# From Imagination to Innovation

MNNF PUBLISHER

# From Imagination to Innovation

**BOOK COMPILATION**
**From Imagination to Innovation**

Published by MNNF Publisher
23-1 Jalan Coco Drive 1,
Taman Bandar Senawang,
70450 Senawang,
Negeri Sembilan, MALAYSIA.



Publication Date: October 2025

National Library of Malaysia

e ISBN 978-967-0052-20-5

# TABLE OF CONTENT

# FOREWORD

All praise and thanks are due to Allah the Most Merciful and the Most Gracious for His abundant blessings, under which the *International Invention & Innovative Competition (InIIC) 2025* was successfully organized virtually. It is with immense gratitude that we announce the results of this momentous event, which took place on the 25 October 2025. Our heartfelt congratulations go out to all the deserving winners who have showcased exceptional talent and ingenuity.

Within the pages of this book, '*From Imagination to Innovation*', lies a treasure trove of knowledge and inspiration. This collection of essays comprises the invaluable contributions of the participants of InIIC 2025, encapsulating their visionary ideas and ground-breaking discoveries. With 21 enriching chapters dedicated to innovation, this compilation serves as a beacon of enlightenment for both practitioners and academics alike, offering an innovative source and a point of reference to nurture and enhance creativity. We extend our sincere appreciation to all the authors who have generously shared their time, thoughts, and ideas in shaping the content of this book.

It is our earnest hope that this book will serve as a catalyst for transformative ideas within your own endeavours. May it kindle the flames of creativity and kindle the spirit of innovation as you embark on the path of designing new products, systems, and solutions. Let this book be your guide, igniting the spark of inspiration and propelling you towards ground-breaking achievements.

# TuMiHApp: Tourists Migrants Health App

**Sadia Choudhury Shimmi[1*] & Md Sayed Uddin[2]**

[1]Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Jalan UMS, 88450 Kota Kinabalu, Sabah, Malaysia.
[2]Faculty of Social Sciences and Humanities, Universiti Malaysia Sabah, Jalan UMS, 88450 Kota Kinabalu, Sabah, Malaysia.

[*]*shimmi_cmc40@ums.edu.my*

**ABSTRACT**
Tourists and migrants face several health issues and a lack of proper healthcare services and facilities. However, they have a fear of the cost and eligibility of healthcare facilities and their availability. Along with this issue, a crucial point is the location of the clinics and hospitals, as well as transport and appointment facilities. Therefore, to overcome all the challenges, this project aims to develop a user-friendly, innovative mobile and smartwatch app for tourists and migrants. Proper research, design, prototyping, testing, and validation are key components of the methodology. After identifying the gaps and needs, TuMiHApp (Tourists Migrants Health App) will be developed with specific details about the users, their current locations, and health status. After identifying the health status, this app will help users find relevant clinics or hospitals, as well as specialist appointments with comparable costs. The unique feature of the app is to provide a healthy diet chart and information on nearby availability, as well as physical and emotional healthcare. Furthermore, an important feature is to incorporate a living lab theme. This app is multilingual and helps to adapt culturally. According to its usability and functionality, prototype testing will appreciate user testing. The app design will be modified based on user feedback. A relevant certification will be obtained after validating the accuracy of healthcare facilities. TuMiHApp supports public health worldwide and reduces disparities, enhancing community health. Both authorised and unauthorised tourists and migrants will obtain proper healthcare and have their health status monitored by preserving the database.

**Keywords:** TuMiHApp, health database, mobile and smartwatch app, healthcare, tourists and migrants' healthcare
.

## 1. INTRODUCTION

Migrants and tourists face significant barriers when seeking appropriate healthcare. Other than native populations, both authorised and unauthorised migrants have a limited chance to use healthcare services, resulting in disparities in health outcomes (Björngren Cuadra & Cattacin, 2020). Obstacles and hardships, including fear of deportation, financial constraints, discriminatory practices, and restrictive policies, prevent unauthorised individuals from seeking medical attention promptly (Davy et al., 2015). Not only that, authorised migrants and tourists experience challenges that limit their healthcare utilisation. They face language barriers, communication difficulties, limited knowledge of their entitlements, and misinformation about administrative processes (Dias et al., 2025; Georgiadou et al., 2025). Inefficiencies in health systems and poorer health outcomes are

due to reliance on emergency services while underutilising preventive and primary care for migrants in Europe (Hernández-Quevedo et al., 2024). Li et al. (2023) proposed a conceptual framework to address these obstacles. The Researchers highlight the characteristics of healthcare systems and the importance of macro-level determinants. They also focus on migrant-specific factors such as time, geographic accessibility, and information availability. Moreover, these findings underscore the urgent need for innovative, technology-driven solutions and a user-centred approach to bridge gaps to support healthcare utilisation across diverse contexts, access, and empower mobile populations with timely health information.

## 2. LITERATURE REVIEW

**Migrants' and Tourists' Difficulties with Healthcare Access:** Migrants encounter delayed treatment and poorer health outcomes due to significant challenges to accessing healthcare. Both documented and undocumented migrants utilise healthcare less than native populations (Björngren Cuadra & Cattacin, 2020). Unauthorised migrants face challenges such as legal restrictions and the fear of deportation (Davy et al., 2015). During the COVID-19 pandemic, research in Thailand found language barriers, financial hardships, and limited-service availability for migrant workers (Wongsuwanphon et al., 2024). Nepali migrants underwent healthcare costs and administrative complexities, despite access to free services in Japan (Adhikari et al., 2023). Due to structural barriers, Internal construction workers in India reported distrust in public services (Kumar et al., 2020).

**Healthcare-Seeking Behaviour among migrants and tourists:** Instead of utilising primary and preventive care, migrants often seek emergency services, resulting in inefficiencies (Hernández-Quevedo et al., 2024). Travellers after returning with malaria highlight issues of knowledge and system accessibility, causing delay in seeking care (Schlagenhauf et al., 2021). In Hong Kong, due to dissatisfaction with local services and language barriers, ethnic minorities turned to medical tourism (Chan et al., 2024). Therefore, due to weak infrastructure and high costs, medical tourism globally faces similar challenges (Jalali et al., 2025).

**Uses of technological mobile health Solutions**: To combat the obstacles, mobile health (mHealth) solutions could mitigate the issue. SMS interventions improved reproductive health knowledge among female migrants in Vietnam (Nguyen et al., 2016). The proposed mHealth frameworks are capable of integrating care for refugees (Sandhu et al., 2019). Multilingual content facilitates app users in mHealth in Turkey among Syrian refugees (Kahraman et al., 2022). Low awareness hinders widespread adoption; mobile technologies have enhanced access in rural Ghana (Boateng et al., 2020). Systematic reviews highlight the positive impact of mHealth on accessibility in resource-limited settings (Naslund et al., 2024).

**Adaptation of framework and its implications**: To explain migrant healthcare utilisation, several frameworks have been invented. Li et al. (2023) proposed a model addressing macro determinants and migrant-specific factors, while Dervić et al. (2024) found that findings from Austria show lower hospitalisation rates among migrants but higher readmission rates, indicating structural barriers. To improve health outcomes for migrants and tourists, comprehensive approaches must combine systemic reforms with innovative technological solutions.

## 3. **METHODOLOGY**

The project follows a proper, systematic, innovative methodology focused on migrants and tourists' user-centred design to create a validated and functional application. To enhance user engagement and real-world applicability, it includes research, review, design, prototyping, testing, feedback, and validation, while utilising a living lab approach.

**Phase 1: Research and Needs Assessment:** The project begins with a literature review and market analysis to identify healthcare access barriers for tourists and migrants and gaps in digital health solutions. To ensure the app design meets the actual needs of users, primary data will be gathered through surveys, interviews, and focus groups with target users, including tourists, migrants, healthcare providers, and policymakers.

**Phase 2: System Design and Architecture:** Using research insights, we will design the TuMiHApp architecture, integrating modules for user registration, including identification details, health profiling, geolocation tracking, along with a cost comparison feature for hospitals and clinics and appointment booking. Wellness modules will provide culturally sensitive information on diet, physical activity, stress management, and adaptation strategies. The design will prioritise accessibility, multilingual support, security, and data privacy compliance (Figure).

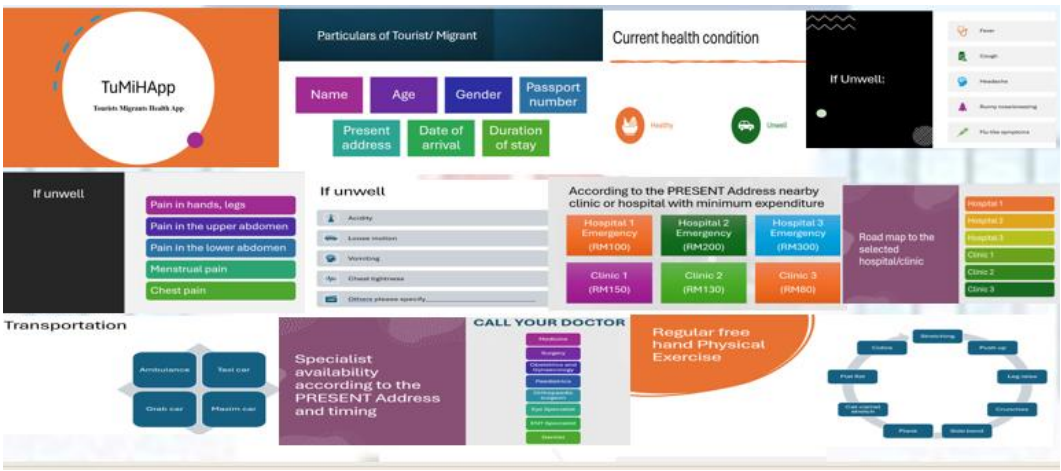


Figure 1: System design and architecture

**Phase 3: Prototyping** - A functional prototype will be developed using agile methods, with an initial focus on core features, including healthcare facility mapping, expenditure comparison, and appointment scheduling. Future iterations will introduce health promotion and wellness modules. The living lab methodology will allow users to engage with the prototype in real-life settings and provide feedback.

**Phase 4: User Testing and Usability Evaluation:** Prototypes will undergo usability testing with various user groups, including tourists and migrants. Standardised tools like the System Usability Scale (SUS) and heuristic evaluations will assess usability. Iterative refinements will enhance navigation, functionality, and overall user experience.

