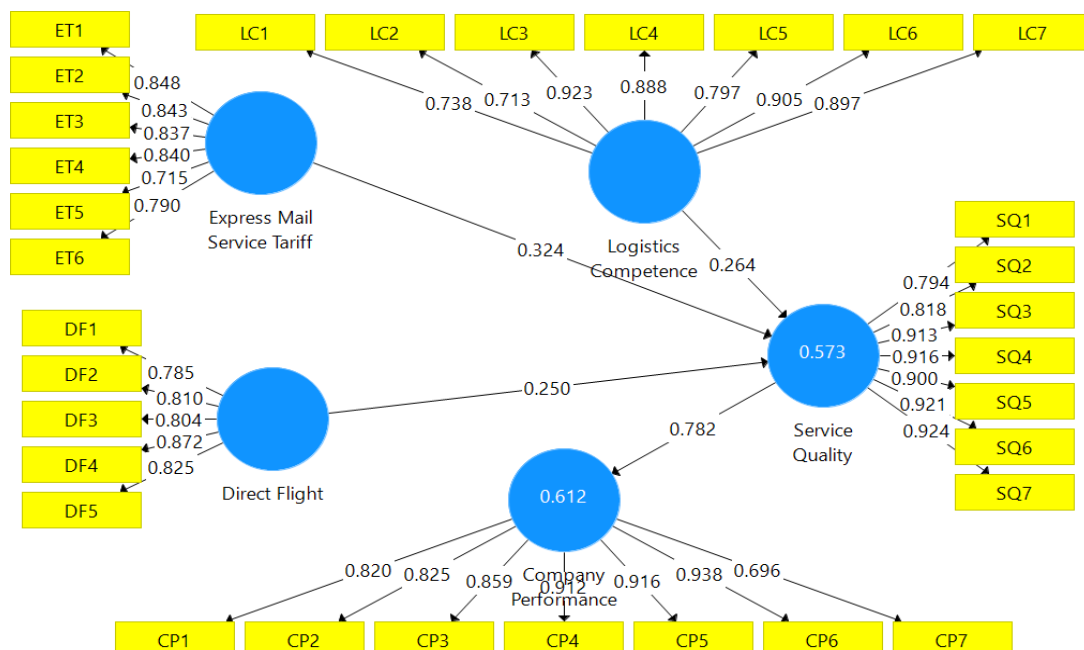


Figure 2.1. Result Research

From the model/diagram above, it can be concluded that Express Mail Service (EMS) Tariff, logistics competence, and direct flight all contribute positively to service quality. Additionally, service quality has a very strong influence on company performance, indicating that improvements in service quality will have a significant impact on the company's performance.

6. Implication and Direction for Future Research

Implication

From the research results, all variables have a positive effect on service quality. However, given that the T Statistic value for the direct flight variable is 2.277, which is the smallest value, it is necessary to reevaluate whether implementing direct flights from Denpasar to destination countries will significantly impact the performance of PT PosIND KCU Denpasar. Alternatively, the company could offer other options that would encourage customers to continue using the services at PosIND KCU Denpasar.

7. Future Research

From the research conducted at PT PosIND KCU Denpasar, the author has successfully demonstrated that EMS Tariff, direct flight, and logistics competence have a positive impact on service quality, and that service quality has a positive and significant impact on company performance. Considering that the variables used in this study still have a relatively small influence on service quality, the author recommends that future researchers seek out or add other variables that could have a stronger impact on service quality, such as innovation, technology, customer feedback, etc.