**Phase 5: Validation and Certification:** The app will be validated for accuracy by cross-checking healthcare facility information with official databases. Beta testing with healthcare

providers will ensure integration into existing services. Compliance assessments will be conducted to secure health technology certifications, data protection approvals, and ethical clearance before launch.

**Phase 6: Continuous Improvement:** Following the app's launch, it will be regularly updated based on user feedback, changes in healthcare policies, and technological advancements. Data analytics will also track the app's impact on health-seeking behaviours and usage patterns among users.

## 4. RESULTS & DISCUSSION

The invention of TuMiHApp aims to create a mobile and smartwatch application for tourists and migrants that mitigates healthcare access barriers. The most important features are real-time geolocation of hospitals and clinics, cost comparisons, appointment booking, and culturally tailored health education. Another novel feature is multilingual support. User testing is expected to show high usability, particularly in navigation. To enhance user engagement by allowing real-time adaptations through the living lab approach.

Due to a lack of health information and cost, the migrants and tourists avoid healthcare. TuMiHApp supports them to overcome the obstacles and healthcare fear (Björngren Cuadra & Cattacin, 2020; Davy et al., 2015). This app supports them by providing comparable costs and available facilities that help them make informed decisions on time.

This app will be appropriate to minimise the cultural and linguistic challenges in healthcare navigation. A unique feature of this app is to guide a healthy diet, location of health foods, and physical and emotional fitness tips (Georgiadou et al., 2025). Supported by various research studies on digital health technologies, increased accessibility, and reduced disparities, TuMiHApp is a valuable tool for underprivileged populations (Davy et al., 2015).

The app will help transition from emergency care to primary and preventive care services. It will depend on user feedback and on utilising the living lab methodology to perform this action (Hernández-Quevedo et al., 2024). Finally, TuMiHApp aims to improve health equity both technically and socially among tourists and migrants.

## 5. CONCLUSION & RECOMMENDATION

TuMiHApp is a unique health app that promotes healthcare access and a healthy lifestyle for tourists and migrants. This app will alleviate the fear and tension associated with locating clinics and hospitals, as well as appointment facilities and comparable costs. This user-centred design app facilitates communication with locals through multilingual support and is culturally adaptable. Recommendations for further modification of the app could expand multilingual support, data privacy support, and be blended with other hospital, clinic and healthcare systems. The distinctive app, like TuMiHApp, should be endorsed by healthcare and policymakers to the public health, equity and proper health service delivery for tourists and migrants.

## REFERENCES

Adhikari, J., Ghimire, S., & Kubota, Y. (2023). Healthcare access and challenges among Nepali migrants in Japan during COVID-19: A cross-sectional study. BMC Public Health, 23, 1051. https://doi.org/10.1186/s12889-023-11051-y

Boateng, D., Agyei-Baffour, P., & Angel, S. (2020). Mobile phones and healthcare access: Barriers and opportunities in rural Ghana. BMC Medical Informatics and Decision Making, 20(1), 14. https://doi.org/10.1186/s12911-020-1040-4

Björngren Cuadra, C., & Cattacin, S. (2020). Access to healthcare for undocumented migrants: A comparative policy analysis in the European Union. *International Journal for Equity in Health, 19*(1), 1–14. https://doi.org/10.1186/s12939-020-01373-3

Chan, H. Y., Lee, P., & Wong, S. Y. (2024). Healthcare access and medical tourism among ethnic minorities in Hong Kong: Barriers and coping strategies. BMC Public Health, 24, 221. https://doi.org/10.1186/s12889-024-17221-2

Cuadra, C., & Cattacin, S. (2020). Access to healthcare for undocumented migrants: A comparative policy analysis in the European Union. International Journal for Equity in Health, 19(1), 1–14. https://doi.org/10.1186/s12939-020-01373-3

Davy, C., Harfield, S., McArthur, A., Munn, Z., & Brown, A. (2015). Barriers to health care for undocumented immigrants: A literature review. *Risk Management and Healthcare Policy, 8,* 157–167. https://doi.org/10.2147/RMHP.S70173

Dervić, E., Ali, O., Deischinger, C., Prieto-Curiel, R., Stütz, R., Mittendorfer-Rutz, E., & Klimek, P. (2024). Healthcare utilization patterns among migrant populations: Increased readmissions suggest poorer access. arXiv. https://doi.org/10.48550/arXiv.2408.16317

Dias, S., Gama, A., Cargaleiro, H., & Martins, M. O. (2025). Barriers in access to health care faced by migrants: A scoping review. *Health Policy, 129*(2), 103–115. https://doi.org/10.1016/j.healthpol.2025.01.002

Georgiadou, E., Laban, C. J., & Jensen, K. (2025). Communication barriers and healthcare access among migrants in Europe. *European Journal of Public Health, 35*(3), 407–415. https://doi.org/10.1093/eurpub/ckae048

Hernández-Quevedo, C., Masseria, C., & Mossialos, E. (2024). Patterns of health services use among migrants in Europe: A population-based study. *BMC Public Health, 24*(1), 172. https://doi.org/10.1186/s12889-024-18472-3

Jalali, M., Haghgoshayie, E., Janati, A., et al. (2025). Health tourism: A global perspective on the barriers and facilitators. Discover Public Health, 22, 157. https://doi.org/10.1186/s12982-025-00545-2

Kahraman, T., Koca, Ö., & Yildirim, M. (2022). Mobile health applications for Syrian refugee women in Turkey: A usability and feasibility study. Frontiers in Public Health, 10, 1025675. https://doi.org/10.3389/fpubh.2022.1025675

Kumar, P., Singh, S., & Dhillon, P. (2020). Migrant workers and access to healthcare during the COVID-19 pandemic in India. Journal of Migration and Health, 1–2, 100004. https://doi.org/10.1016/j.jmh.2020.100004

Naslund, J. A., Aschbrenner, K. A., & Marsch, L. A. (2024). Advantages of mHealth utilization in mental health services: A systematic review of reviews. Global Mental Health, 11, e23. https://doi.org/10.1017/gmh.2024.15

Nguyen, H. T., Vu, S. H., Tran, T. T., & Hoang, T. H. (2016). mHealth reproductive health intervention for female migrants in Vietnam: A pilot study. Reproductive Health, 13, 55. https://doi.org/10.1186/s12978-016-0172-6

Sandhu, S., Bjerre, N. V., Dauvrin, M., Dias, S., & Gotsens, M. (2019). mHealth and refugees: Conceptualizing an integrated care model. Journal of Medical Internet Research, 21(5), e10454. https://doi.org/10.2196/10454

Schlagenhauf, P., Grobusch, M. P., & Petersen, E. (2021). Delayed healthcare-seeking and malaria in returning travellers: A systematic review. Travel Medicine and Infectious Disease, 40, 101941. https://doi.org/10.1016/j.tmaid.2021.101941

Wongsuwanphon, S., Chottanapund, S., Knust, B., & Wongjindanon, N. (2024). Access to healthcare services and factors associated with unmet needs among migrants in Phuket Province, Thailand. BMC Health Services Research, 24, 1161. https://doi.org/10.1186/s12913-024-11589-6

# FlexiGrow: Expandable Vertical Farming System

Nurashikin Nazer Mohamed, Khairunnisa Ibrahim, Nazhan Nazari, Dayang Nurjasnita Awang Masidi & Sharifah Nursyakirin Wan Edenin

Faculty of Economics, Business and Accounting
i-CATS University College

*nurashikin.nazerm@icats.edu.my*

**ABSTRACT**
Urbanisation and limited land availability have heightened the demand for sustainable food production systems suited to compact urban environments. This study introduces FlexiGrow: Expandable Vertical Farming System, a low-cost, portable solution designed to promote sustainable home gardening among urban households. The project addresses critical challenges such as restricted space, high equipment cost, and the lack of climate-suitable designs for tropical regions. FlexiGrow features an adjustable bamboo frame constructed from recycled materials and equipped with lockable caster wheels for mobility and stability. The fully manual, soil-based system eliminates dependence on electricity and complex hydroponic mechanisms, making it environmentally responsible and easy to operate. A design-based innovation approach was adopted, involving problem identification, prototype construction, and testing. Leafy vegetables, including spinach and lettuce, were planted to evaluate adaptability, growth performance, and user satisfaction. Findings showed that FlexiGrow effectively achieved its objectives of flexibility, portability, and sustainability. The adjustable frame functioned efficiently in confined spaces, while the mobile base enabled easy relocation for optimal sunlight. Plants exhibited healthy growth, confirming the system's suitability for small-space urban farming. User responses highlighted its simplicity, practicality, and appealing design, demonstrating its potential for both individual and community applications. FlexiGrow offers a sustainable and adaptable model for urban agriculture by combining eco-friendly materials with practical functionality. It advances the United Nations Sustainable Development Goals (SDGs) Zero Hunger, Responsible Consumption and Production, and Climate Action by supporting household food security and encouraging greener urban living.

**Keywords:** Urban farming, vertical agriculture, sustainable design, food security

## 1. INTRODUCTION

The literature reveals a growing consensus that small-space urban farming represents not merely an alternative to traditional agriculture, but a fundamental shift toward more resilient, localized, and environmentally sustainable food production methods (Buragohain et al., 2024). As urban populations continue to expand, traditional agricultural systems face mounting pressure from land scarcity, climate change, and the growing distance between production sites and consumers (Khan et al., 2020). These challenges have accelerated

interest in innovative food production strategies that can be practiced within limited urban environments.

Urbanisation has transformed modern living, particularly in cities where residents often live in apartments or intermediate landed houses with restricted outdoor spaces. This transformation has drastically reduced opportunities for home gardening, while growing concerns about food security, climate change, and sustainable lifestyles have encouraged people to explore urban farming as a viable alternative. Vertical and small-space farming systems have become increasingly important as they maximise space, minimise resource use, and support sustainable food production close to consumers. Socially, these systems contribute to food security by providing fresh produce in urban food deserts, while also offering educational opportunities and community engagement benefits that strengthen social cohesion in urban neighborhoods (Sinha et al., 2024).

However, the adoption of vertical farming systems in Malaysia remains limited due to several challenges. Many existing systems are expensive, non-portable, and unsuitable for Malaysia's hot and humid tropical climate. Most commercial vertical structures rely on imported parts, hydroponic pumps, and electronic components that require significant maintenance and increase costs. At the same time, the country continues to face growing concerns over plastic waste, with limited initiatives that successfully integrate recycling into agricultural innovation. To create a more inclusive and sustainable urban farming solution, a locally adaptable, low-cost, and mobile design is needed.

Building-integrated agriculture has emerged as a particularly promising approach, with studies exploring how food production can be seamlessly incorporated into rooftops, facades, and interior spaces of residential buildings (Pakravan et al., 2022). Inspired by this concept, the current project introduces FlexiGrow: Expandable Vertical Farming System, a sustainable, low-cost, and portable solution designed specifically for small urban spaces. FlexiGrow combines recycled materials such as bamboo and plastic pots in a modular, expandable design that can be folded or adjusted based on available space. Equipped with wheels at the base, the system can be moved easily for sunlight exposure or storage during bad weather, allowing users to maintain small-scale food production conveniently within their homes.

The novelty of FlexiGrow lies in its combination of adjustability, portability, and eco-friendliness. It promotes responsible resource use through recycling, supports local food security by enabling home-based farming, and enhances sustainability by reducing dependence on commercial food supply chains. Furthermore, this innovation aligns with the United Nations Sustainable Development Goals (SDGs), particularly Goal 2: Zero Hunger, Goal 12: Responsible Consumption and Production, and Goal 13: Climate Action. By turning limited urban spaces into productive green environments, FlexiGrow demonstrates how small-scale innovation can contribute to broader environmental and social transformation, making urban farming accessible, affordable, and sustainable for all.

## 2. METHODOLOGY

The development of FlexiGrow was guided by a design-based innovation approach that involved three main stages: identifying the problem, constructing the prototype, and testing the system's performance.

The first stage focused on problem identification and concept development. Observations and informal discussions with urban residents revealed that many people were interested in home gardening but lacked the space and resources to do so effectively. Most commercial vertical farming products were either too costly or too large for home use. Based on these insights, the project aimed to create a compact, affordable, and mobile vertical planting system that could fit into small areas such as balconies, corridors, or patios.

During the prototype construction stage, materials such as recycled bamboo and plastic pots were selected for their affordability, durability, and availability. The bamboo structure was designed in an X-shaped expandable form, allowing the frame to be adjusted to suit different space requirements. To make the system mobile, four lockable caster wheels were installed at the base, ensuring that users could easily reposition the system without disturbing the plants. The prototype was designed to be easy to assemble, lightweight, and sturdy enough to hold multiple pots securely.

The final stage involved testing and evaluation of the FlexiGrow prototype. The system was tested by planting leafy vegetables such as spinach and lettuce in soil-filled pots. The structure's height and width were adjusted to test its flexibility, and the entire system was moved periodically to evaluate mobility and stability. The experiment also observed how plants responded to varying sunlight positions when the system was relocated. Data were collected on plant growth, ease of watering, and overall user experience. Feedback from users was recorded to assess convenience, design appeal, and satisfaction with its functionality.

## 3. RESULT

The testing and evaluation process demonstrated that FlexiGrow successfully met its objectives of being adaptable, affordable, and sustainable for small urban spaces. The adjustable bamboo frame worked effectively, allowing users to modify the system's height and width based on the available area. The wheeled base made the system highly portable, enabling users to move it easily to locations with better sunlight or to bring it indoors during heavy rain. The locking mechanism kept the structure stable during use, ensuring that plants remained upright and secure.

Figure 1: FlexiGrow prototype expanded position

Figure 2: FlexiGrow prototype folded position

Figure 3: Fully functional FlexiGrow system with growing salad vegetables

The vegetables planted during the experiment grew healthily, indicating that the system provided suitable conditions for growth, including adequate sunlight exposure, effective water flow and drainage, and structural stability. As shown in Figure 3, the FlexiGrow system successfully supported the cultivation of salad vegetables, demonstrating its practicality and efficiency as a compact urban farming solution. The structure's natural materials also helped maintain an ideal balance between lightness and strength. Users who tested the prototype praised its practicality, simplicity, and aesthetic design. They reported that it required minimal effort to maintain and was easy to assemble, making it ideal for families, students, or older adults who wanted a low-maintenance gardening system.

In addition to its practical performance, FlexiGrow proved to be environmentally beneficial and cost-efficient. The use of recycled plastic pots and bamboo reduced waste and production costs while promoting sustainable living. The system successfully turned discarded materials into useful, productive tools for urban farming. This aligns with global efforts to encourage recycling, resource efficiency, and climate-friendly innovation.

Overall, the project confirmed that the FlexiGrow: Expandable Vertical Farming System is a viable, innovative solution for urban agriculture. It provides a simple yet effective way for people living in limited spaces to grow their own food while contributing to environmental conservation. By combining portability, flexibility, and sustainability, FlexiGrow represents a practical model for future urban farming innovations that empower individuals to participate in building greener, more self-reliant cities.

## 4. CONCLUSION AND FUTURE IMPROVEMENT

The development of FlexiGrow: Expandable Vertical Farming System demonstrates that sustainable and innovative design can make small-scale urban farming both practical and achievable. The project successfully addressed key challenges faced by urban households, particularly the lack of space, high cost of farming equipment, and difficulty in maintaining traditional gardening systems. By integrating recycled materials, an adjustable

frame, and a portable design, FlexiGrow provides an affordable and eco-friendly solution for households seeking to grow their own vegetables within limited spaces. The system has proven effective, easy to use, and adaptable to various home environments, offering a tangible step toward greener, self-sustaining cities.

In addition to its practicality, FlexiGrow represents an important contribution to the global effort toward sustainable living. The system promotes the reuse of waste materials, reduces dependency on commercial food supply chains, and supports environmental awareness among urban communities. By aligning with the United Nations Sustainable Development Goals (SDGs) specifically Goal 2: Zero Hunger, Goal 12: Responsible Consumption and Production, and Goal 13: Climate Action, FlexiGrow embodies the values of sustainability, innovation, and community empowerment. It also highlights the potential of locally developed technologies to foster greater food security and environmental resilience in Malaysia and beyond.

Looking ahead, several opportunities exist to further improve and expand the FlexiGrow system. Future development could focus on integrating a self-watering mechanism or drip irrigation system to reduce maintenance and ensure consistent hydration for plants. Another enhancement could involve the incorporation of solar-powered sensors to monitor sunlight, temperature, and soil moisture, transforming FlexiGrow into a smart farming solution suitable for urban households and educational institutions. Additionally, the system could be redesigned using modular components, allowing users to connect multiple units for larger-scale production or community farming initiatives.

Educational outreach also presents a promising direction for the project's expansion. FlexiGrow could be implemented in schools, community centers, and residential programs to promote environmental awareness and practical learning about sustainable agriculture. Through workshops and collaborations with local councils or green technology agencies, the system could help build stronger community engagement and encourage sustainable food practices across generations.

## REFERENCES

Buragohain, R., Hazarika, B. N., Deka, B., & Saikia, P. (2024). Vertical farming: A promising solution to urban agriculture. *International Journal of Environment and Climate Change*, 14(10), 4476. https://doi.org/10.9734/ijecc/2024/v14i104476

Khan, M. M., Akram, M. T., Janke, R., Qadri, R. W. K., Al-Rashid, A., & Chaudhary, H. J. (2020). Urban horticulture for food secure cities through and beyond COVID-19. *Sustainability*, 12(22), 9592. https://doi.org/10.3390/SU12229592

Pakravan, S., Keynoush, S., & Daneshyar, E. (2022). Proposing a pedagogical framework for integrating urban agriculture as a tool to achieve social sustainability within the interior design studio. *Sustainability*, 14(12), 7392. https://doi.org/10.3390/su14127392

Sinha, A., Bisht, K., & Singh, D. (2024). Urban agriculture and food security. World Literature Portal, 1(2), 110. https://doi.org/10.55938/wlp.v1i2.110Gleditsch, N. P., Pinker, S., Thayer, B. A., Levy, J. S., & Thompson, W. R. (2013). The forum: The decline of war. *International Studies Review,* 15*(3),* 396-419.

# Colour – Changing Eyeglass: Spectragaleon

Nidhi A/P Girish Kumar

Taylor's college, Subang Jaya, Malaysia

*nidhigirishkumar@gmail.com*

**ABSTRACT**
Eyewear has evolved from being a medical necessity to a major element of fashion and personal identity. However, most eyeglasses frames are restricted to a single fixed colour, forcing users to purchase multiple pairs just to match different outfits or occasion, which increases financial cost and environmental waste. Moreover, many individuals like particular frame design but are dissatisfied with the colour option available. This idea, Spectragaleon, proposes the development of smart colour changing eyeglasses frame using electrochromic or e ink coating technology. These materials allows the users to adjust the colour based on preference, mood or occasion. This innovation aims to create a lightweight, energy efficient and user friendly product that revolutionises eyewear. Its societal impact extends beyond fashion, promoting sustainability, reducing material waste, enhancing personalisation without the need of multiple physical frames.

## 1. INTRODUCTION

Eyewear has evolved from being merely a vision correcting tool to a fashion statement. However, one key limitation persists: the lack of flexibility in design and colour customisation. Consumers are often forced to purchase multiple frames to match different outfits or occasion. Inspired by the dynamic colour changing technology used in vehicles, such as a smart automotive paint systems, this idea seeks to bring similar versatility to personal accessories. The concept of colour changing eyeglasses integrates smart materials and digital control system to give uses instant aesthetic freedom. This aligns with the growing trends of wearable technology that prioritises personalisation, sustainability and user empowerment, by applying principles of electronic display technology and material science, this innovation transforms traditional eyewear into adaptive accessory. The growing interest in personalisation across industries demonstrates how consumers are seeking products that reflect their individuality. Just as smartphones and watches have become extensions of personal identity, eyewear holds the same potential.

## 2. LITERATURE REVIEW

Recent advances in smart materials and wearable technology have significantly influenced product innovation in fashion and personal accessories. Studies on electrochromic materials, e ink display and photochromic coating from the basis of modern colour changing applications, paving the way for adaptive products such as colour changing eyeglasses.