Reference

- Abu-nazir, W. (2016). Impact of Customer Service Quality on Business Performance in Hospitality Industries: An empirical study. 17(4).
- Anggraini, Y., & Putri, N. M. (2023). The Effect of Product Innovation, Price, and Service Quality on Purchasing Decisions for Herbalife Products. 3(1), 76–92. <https://doi.org/10.21154/joie.v2i2.3968>
- Fadhilah, M., Cahya, A. D., & Ardiansyah, M. J. (2022). KONSUMEN ALFAMART The Effect of Price and Service Quality on Consumer Satisfaction with Purchasing Decisions as Mediating Variables on Alfamart Consumers. 5, 125–131.
- In, C., & Employee, I. (2023). Competence, and organizational commitment in improving employee performance 21 | 1 | 2023. 21(1), 228–241.
- Kankam, G. (2023). Service quality and business performance: the mediating role of innovation. Discover Analytics. <https://doi.org/10.1007/s44257-023-00006-7>
- Kasus, S., Sekolah, P., & Binasehat, O. (2022). Pengaruh Harga, Kualitas Pelayanan dan Fasilitas terhadap Kepuasan Pelanggan. 31(02), 31–41.
- Kim, M. K., Narasimhan, R., & Schoenherr, T. (2020). Leveraging Logistics Competence in New Product Sourcing: The Role of Strategic Intent and Impact on Performance. Logistics, 4(4). <https://doi.org/10.3390/logistics4040024>
- Korniichuk, Y., Starokon, Y., & Shkatula, O. (2020). Logistics Competence as A Component of The Professional Competence of a Future Officer. Systemy Logistyczne Wojsk, 52(1). <https://doi.org/10.37055/slw/129244>
- Lermatan, E. E., Fauzi, R., Sakti, J., Ghafar, A., Krisnawati, S., & Prakoso, O. S. (2023). The Effect of Staff Competence, Customer Satisfaction, and Service Quality on Cargo Shipping Service User Loyalty. 1(2), 91–100.
- Logistics Competence as A Component of The. (2020). 3811(52).

- Santoso, R. A. (2023). Analysis of the Effect of Competence on Customer Complaint Handling Performance with Organizational Commitment as a Moderation Variable: A Study on PT Pos Indonesia (Persero). 13(1), 358–373.
- Tammubua, M. H., & Surpto, D. (2022). Analysis of Competence and Service Quality on Customer Satisfaction and Loyalty in Eastern Indonesia Border Tourism. 3016–3031.
- Uvet, H. (2020). Importance of Logistics Service Quality in Customer Satisfaction: An Empirical Study. 13(1), 1–10.
- Wakhidah, L. N., & Pramusinto, H. (2021). Pengaruh Kompetensi, Disiplin Pegawai, dan Lingkungan Kerja Fisik terhadap Kualitas Pelayanan Pegawai. 1(3), 265–271. <https://doi.org/10.15294/baej.v1i3.46520>
- Winata, A., & Prabowo, B. (2022). Pengaruh Harga, Fasilitas dan Kualitas Pelayanan terhadap Loyalitas Pelanggan dengan Kepuasan Pelanggan sebagai Variabel Intervening pada London Beauty Center (LBC) Sidoarjo. 3(4), 810–822.

The Role of Dynamic Logistic Capabilities which is Influenced by Customer Experience and Operational Excellent for PT Pos Indonesia Regional West Java

Arif Yudha Wahyudi & Dr Agus Purnomo M.T. (Lecturer Supervisor)
Universitas Logistik dan Bisnis Internasional, Indonesia

Abstrak

This research aims to determine and analyze the influence of customer experience and operational excellence on the dynamic logistic capabilities of PT Pos Indonesia (Persero) West Java. The type of research used in this research is quantitative research. The data collection method was carried out by interviews, with a list of questions (questionnaire). The population in this study was customers of PT Pos Indonesia (Persero) located in 20 cities and districts in West Java Province. The research sample uses the sampling / census method. In this study, the number of respondents from the population was relatively small, namely 55 people. Data processing was carried out using Partial Least Square SEM (SmartPLS) where the results obtained that there is a positive influence between customer experience (X1) on dynamic logistic capabilities (Y) and there is a positive and significant influence between operational excellence (X2) on dynamic logistic capabilities of PT Pos Indonesia (Persero) West Java.