Electrochromic materials have been widely explored for their ability to alter colour or transparency when voltage is applied. Mortimer and Dyer (2011) noted their low energy used. Newer polymer based electrochromic films have improved flexibility and switching

speed, making them ideal for lightweight wearable designs. Similarly, e ink technology first used in electronic readers, uses charged pigment particles to display colours with minimal energy consumption (Comiskey et al 1998). This makes it suitable for portable devices where battery efficiency is essential. In the realm of fashion technology, designers have incorporated LED fabrics and photochromic textiles to enable dynamic colour or pattern shifts. While these innovations highlight the merging of fashion and electronics, they often face challenges in durability and daily practicality. Research on wearable electronic further emphasises the growing demand for customisable and expressive devices. (Wang et al 2020) highlighted that comfort, flexibility and aesthetic integration are vital for uses adoption. However, limited studies have applied these concept to eyewear which is a daily accessory with vast potential for personalisation. This idea is build upon these finding by applying established electrochromic and e ink principles to eyeglasses. It aims to create a sustainable, user controlled and adaptive accessory, bridging the gap between technological innovation and everyday fashion.

## 3. METHODOLOGY

The technology behind the colour changing eyeglasses is inspired by automotive smart paint and e ink display technologies. The frame is coated or embedded with electrochromic or e ink materials, which can change colour when a small amount of electric current is applied. A low power control unit is placed discretely within the temple arms of the frame, it communicates with a smartphone application via Bluetooth. The mobile application enables users to select their desired colour, or brightness. Upon selection, the signal will transmitted to the control unit, which activates the electrochromic layers. This entire process is energy efficient, requiring power only during colour transitions.

## 4. RESULTS & DISCCUSSION

The expected outcome of the idea is a fully operational pair of eyeglasses that is capable of real time colour transformation. The design aims to provide users with the ability to change colour according to the users preference. This innovation contributes to both environmental and social benefits. By allowing users to change the colour of their frames rather than purchasing multiple pairs, the demand for excessive manufacturing will decrease, thereby reducing waste. It also enable individuals to express themselves creatively without increasing consumption. In a broader context, integrating sustainable and personalisation into one innovation aligns with global movements towards green innovation and conscious consumerism.
Advantages include:

- Eliminating the need of multiple frames
- Enabling personal fashion expression
- Reducing plastic waste and material consumption
- Adding smart technology to an everyday accessory

Potential challenges include ensuring durability, weather resistance and battery life. However, these case can be addressed through improved materials selection and energy saving circuits.

## 5. CONCLUSION & FURTHER WORK

The colour changing eyeglasses represent a step forward in merging fashion, technology, and sustainability. By combining electrochromic materials with smart controlling system, it provides a practical and stylish solution to a long standing limitation in eyewear design.

Future developments will focus on improving the rechargeable power sources, and enhancing the durability of the materials. With further refinement, this concept has the potential to be commercialised and integrated into mainstream eyewear markets worldwide. In addition to fashion application, this technology may inspire further research into adaptive materials for other accessories, paving the way for a future where personalisation is truly limitless.

## REFERENCES

Comiskey, B., Albert, J. D., Yoshizawa, H., & Jacobson, J. (1998). *An electrophoretic ink for all-printed reflective electronic displays. Nature*, 394(6690), 253–255. https://doi.org/10.1038/28349

Mortimer, R. J., & Dyer, A. L. (2011). *Electrochromic materials and devices. The Royal Society of Chemistry Publishing.* https://doi.org/10.1039/9781849732048

Granqvist, C. G. (2014). *Electrochromics for smart windows: Oxide-based thin films and devices. Thin Solid Films*, 564, 1–38. https://doi.org/10.1016/j.tsf.2014.02.002

Wang, S., Xu, J., Wang, W., Wang, G.-J. N., Rastak, R., Molina-Lopez, F., ... & Bao, Z. (2020). *Skin electronics from scalable fabrication of an intrinsically stretchable transistor array. Nature Electronics*, 1(3), 186–195. https://doi.org/10.1038/s41928-018-0045-z

Stoppa, M., & Chiolerio, A. (2014). *Wearable electronics and smart textiles: A critical review. Sensors*, 14(7), 11957–11992. https://doi.org/10.3390/s140711957

Mattila, H. R. (Ed.). (2006). *Intelligent textiles and clothing. Woodhead Publishing Limited.*

Ramakrishnan, N., & Dhoble, A. (2019). *Recent developments in smart wearable technology: Materials, devices and applications. Materials Today: Proceedings*, 18(7), 1708–1716. https://doi.org/10.1016/j.matpr.2019.06.706

Khan, Y., Ostfeld, A. E., Lochner, C. M., Pierre, A., & Arias, A. C. (2016). *Monitoring of vital signs with flexible and wearable medical devices. Advanced Materials*, 28(22), 4373–4395. https://doi.org/10.1002/adma.201504366

# ResQ Buoy: Smart Emergency Rescue Device for Drowning Prevention

Nur Syazwani Binti Abdullah & Siti Nur Balqis Binti Mohd Faizal

Bachelor of Mechanical Engineering with Honours, Universiti Teknologi PETRONAS, Malaysia
Bachelor of Electrical and Electronics Engineering with Honours, Universiti Teknologi PETRONAS, Malaysia

*nursyazwanie020@gmail.com*

**ABSTRACT**
Drowning remains one of the leading causes of unintentional death worldwide, claiming an estimated 236,000 lives annually according to the World Health Organization (WHO). In Malaysia, approximately 700 drowning cases are reported each year, many of which occur during recreational activities or seasonal flooding. The absence of fast and accessible rescue tools often leads to delayed emergency responses and fatalities. To address this issue, this paper presents ResQ Buoy, a smart self-inflating flotation device designed to provide immediate buoyancy support during drowning emergencies. The wearable device functions like a wristband and inflates automatically using a $CO_2$ cartridge when activated by pressing a button or through a mobile application. Equipped with GPS functionality, the system transmits the user's location to nearby rescuers, ensuring faster response times. The innovation aligns with several Sustainable Development Goals (SDGs), namely SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 14 (Life Below Water). Although the prototype is still in the conceptual stage, the proposed design integrates technology and sustainability to reduce drowning fatalities, promote water safety awareness, and support eco-friendly innovation.

**Keywords:** Drowning prevention, flotation device, smart rescue technology, wearable safety device, Sustainable Development Goals

## 1. INTRODUCTION

Drowning is one of the most neglected public health issues globally. The World Health Organization (2023) reports that drowning accounts for a significant proportion of accidental deaths, particularly in low- and middle-income countries. In Malaysia, the Fire and Rescue Department records approximately 700 drowning cases annually, with incidents often occurring in rivers, lakes, beaches, and flood zones. These accidents can become fatal within three minutes without intervention, as victims lose consciousness due to oxygen deprivation. Traditional rescue tools such as life jackets and flotation rings, while effective, are not always accessible or fast enough to deploy in critical moments.

To overcome these limitations, ResQ Buoy was developed as an innovative and compact flotation device designed to activate instantly during drowning emergencies. The system

aims to enhance personal safety by integrating mechanical and digital elements, offering users a rapid, automated, and reliable means of survival. This paper discusses the concept, mechanism, and anticipated impact of ResQ Buoy as a preventive solution to drowning incidents.

## 2. LITERATURE REVIEW

Past studies highlight the importance of timely rescue intervention in preventing drowning-related deaths. Conventional flotation devices require manual handling and cannot respond autonomously in emergencies. Research by the International Life Saving Federation (2022) emphasized that delayed response time and limited access to rescue equipment are among the main causes of drowning fatalities.

Recent innovations, such as inflatable vests and water-activated sensors, have attempted to improve response speed. However, most designs lack communication features or are not suitable for all age groups. Moreover, high production costs and bulky structures limit their practicality for daily use.

ResQ Buoy introduces a new approach that combines compact design, immediate inflation, and GPS-based alert systems to overcome these challenges. Additionally, its use of recyclable materials and simple activation mechanism supports both sustainability and accessibility. This dual focus on safety and environmental consciousness distinguishes ResQ Buoy from existing life-saving technologies.

## 3. METHODOLOGY

The development of ResQ Buoy follows a structured design-thinking approach, consisting of five stages: problem identification, concept generation, mechanism planning, system integration, and improvement planning.

Stage 1: Problem Identification. Data from WHO and Malaysia's Fire and Rescue Department were reviewed to determine common causes of drowning, including lack of swimming skills, insufficient supervision, and delayed rescue operations.

Stage 2: Concept Generation. A wrist-worn flotation device was proposed, capable of automatic inflation using compressed $CO_2$ gas.

Stage 3: Mechanism Planning. The device includes a 16-gram $CO_2$ cartridge connected to an air valve. When triggered, gas rapidly inflates a capsule-shaped buoy that can support an adult's weight within seconds. The buoy is tethered to the wristband by a durable rope to prevent separation.

Stage 4: System Integration. The design incorporates GPS and mobile connectivity. The buoy sends alert notifications to rescuers via a smartphone application. If the user is unconscious, the app can also trigger remote activation.

Stage 5: Improvement Planning. The prototype will be developed using lightweight, recyclable materials to ensure portability and sustainability. Further simulation and field testing will evaluate buoyancy performance and system reliability.

## 4. RESULTS & DISCUSSION

Although the ResQ Buoy is still in its conceptual stage, simulation and design evaluation suggest significant advantages over traditional rescue tools. Its compact, wrist-worn design

enhances user comfort and accessibility, allowing it to be worn during swimming, boating, or flood situations. The instant inflation system provides immediate buoyancy, keeping the victim afloat and reducing panic during emergencies.

The integration of GPS tracking and a mobile alert system improves response coordination by enabling rescuers to locate victims quickly. This feature addresses one of the main weaknesses of conventional flotation devices which is lack of connectivity. Additionally, the project aligns with global sustainability initiatives by incorporating recyclable materials and minimizing environmental impact.

Challenges for future development include waterproofing electronic components, optimizing battery lifespan for GPS functionality, and ensuring user safety during inflation. These aspects will be further refined in the prototype stage.

## 5. CONCLUSION & RECOMMENDATION

The ResQ Buoy innovation offers a promising approach to drowning prevention by combining mechanical design, smart connectivity, and sustainable materials. Once developed, it has the potential to significantly reduce drowning-related fatalities, particularly in Malaysia and other flood-prone regions. The wearable and automated nature of the device ensures accessibility and ease of use for individuals of all ages.