1. Introduction

Currently, PT Pos Indonesia (Persero) as a state-owned company is a business entity that is experiencing the consequences of the hyper-competence century, where customers are getting smarter so they can easily compare existing services. With increasing customer demands, standards have shifted so that service that was previously considered great is now felt to be mediocre. The current demands of the public or users of logistics services are products that are cheap/efficient but delivered quickly. Apart from that, local and global competitors can easily mushroom and play on the same land. PT Pos Indonesia (Persero) West Java Regional has 3 main branch offices and 15 branch offices covering 20 cities and district areas throughout West Java Province. As a business entity, PT Pos Indonesia Regional West Java currently has a logistics business portfolio in 2024 that has grown from 2023, but the problem is that it has not yet reached the target set by the company. Influencing factors include customer experience and operational excellence, where these 2 factors will influence dynamic logistics capabilities which have an impact on the logistics revenue performance of PT Pos Indonesia (Persero) West Java Region.

2. Literature Review

Customer experience is different from customer service. Customer service provides solutions and handles customers, in this case the company as the subject is more active in providing services and providing solutions to customers. Customer experience is more about the customer's perspective when enjoying services from the company. Customer experience is customer satisfaction with the services or products the company offers (Dewi Maharani, 2022). Therefore, every business must be able to create a good customer journey according to customer needs. With good customer experience management, customers will trust the company's brand. The definition of customer experience is the customer's perception of rational, physical, emotional, subconscious, and psychological interactions with parts of an organization (Pradhita, 2013).

Customer experience indicators include: feel, sense, think, act, and relate (Febrina Salim and Catherine et al., 2013). Customer value is a customer's assessment of a product to compare whether there is added value from the product. With these 5 indicators, a survey is conducted on PT Pos Indonesia customers in the West Java Regional work area. The concept of operational excellence was first introduced in the early 1970s by Dr. Joseph M. Juran in teaching Japanese business leaders how to improve quality. Operational Excellence (OpEx) is a business management approach that emphasizes continuous improvement in all aspects of the business and all business processes by creating a culture where management and employees are invested in business results and are empowered to implement change (Found et al., 2018).

Every organization continues to be faced with many challenges, both internal and external. For this reason, organizations need to understand the importance of operational excellence. Operational excellence is a business strategy that will make an organization more consistent and superior to its competitors. They are able to run a business with lower operational risk, cheaper operational costs, and relatively higher income (Ifada & Ali, 2018).

Operational excellence can be measured by several indicators as follows: customer focus, continuous improvement, lean thinking, standardization, employee involvement, agility and flexibility, continuous learning and training, process visibility and transparency and leadership commitment and support. Wang and Ahmed (2007) identified three main component factors of dynamics capabilities, which can be considered as the three main dimensions of dynamic capabilities:

- Adaptive dimension
- Absorption dimensions
- Innovative dimension

3. Methodology

Research Design

This research uses an explanatory survey method which analyzes causal relationships between variables. Information from part of the population is collected empirically to find out the opinion of part of the population.

Data Sources and Sampling Techniques

After observing the problem and taking the title of the article, indicators for each variable were compiled. Next, a 17-question questionnaire that uses a five-point Likert scale was prepared. The questionnaires were distributed to corporate/logistics customers in all main branch offices and branch offices of PT Pos Indonesia in the West Java region, totaling 18 offices or 20 district cities in the West Java region. To make it easier to return the questionnaire, a Google link for respondents to make it easier to fill out the questionnaire was created and shared. This proposal establishes a customer experience and operational excellence model using variance-based Partial Least Squares Structural Equation Modeling (PLS-SEM).

4. Result

In this research, using PLS SEM software, 2 models were evaluated, namely the outer model and the inner structural model. Model evaluation is used to determine the validity and reliability of the model. Convergent validity is determined by a factor loading value ≥ 0.7 and an average variance extracted (AVE) value ≥ 0.5 . Meanwhile, discriminant validity is measured by ensuring that the square root of the AVE (Fornell-Lacker criterion) is greater than the correlation between latent constructs.