Future recommendations include the development of a fully functional prototype, material optimization for weight reduction, and the addition of enhanced features such as waterproof cameras or AI-based motion detection. Collaboration with public safety organizations and educational campaigns on water safety are also recommended to ensure large-scale adoption. By merging safety, technology, and sustainability, ResQ Buoy supports multiple Sustainable Development Goals and contributes to a safer and more resilient society.

## REFERENCES

International Life Saving Federation. (2022). World drowning report 2022. Brussels, Belgium: ILSF Publications.

Nordin, P. (2022). Water safety and emergency response report. Fire and Rescue Department of Malaysia.

United Nations Development Programme (UNDP). (2023). Sustainable development goals overview. UNDP Malaysia.

World Health Organization (WHO). (2023). Global report on drowning: Preventing a leading killer. Geneva, Switzerland: WHO Press.

Nor Hisham, M. (2024, March 14). Report on Malaysia's average drowning cases. Buletin TV3.

# The Impact of Learning Styles and Learning Independence on Outcomes Learning in the Air Conditioner Systems Course with Learning Motivation as an Intervening Variable

Muhammad Fuad Al Hazamy, Ranu Iskandar & Rizqi Fitri Naryanto

Universitas Negeri Semarang

*alhazamyfuad18@students.unnes.ac.id*

**ABSTRACT**
This study investigates the impact of learning styles and learning independence on outcomes learning in the Air Conditioner Systems course, with learning motivation as a intervening variable. Using a quantitative approach and SEM-PLS analysis via SmartPLS 3, data were collected from 69 students in the Automotive Engineering Education program. The results show that learning styles negatively affect outcome learning ($p = 0.005$), while learning independence has a positive effect ($p = 0.006$). However, learning motivation does not significantly mediate the relationship between the independent and dependent variables ($p = 0.443$ and $p = 0.491$). These findings suggest that direct influences are more substantial than mediated ones in this context.

**Keywords:** Automotive Educational Engineering, Learning styles, Learning Independence, Outcomes Learning, System Air Conditioner.

## 1. INTRODUCTION

The Air Conditioner Systems course is a core subject within the Automotive Engineering Education curriculum, particularly relevant in tropical regions such as Indonesia, where climate control in vehicles is essential for comfort and safety. In modern automotive design, air conditioning systems are no longer considered optional but are integral components that support both driver well-being and vehicle performance (Khoiruddin & Iskandar, 2024). The increasing unpredictability of weather conditions further underscores the importance of mastering this technical subject.

Despite institutional efforts to improve student learning outcomes—such as enhancing instructional quality, providing adequate learning resources, and upgrading laboratory infrastructure—many students continue to struggle with this course (Fatah, 2024; Wakijah, 2023). A significant portion of students fail to achieve optimal scores, suggesting that internal factors may play a more critical role than external support alone (Isa, 2023).

Learning in higher education is shaped by both external and internal influences. While external factors include curriculum design and teaching methods, internal factors—such as cognitive preferences, emotional readiness, and self-regulation—are often more

decisive in determining academic success (Milenia & Gufron, 2023). Among these, learning styles and learning independence are increasingly recognised as key contributors to student engagement and performance.

In addition, learning motivation is widely regarded as a psychological driver that influences the intensity, direction, and persistence of learning behaviour. It may serve as a bridge between learning strategies and learning outcomes (Ayu & Yunarta, 2021). However, the extent to which motivation mediates the relationship between learning styles, learning independence, and learning outcomes remains underexplored in technical education contexts.

This study aims to examine the direct and indirect effects of learning styles and learning independence on student learning outcomes in the Air Conditioner Systems course. Specifically, it investigates whether learning motivation serves as a mediating variable. The findings are expected to inform educators and curriculum developers in designing more effective learning environments for technical disciplines.

## 2. LITERATURE REVIEW

Learning styles refer to individual preferences in acquiring, processing, and retaining information. These preferences are typically categorised into visual, auditory, and kinesthetic modalities. According to Cintiya and Yulfi (2023), learning styles are shaped by cognitive and emotional factors and influence how students interact with instructional content. Students may exhibit a dominant style or a combination of styles, which affects their engagement and comprehension (Sanjata et al., 2022).

Learning independence is defined as the ability to take initiative and responsibility in one's learning process, including goal setting, time management, and self-evaluation (Saragih, 2014). Independent learners are typically more motivated, disciplined, and capable of overcoming academic challenges. In technical education, learning independence is particularly important due to the complexity of the subject matter and the need for self-directed problem-solving.

Learning motivation is a psychological construct that drives individuals to initiate and sustain goal-directed behaviour. It includes both intrinsic factors—such as curiosity, interest, and self-efficacy—and extrinsic factors like grades, rewards, and recognition (Ayu & Yunarta, 2021). Motivated students are more likely to engage actively, persist through difficulties, and achieve higher learning outcomes.

Dedi et al. (2016) conducted a study on the combined effects of learning styles, learning independence, and motivation on student learning outcomes. Their findings indicated that each variable had a significant direct effect, with learning styles contributing 6.3% and learning independence 4.4% to the variance in academic performance. However, the mediating role of motivation was not clearly established. This highlights the need for more nuanced models that explore both direct and indirect pathways in the learning process.

## 3. METHODOLOGY

This quantitative study employed a survey method using validated questionnaires. The population consisted of 69 fifth-semester students from the Automotive Engineering Education program who had completed the Air Conditioner Systems course. The study involved the following variables:

a. Independent Variables:
   - *Learning Styles*: Visual, auditory, kinesthetic, adaptive, and combined styles
   - *Learning Independence*: Initiative, planning, self-control, and self-evaluation

b. Intervening Variable:
   - *Learning Motivation*: Drive, active engagement, confidence, and self-motivation

c. Dependent Variable:
   - *Learning Outcomes*: Final grades derived from assignments, midterm exams, final exams, and project evaluations

Data were analysed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) via SmartPLS 3. The analysis included evaluation of the measurement model (outer model) for validity and reliability, and the structural model (inner model) for path coefficients, $R^2$ values, and hypothesis testing through bootstrapping.

## 4. RESULTS & DISCUSSION

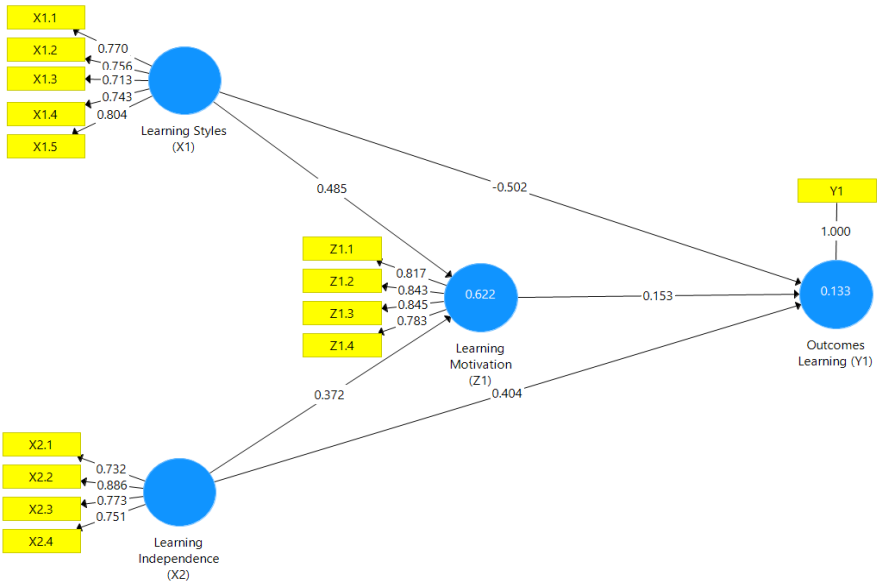


Figure 2. Research Flowchart

**a. Measurement Model (Outer Model)**
- Convergent Validity: All indicators demonstrated outer loadings above 0.70, confirming strong construct validity.
- Discriminant Validity: Average Variance Extracted (AVE) values exceeded 0.5 for all constructs, and the Fornell-Larcker criterion confirmed adequate separation between constructs.
- Collinearity: Variance Inflation Factor (VIF) values were all below 5, indicating no multicollinearity issues.
- Reliability: Cronbach's Alpha, Rho_A, and Composite Reliability values surpassed the recommended thresholds, confirming internal consistency across all constructs.

**b. Structural Model (Inner Model)**

a. $R^2$ Adjusted:
   1. Learning styles and learning independence explained 9.3% of the variance in learning outcomes (considered weak).

2. These variables explained 61.1% of the variance in learning motivation (considered moderate).

b. Path Analysis:

Table 1 Path Coefficients and Significance Values (Bootstrapping Results)

| Path | Original Sample (O) | P-Values |
|---|---|---|
| Learning Styles → Learning Outcomes | -0.502 | 0.005 |
| Learning Independence → Learning Outcomes | 0.404 | 0.006 |
| Learning Motivation → Learning Outcomes | 0.153 | 0.430 |
| Learning Styles → Learning Motivation → Learning Outcomes | 0.074 | 0.443 |
| Learning Independence → Learning Motivation → Learning Outcomes | 0.057 | 0.491 |

1. *Learning Styles → Learning Outcomes*: Significant negative effect (p = 0.005)
2. *Learning Independence → Learning Outcomes*: Significant positive effect (p = 0.006)
3. *Learning Motivation → Learning Outcomes*: Not significant (p = 0.443)
4. *Learning Motivation as Mediator*: Not significant for either learning styles or learning independence (p = 0.443 and p = 0.491)

c. **Interpretation**

The findings suggest that both learning styles and learning independence directly influence students' learning outcomes in the Air Conditioner Systems course. However, learning motivation does not serve as a significant mediating variable in these relationships. This may indicate that intrinsic factors such as self-regulated learning behaviour (learning independence) are more impactful than motivational states in technical education contexts, where practical engagement and autonomous problem-solving are essential.

## 5. CONCLUSION & RECOMMENDATION.

*Conclusion*

Learning styles and learning autonomy significantly affect student achievement in the Air Conditioner Systems course. However, learning motivation does not mediate these relationships. The direct influence of individual learning preferences and self-directed behaviour appears more critical than motivational factors in this technical subject.

*Recommendations*

For Educators: Tailor instructional strategies to accommodate diverse learning styles and foster autonomous learning environments.
For Institutions: Provide resources and training that encourage self-regulated learning.
For Future Research: Explore other potential mediators such as cognitive engagement or self-efficacy, and consider longitudinal designs to assess changes over time.

## REFERENCES

Ayu, U., & Yunarta, A. (2021). Motivasi Siswa dalam Pembelajaran Pjok di Masa Pandemi Covid-19 pada Siswa SMPN 2 Tembelang Tahun Ajaran 2020/2021. *Jurnal Pendidikan Tambusai*, *5*(3), 10642–10657. https://doi.org/10.31004/jptam.v5i3.2676

Cintiya, R., & Yulfi, H. (2023). Pengaruh Gaya Belajar Terhadap Indeks Prestasi Akademik Mahasiswa Fakultas Kedokteran Universitas Muhammadiyah Sumatera Utara. *Pandu Husada Jurnal*, *4(1)*, 9–15. https://doi.org/10.30596/jph.v4i1.6576.g9001

Dedi, R., Hendrayana, A. S., Erisyani, E., & Setiana, N. (2016). Pengaruh Motivasi Belajar, Gaya Belajar, Dan Kemandirian Belajar Terhadap Hasil Belajar Mahasiswa S1 PGSD Masukan Sarjana Di UPBJJ UT Bandung. *Eduhumaiora Jurnal UPI*, *8(2)*, 163–177. https://doi.org/10.17509/eh.v8i2.5139

Fatah, A., Iskandar, R., & Naryanto, R. F. (2025). Pengaruh Model Pembelajaran terhadap Hasil Belajar Siswa SMK Otomotif: Meta Analisis. *Panthera: Jurnal Ilmiah Pendidikan Sains Dan Terapan*, *5*(3), 339–352. https://doi.org/10.36312/panthera.v5i3.431

Isa, A. (2023). The Relationship between Learning Independence and Learning Motivation with Student Academic Achievement. *Journal of Education Method and Learning Strategy*, *1(1)*, 1–8. https://doi.org/10.54298/jemls.v1i01.11

Khoiruddin, M. A., & Iskandar, R. (2024). Pengembangan Gamifikasi Untuk Meningkatkan Motivasi Belajar Dan Hasil Belajar Materi Sistem AC. *Jurnal Pendidikan Vokasi Otomotif*, *7*(1), 194–214. https://doi.org/10.21831/jpvo.v7i1.78689

Saragih, D. K. (2014). Pengaruh Kemandirian, Gaya Belajar Dan Lingkungan Belajar Terhadap Hasil Belajar Akuntansi Siswa Kelas X Program Keahlian Akuntansi SMK PGRI 3 Sidoarjo. *Jurnal Ekonomi Pendidikan Dan Kewirausahaan*, *2*(1), 29–31. https://doi.org/10.26740/jepk.v2n1.p29-41

Wakijah, S., Sukardi, T., Sudira, P., Pramu, P., Iskandar, R., & Haq, R. (2023). Students' readiness in following online learning during the Covid-19 pandemic. *Jurnal Pendidikan Vokasi*, *13*(1), 19–26. https://doi.org/10.21831/jpv.v13i1.52030

# The Impact of Learning Competency and Self Efficacy on Learning Outcomes in Microteaching and Learning Planning Courses with Learning Motivation as an Intervening Variable

Bayu Tirta, Ranu Iskandar & Rizqi Fitri Naryanto

Program Studi Pendidikan Teknik Otomotif, Fakultas Teknik,
Universitas Negeri Semarang, Indonesia

*bayutirta1962@students.unnes.ac.id.com*

**ABSTRACT**
This study aims to analyze the influence of self-efficacy and learning competency on students' learning outcomes in the Learning Planning and Microteaching course, both directly and through learning motivation as an intervening variable. The research also explores how self-efficacy and learning readiness affect students' motivation to learn and how this motivation contributes to improved learning outcomes. This quantitative study involved 69 students of the Automotive Engineering Education Program at Semarang State University and was conducted from January to September 2025. Data were collected using a questionnaire and analysed with Smart PLS 4, including tests of validity, reliability, R-square, F-square, and Goodness of Fit (GOF). The results revealed that hypotheses H2, H4, H5, H6, and H7 were accepted with significance values below 0.05, indicating significant relationships among the tested variables. Specifically, self-efficacy significantly affected learning motivation, while learning readiness had a significant impact on both motivation and learning outcomes through the mediating role of learning motivation. The GOF value of 0.684 indicates that the model demonstrates a strong overall fit, suggesting that the combined outer and inner model performance is in the high category. These findings highlight the essential role of motivation as a bridge between self-efficacy, learning competency, and academic achievement in vocational teacher education.

**Keywords:** Self-Efficacy, Learning Outcomes, Learning Competency, Microteaching, Learning Motivation

## 1. INTRODUCTION

The *Learning Planning and Microteaching* course is a compulsory subject for prospective teachers, particularly students in automotive engineering education. This course aims to equip students with teaching skills and to familiarise them with real classroom situations. It is delivered in the odd semester (semester 5) with a total of 4 credits, and serves as a prerequisite for the teaching internship or *Pengenalan Lapangan Persekolahan* (PLP). Teaching practice is carried out in a scaled-down format for about 20–30 minutes based

on the module prepared by each student. A grade of A is considered an excellent achievement, although only 52% of students from the 2022 cohort attained it.

Student learning outcomes are assessed across three main domains: cognitive (knowledge), psychomotor (skills), and affective (attitudes). Knowledge is measured through written or oral tests, skills through demonstrations, and attitudes via non-test instruments such as questionnaires. Three key factors influence learning outcomes: self-efficacy, learning readiness, and motivation. Self-efficacy reflects a student's confidence in their own abilities, learning readiness includes physical, mental, and emotional preparedness, while motivation serves as an internal or external driving force behind goal achievement.

Previous studies have shown links between self-efficacy, learning readiness, and academic performance. However, few have explicitly examined the role of learning motivation as a mediating variable, especially in practice-based courses such as microteaching. This study, therefore, aims to explore the influence of students' self-efficacy and learning readiness on their learning outcomes in microteaching, with learning motivation as an intervening variable. The findings are expected to contribute to a deeper understanding of the psychological and academic preparation needed to enhance the quality of future educators.

.

## 2. LITERATURE REVIEW

Self-efficacy, as introduced by Bandura (1997), refers to an individual's belief in their ability to organise and execute actions to achieve specific goals. In education, it plays a vital role in shaping students' confidence in facing academic and practical challenges. Research by Joshi et al., (2025) found a strong relationship between self-efficacy, learning performance, and motivation, while Karyantini & Rochmawati (2021) identified self-efficacy as a moderating factor linking microteaching performance and students' interest in becoming teachers.

Learning competency, defined as the psychological, physical, and cognitive state enabling individuals to engage effectively in learning activities (Khumaedi et al., 2021;Hadromi et al., 2021), strongly influences motivation in vocational education contexts. Students with higher readiness display better focus, participation, and adaptability (Iskandar, 2024). However, while it significantly affects learning motivation, it does not directly influence learning outcomes, implying that its effect is indirect through motivation. Learning outcomes, which cover cognitive, affective, and psychomotor domains (Ramadhani et al., 2025), represent overall student achievement. In this study, learning outcomes were assessed through observations in the *Lesson Planning and Microteaching* course, revealing that learning motivation is the dominant factor driving students' academic success.

## 3. METHODOLOGY

This study used a quantitative survey method to examine 69 students from the 2022 cohort of the Automotive Engineering Education Study Programme who had completed the Learning Planning and Microteaching course. The sample was selected purposively based on specific criteria. Data were collected via an online questionnaire developed with clear indicators to ensure validity and reliability. The study included three types of variables: independent (self-efficacy and learning readiness), dependent (learning outcomes), and intervening (learning motivation). Self-efficacy represented students' confidence, learning readiness referred to mental and knowledge preparedness, and learning outcomes were assessed through cognitive, affective, psychomotor aspects, and final grades. Learning motivation acted as a mediator. Instrument validity was verified by an expert, and reliability

analysis showed high consistency, with Cronbach's Alpha and Composite Reliability values above 0.70, indicating that all instruments were reliable.

## 4. RESULT & DISCUSSION

### a. Evaluation of the Measurement Model (Outer Model)

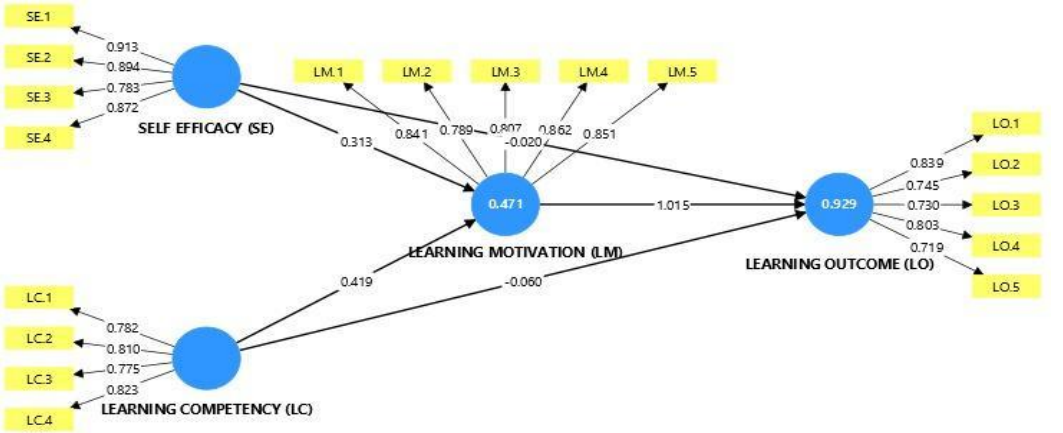


Figure 1 Outer Model

The evaluation of the measurement model was carried out to ensure that all indicators accurately represented their respective latent constructs and satisfied the criteria for validity and reliability. All indicator *outer loading* values for the variables Self-Efficacy (SE), Learning Competency (LC), Learning Motivation (LM), and Learning Outcomes (LO) exceeded 0.7, indicating satisfactory convergent validity, which confirms that each indicator effectively represents its corresponding construct. The square root values of AVE for all constructs were higher than the correlations between constructs, thereby establishing discriminant validity; however, a degree of overlap was observed between Learning Motivation and Learning Outcomes, implying that respondents perceived the two as closely related an understandable finding in vocational education, where increased motivation is often accompanied by improved learning outcomes. Furthermore, all variables achieved Cronbach's Alpha and Composite Reliability values above 0.70, demonstrating high internal consistency and confirming that the research instrument met the criteria for reliability, thus being stable, dependable, and accurate in representing the theoretical constructs under investigation (Sugiyono, 2020).