The reliability of the model was assessed using Cronbach's Alpha (≥ 0.70) and Composite Reliability (≥ 0.70). The model includes the R-squares value (determinant coefficient), Statistical T Value, and P-value. If the R-Squares are 0.75, 0.5, and 0.25, then it can be confidently concluded that the influence of the exogenous variable on the endogenous variable is strong, moderate, and weak. To determine the significance of the influence between variables with a significance level of 5%, a t value greater than 1.65 and a P value less than 0.05 are used.

Table: Outer Struktur Model Result Table 1 Validity and Reliability of the Variables

Vrb	Ide	F_L	Cron_α	Com_R	A_VE
Customer Experience			0,859	0,865	0,704
CE1	An interesting experience regarding the services offered by PT Pos Indonesia	0,779			
CE2	Satisfied with the services provided by PT Pos Indonesia	0,894			
CE3	Satisfied with the problem solving provided by PT Pos Indonesia	0,867			
CE4	Customers get added value for the services provided by PT Pos Indonesia when compared to other Courier and Logistics services	0,811			
Operational Excellence			0,933	0,937	0,654
OE1	PT Pos Indonesia Focus on customers	0,732			
OE2	PT Pos Indonesia make continuous improvements	0,771			
OE3	PT Pos Indonesia provides simple and streamlined services	0,806			
OE4	PT Pos Indonesia has standardization in service	0,863			
OE5	PT Pos Indonesia really pays attention to employee involvement	0,855			
OE6	PT Pos Indonesia has great agility and flexibility	0,837			
OE7	PT Pos Indonesia carries out continuous learning and training	0,826			
OE8	PT Pos Indonesia has process visibility and transparency	0,764			
OE9	PT Pos Indonesia has commitment and leadership support	0,814			
Dynamic Capabilities			0,844	0,866	0,763
DC1	PT Pos Indonesia is able to identify and exploit emerging markets, including the company's ability to adapt their product-market scope to respond to external opportunities	0,930			
DC2	PT Pos Indonesia is able to recognize the value of new external information, understand it, and utilize it for commercial purposes	0,835			
DC3	PT Pos Indonesia has the company's ability to develop new products and/or markets, through aligning strategic innovation orientation with innovative processes and behavior	0,853			

Composite reliability value is more than 0.7 and value Cronbach's Alpha is more than 0.7, then it meets the reliability criteria. The AVE value is more of 0.5 then it meets the criteria

Table 2 Validity and Reliability of the Variables

	Customer Experience	Dynamic Capabilities	Operational Excellence
Customer Experience	0,839		
Dynamic Capabilities	0,593	0,874	
Operational Excellence	0,694	0,809	0,809

Inner Structure Model Result Table 3 R-Squares (Determinant Coefficient)

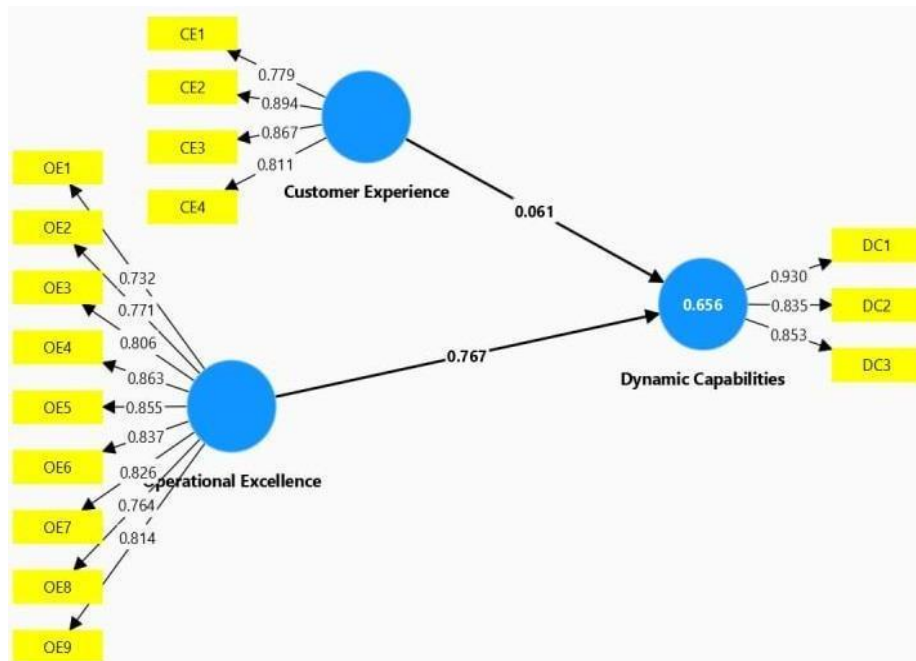
To determine the significance of the influence between variables at the 5% significance level, a t-value greater than 1.65 must be used and a P value less than 0.05 must be used.