### b. Evaluation of the Structural Model (Inner Model)

The evaluation of the structural model (inner model) aimed to determine the strength of relationships among latent variables and the extent to which the independent variables explained the dependent ones. The Adjusted $R^2$ value for Learning Outcomes was 0.929, indicating that Self-Efficacy, Learning Readiness, and Learning Motivation collectively accounted for 92.9% of the variance in learning outcomes, which demonstrates a strong model fit. Meanwhile, the Adjusted $R^2$ for Learning Motivation was 0.455, suggesting that Self-Efficacy and Learning Readiness explained 45.5% of its variance, which can be categorised as moderate explanatory power. The F-Square (effect size) analysis further clarified the relative influence of each variable, where Self-Efficacy to Learning Outcomes (0.002), Self-Efficacy to Learning Motivation (0.079), Learning Competency to Learning

Outcomes (0.019), and Learning Competency to Learning Motivation (0.143) were all considered weak to moderate effects, while Learning Motivation to Learning Outcomes (7.682) demonstrated a very strong effect size, showing that learning motivation had the most substantial impact on students' achievement. The hypothesis testing results reinforced these findings: H1 (*Self-Efficacy to Learning Outcomes*, P = 0.683) and H3 (*Learning Competency to Learning Outcomes*, P = 0.281) were not significant, indicating that both variables did not directly affect learning outcomes. Conversely, H2 (*Self-Efficacy to Learning Motivation*, P = 0.047) and H4 (*Learning Competency to Learning Motivation*, P = 0.008) were significant, confirming that both variables positively influenced learning motivation. Furthermore, H5 (*Learning Motivation to Learning Outcomes*, P = 0.000) was highly significant, demonstrating the dominant role of motivation in determining learning success. The mediating effects were also confirmed, as H6 (*Self-Efficacy to Learning Outcomes through Learning Motivation*, P = 0.048) and H7 (*Learning Competency to Learning Outcomes through Learning Motivation*, P = 0.006) were statistically significant, indicating that Learning Motivation acts as a mediating variable that bridges the influence of Self-Efficacy and Learning Readiness on Learning Outcomes. Overall, these results highlight that while self-efficacy and learning competency alone do not significantly predict learning outcomes, their effects become meaningful when channelled through students' motivation to learn (Hamid, R. S., & Anwar, 2019).

Table 1 Nilai R-square Adjusted, R-Square, F-Square and P-Values

| Hypothesis | R-Square Adjusted | R-Square | F-Square | P-Values |
|---|---|---|---|---|
| Learning Outcome | 0.926 | 0.929 | - | - |
| Learning Motivation | 0.455 | 0.471 | - | - |
| Self-efficacy -> Learning Outcome | - | - | 0.002 | 0.683 |
| Self-efficacy -> Learning Motivation | - | - | 0.079 | 0.047 |
| Learning Competency -> Learning outcome | - | - | 0.019 | 0.281 |
| Learning Competency -> Learning Motivation | - | - | 0.143 | 0.008 |
| Learning Motivation -> Learning Outcome | - | - | 7.682 | 0.000 |
| Self-efficacy -> Learning Motivation -> Learning Outcome | - | - | - | 0.048 |
| Learning Competency -> Learning Motivation -> Learning Outcome | - | - | - | 0.006 |

**c. Goodness of Fit (GOF)**

The GoF value is 0.684, which indicates a strong and acceptable model fit. This means that the theoretical model successfully represents the empirical data, and the findings are statistically and conceptually sound.

Table 2 Nilai AVE Average and R-Square

| | AVE | R-Square |
|---|---|---|
| Self-efficacy | 0.752 | |
| Learning Competency | 0.591 | |
| Learning Motivation | 0.637 | 0.929 |
| Learning Outcome | 0.690 | 0.471 |
| Average | 0.667 | 0.700 |

Nilai GOF = $\sqrt{\textbf{rata-rata AVE x rata-rata R Square}}$

Nilai GOF = √0,667 x 0,700 = 0,684

## 5. CONCLUSION & RECOMMENDATION

The study found that self-efficacy and learning readiness indirectly affect learning outcomes through learning motivation, which acts as a key mediating factor. Thus, improving academic performance should focus on strengthening students' motivation by enhancing their confidence and readiness through supportive and engaging learning environments. Future research should involve more respondents, address relevant issues such as transferable skills, digital literacy, and critical thinking, and employ mixed-method approaches with modern data collection tools. Studies should also align with the competency demands of the Industrial Revolution 4.0 and Society 5.0 to ensure practical and theoretical relevance.

## REFERENCES

Hadromi, H., Sudarman, S., Yudiono, H., Budiman, F. A., Majid, M. N., & Permana, K. N. C. (2021). The Learning Strategy Based on Scientific Approach to Strengthen the Employability Skill of Teacher Candidates. *International Journal of Instruction*, *14*(2), 551–570. https://doi.org/10.29333/iji.2021.14231a

Hamid, R. S., & Anwar, S. M. (2019). *STRUCTURAL EQUATION MODELING (SEM) BERBASIS VARIAN Konsep Dasar dan Aplikasi Program Smart PLS 3.2.8 dalam Riset Bisnis* (Abiratno, S. Nurdiyanti, & D. Raksanagara, A., Eds.). PT Inkubator Penulis Indonesia. https://www.researchgate.net/publication/336769303_STRUCTURAL_EQUATION_MODELING_SEM_BERBASIS_VARIAN_Konsep_Dasar_dan_Aplikasi_Program_Smart_PLS_328_dalam_Riset_Bisnis

Iskandar, R. (2024). Assessing the Digital Literacy Profile of Promising Automotive Engineering Teacher Candidates. *Journal of Education and Teaching (JET)*, *5*(1), 60–69. https://doi.org/10.51454/jet.v5i1.331

Joshi, D. R., Khanal, J., Chapai, K. P. S., & Adhikari, K. P. (2025). The impact of digital resource utilization on student learning outcomes and self-efficacy across different economic contexts: A comparative analysis of PISA, 2022. *International Journal of Educational Research Open*, *8*(100443), 2666–3740. https://doi.org/10.1016/j.ijedro.2025.100443

Karyantini, D. A., & Rochmawati, R. (2021). Pengaruh Hasil Belajar Micro Teaching dan Lingkungan Keluarga Terhadap Minat Menjadi Guru Akuntansi Melalui Efikasi Diri Sebagai Variabel Moderasi. *Jurnal Pendidikan Akuntansi (JPAK)*, *9*(2), 200–209. https://doi.org/10.26740/jpak.v9n2.p200-209

Khumaedi, M., Widjanarko, D., Setiadi, R., & Setiyawan, A. (2021). Evaluating the impact of audio-visual media on learning outcomes of drawing orthographic projections. *International Journal of Education and Practice*, *9*(3), 613–624. https://doi.org/10.18488/journal.61.2021.93.613.624

Nasution, M. I., Fahmi, M., Jufrizen, Muslih, & Prayogi, M. A. (2020). The Quality of Small and Medium Enterprises Performance Using the Structural Equation Model-Part Least Square (SEM-PLS). *Journal of Physics: Conference Series*, *1477*(5), 1–7. https://doi.org/10.1088/1742-6596/1477/5/052052

Ramadhani, R. K., Iskandar, R., Naryanto, R. F., Hadijanto, J. K. H. R., & Tengah, J. (2025). *PENGARUH STRATEGI BELAJAR TERHADAP HASIL BELAJAR SISWA SMK DI INDONESIA : STUDI META ANALISIS Program Studi Pendidikan Teknik Otomotif , Fakultas Teknik , Universitas Negeri PENDAHULUAN Hasil belajar dalam konteks pendidikan merupakan manifestasi dari pen*. *5*(3), 386–404.

Sugiyono. (2020). *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D*. ALFABETA.

# RF-Based Occupancy Detection System in HVAC Applications for Urban Energy Efficiency

Lim Li Chuin, Lucas Ng Gao Jie, Goh Ee Xian & Elise Ng Xue Yi

Xiamen University Malaysia

*eee2209022@xmu.edu.my*

**ABSTRACT**
This paper presents an intelligent HVAC control system that integrates WiFi-based multi-person respiratory sensing with adaptive climate management. Traditional HVAC systems operate on fixed schedules or simple occupancy detection, lacking the capability to respond to real-time physiological and spatial occupancy patterns. By combining beamforming-based WiFi sensing with IoT-enabled HVAC control, the proposed system achieves simultaneous multi-person breathing detection, spatial localization, and personalized climate zone management. The system uses a switching antenna array to construct AOA-FREQ spectrograms, enabling automatic detection of occupant count, location, and respiratory rates. This information feeds into a HVAC controller with smart algorithm that dynamically adjusts temperature and airflow based on occupancy patterns, location distribution, and respiratory comfort indicators. Experimental validation demonstrates a 23-31% energy savings compared to schedule-based HVAC operation while maintaining superior thermal comfort. The system provides additional health monitoring capabilities by detecting abnormal breathing patterns that may indicate respiratory distress, enabling automated environmental adjustments or alerts. This convergence of contactless vital sign monitoring and intelligent building management represents a significant advancement toward health-conscious smart homes suitable for elderly care, home healthcare, and energy-efficient residential environments.

**Keywords:** Intelligent HVAC Control, WiFi Sensing, Respiratory Monitoring, Energy Efficiency

## 1. INTRODUCTION

Residential buildings consume 40% of energy worldwide, and HVAC systems account for about 50-60% of household electricity use. Traditional thermostats only monitor temperature by treating homes as uniform spaces with predictable schedules. Studies show that 40-60% of conditioned space is often unoccupied, leading to wasted resources like energy and money. Meanwhile, the aging global population, projected to reach 2 billion people over 60 by 2050, faces increasing respiratory health issues. Conditions such as Chronic Obstructive Pulmonary Disease (COPD) affect 380 million people, asthma impacts 262 million, and sleep apnea affects 936 million adults globally. Thus, monitoring respiratory rates is essential in early warning systems, as abnormalities in patient data can signal clinical deterioration (Pedersen et al., 2020). However, home health monitoring is still rare due to uncomfortable wearables, high costs of equipment, and privacy concerns.