	R-square	R-square adjusted
Dynamic Capabilities	0,656	0,643

The R Square value of 656 means that the endogenous variable dynamic capabilities is influenced by 65.6% by the customer experience and operational excellence variables, while 34.4% is influenced by other factors outside the variables studied.

Table 4: Hypothesis Testing Conclusion for all Research Hypotheses

	Original Sample (O)	Sample Mean (M)	Standard deviation (STDEV)	T statistics ((O/STDEV))	P values	HTC
CE	0,905	0,900	0,033	27,120	0,000	Accepted
DC	0,906	0,904	0,027	33,183	0,000	Accepted
OE	0,944	0,943	0,014	67,103	0,000	Accepted



5. Conclusions and Implications

This research aims to examine the direct influence of customer experience and operational excellence on the dynamic logistics capacity of PT Pos Indonesia (Persero) in the West Java region. Research results show that customer experience has a direct impact on dynamic capacity. The operational excellence factor also has a direct and significant influence on the dynamic logistics capacity of PT Pos Indonesia (Persero) in the West Java Region. With this research we draw out two main theoretical implications. First, proposing the use of customer experience as a strategic effort to be implemented both internally and externally. Second, operational excellence is a strategic effort to increase the dynamic capacity of PT Pos Indonesia (Persero) so that PT becomes the choice for consumers to use its logistics services. The role of human resources is very important in improving both providing an excellence experience to customers and operational excellence in delivering logistics services.

Bibliography

- Dewi Maharani, S. (2022).
- Febrina Salim dan Catherine, K., Fransisca Andreani, D., & Jurusan Manajemen Perhotelan, M. (2013). *Pengaruh Customer Experience Dan Kepercayaan Terhadap Kepuasan KONSUMEN DI TX TRAVEL KLAMPIS*. www.txtravel.com
- Found, P., Lahy, A., Williams, S., Hu, Q., & Mason, R. (2018). Towards a theory of operational excellence. *Total Quality Management & Business Excellence*, 29(9–10), 1012–1024.
- Ifada, N. T., & Ali, H. (2018). *Faktor-Faktor Yang Mempengaruhi Keunggulan Operasional: Analisis Sistem Perusahaan, Sistem Manajemen Rantai Pasokan Dan, Sistem Manajemen Hubungan Pelanggan (Literature Review Manajemen Pemasaran)*.
- Pradhita, R. (2013). *Pengaruh Customer Experience Terhadap Loyalitas Pelanggan Dengan Customer Satisfaction Sebagai Variabel Intervening Butik Plus Gallery Medan*.
- Wang, C.L., Ahmed, P. K. 2007. Dynamic capabilities: A review and research agenda, *International Journal of Management Reviews*, 9, 31-51



PROCEEDING

“HARMONY IN DIVERSITY: FOSTERING UNITY
SUSTAINABLE RESEARCH AND INNOVATION SOCIETY”

24 - 25 JULY 2024

e ISBN 978-967-2742-35-7



9 789672 742357