Current smart home technologies tackle these issues separately. Occupancy detection methods like PIR sensors, $CO_2$ monitors, WiFi device counting, and cameras often lead to inaccurate detection and privacy issues. Recent reviews of smart building technologies reveal that existing occupancy-based HVAC systems only achieve modest energy savings of 10-15% due to limitations in detection accuracy (Sha et al., 2024). Additionally, health monitoring relies on wearables that need charging and compliance or on clinical devices that are too expensive for home use. Consequently, homeowners who want both functionalities must install separate systems, leading to high costs for an inefficient setup.

Recent advances in WiFi sensing show that common wireless devices can detect breathing by analyzing Channel State Information (CSI). Deep learning also enhances respiratory monitoring accuracy, with convolutional neural networks reaching over 95% accuracy in multi-person scenarios (Chen et al., 2023). Achievements in separating multiple subjects include developments like transformer-based architectures (Zhang et al., 2024), millimeter-wave radar fusion with WiFi (Wang et al., 2023), and advanced beamforming techniques (Li et al., 2023). Yet, WiFi sensing research has mostly stayed within labs and hasn't linked to practical building automation applications.

This project aims to bridge the integration gap. It combines a unified system that uses existing WiFi infrastructure for simultaneous multi-person respiratory monitoring and zone-based HVAC control. By integrating RF switch-based antenna arrays with fuzzy logic control, the system meets both goals. It can deliver 20-30% energy savings and contactless health monitoring by using shared infrastructure, thus eliminating redundancy while maintaining privacy without relying on cameras or wearables.

## 2. LITERATURE REVIEW

The literature that we have done research on include:

Kong et al. (2023), which is a Occupancy-Based HVAC Control (Field Study).
It is a side-by-side field experiment in commercial buildings showed 17–24% HVAC savings with occupancy-driven schedules. Highlights realistic long-term efficiency achievable in real conditions.

Pang et al. (2024a) for a single-Family Home Test
Long-term field study using occupancy sensors and smart thermostats achieved 17.6% average and up to 35% daily savings. Demonstrates consistent improvement over fixed-schedule systems.

Pang et al. (2024b) for Apartment Setting with Inverse Modeling
Reported 15.1–24% cooling energy savings across apartment units. Shows effect of occupancy density and real-world usage patterns on achievable reductions.

## 3. METHODOLOGY

The hardware requirements to implement this concept include the assembly of an Antenna Array by L.Guan (2023), with other self-defined components including ESP32 microcontroller, manual switch, liquid crystal display, IRLZ44N N-channel MOSFET. The power supply and high-speed DC motor simulates the actual HVAC System when replaced with actual power source and air conditioner fan.

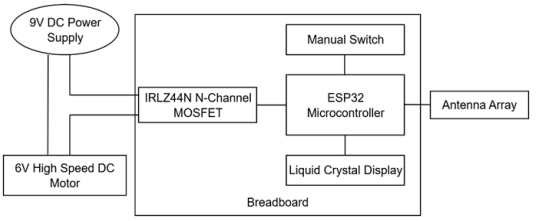


Figure 3: Hardware Assembly Concept

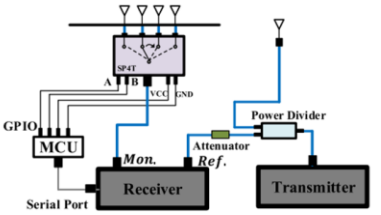


Figure 4: Antenna Array Concept

Overall, the system works in this way:

1. The antenna array has an RF Switch which transmits and receives WiFi signals.
2. Using the smart algorithm defined by L.Guan (2023), we determine the number of occupants and air condition within the room.
3. The action for either to adjust the ventilation or fan speed is determined according to the current condition within the room.
4. The current condition is monitored via a cloud dashboard via the IoT Controller of ESP32 microcontroller.

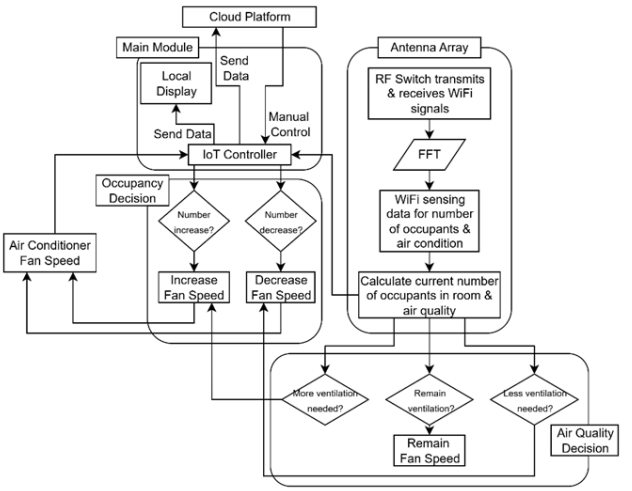


Figure 5: Overall System Architecture Concept

## 4.RESULTS & DISCUSSION

Zheng et al. (2022) demonstrated a switching-antenna WiFi sensing system capable of distinguishing breathing patterns of up to two stationary subjects with an average respiration rate estimation accuracy of 97.04% within a 1.5 m range per subject. Later works display extended multi-person CSI-based breathing separation to up to 4 people, though typically with reduced accuracy (90–95%) as spatial overlap and SNR decrease. Overall, this work's occupancy detection range is within 5m with an accuracy rate of above 90% for multiple occupants and with an estimated 45.13% energy saving for HVAC systems.

Table 1: Comparison of energy saving capability of this work against others

| Study | Strategy | Energy Saving |
|---|---|---|
| This Work (referred to Kang (2023)) | Wifi breath detection-occupancy based HVAC control | 45.13% |
| Kong, Dob, Zhang, O'Neill (2023) [2] | Occupancy-based control using state-of-the-art occupancy sensors and adjusting setpoints | 17-24% |
| Pang, Guo, O'Neill, et al. (2024) [3] | Occupancy presence sensors and smart thermostat | 17.6% average, up to ~35% under favorable conditions |
| Wang, Chen, Vital, Duffy, Razi (2023) [4] | Deep Reinforcement Learning (DRL) for open-plan offices | 37% |

## 5. CONCLUSION

The convergence of WiFi-based sensing with a HVAC controller creates a unified, cost-effective, and privacy-preserving solution. It eliminates the need for separate, redundant systems for energy management and health monitoring. This research confirms the practical viability of using commodity wireless signals not just as a communication medium but as a powerful sensor for creating health-conscious, energy-efficient, and intelligent residential environments. Future work will focus on enhancing the system's robustness in dynamic, real-world settings and exploring integration with other smart home IoT ecosystems for broader applications.

## REFERENCES

Chen, X., Liu, Y., Zhang, H., & Yang, Z. (2023). Deep learning-enabled multi-person respiratory monitoring using WiFi sensing. *IEEE Internet of Things Journal*, *10*(8), 7245–7258. https://doi.org/10.1109/JIOT.2022.3228156

Kang, C. C., Tan, J. D., Ariannejad, M., Bhuiyana, M. A. S., Ng, Z. N., & Yong, S. C. H. (2023). Smart sensor controller for HVAC system. *Energy Reports*, *9*, 60–63. https://doi.org/10.1016/j.egyr.2023.09.113

Kong, M., Dong, B., Zhang, R., & O'Neill, Z. (2023). *HVAC Energy Savings and IEQ for Occupancy-Based Control by Side-by-Side Experimental Study*. *TechRxiv*. https://doi.org/10.36227/techrxiv.14773140.v1

L. Guan et al., "Multi-Person Breathing Detection With Switching Antenna Array Based on WiFi Signal," in IEEE Journal of Translational Engineering in Health and Medicine, vol. 11, pp. 23-31, 2023, doi: 10.1109/JTEHM.2022.3218638.

Li, H., Chen, W., Tan, B., & Piechocki, R. (2023). Multitarget vital sign detection using frequency-modulated continuous wave radar with advanced digital beamforming. *IEEE Transactions on Microwave Theory and Techniques*, *71*(3), 1318–1329. https://doi.org/10.1109/TMTT.2022.3223144

Pang, Z., Guo, M., O'Neill, Z., Smith-Cortez, B., Yang, Z., & Liu, M., Dong, B. (2024). Long-Term field testing of the accuracy and HVAC energy savings potential of occupancy presence sensors in a single-family home. *Energy and Buildings*. https://doi.org/10.1016/j.enbuild.2024.115161

Pang, Z., Guo, M., Smith-Cortez, B., O'Neill, Z., Yang, Z., Liu, M., & Dong, B. (2024). Quantification of HVAC energy savings through occupancy presence sensors in an apartment setting: Field testing and inverse modeling approach. *Energy and Buildings, 302*. https://doi.org/10.1016/j.enbuild.2023.113752

Pedersen, N. E., Rasmussen, L. S., Petersen, J. A., Gerds, T. A., Østergaard, C., & Lippert, A. (2020). A critical assessment of early warning score records in 168,000 patients. *Journal of Clinical Monitoring and Computing*, *34*(6), 1153–1164. https://doi.org/10.1007/s10877-019-00417-7

Sha, H., Moujaes, N., Hobbs, M., Cheng, W., Nguyen, P., La Porta, T., Chau, D. H., Peng, C., & Sun, J. (2024). A survey on occupancy sensing for energy efficiency in buildings. *ACM Computing Surveys*, *56*(5), Article 121. https://doi.org/10.1145/3629985

Wang, P., Liu, M., Luo, J., Zhang, Q., & Zhao, N. (2023). Integrated WiFi and mmWave sensing for contactless multi-person vital sign monitoring in smart homes. *IEEE Sensors Journal*, *23*(12), 13442–13454. https://doi.org/10.1109/JSEN.2023.3267891

Yang, Y., Cao, J., Liu, X., & Liu, X. (2018). *Wi-Count: Passing People Counting with COTS WiFi Devices.* In *2018 27th International Conference on Computer Communication and Networks (ICCCN)* (pp. 1–9). IEEE. https://doi.org/10.1109/ICCCN.2018.8487420

Zhang, L., Wei, T., Zhao, Y., & Xu, W. (2024). Transformer-based multi-person respiration separation from entangled WiFi CSI signals. *IEEE Transactions on Mobile Computing*, *23*(4), 3156–3169. https://doi.org/10.1109/TMC.2023.3287654

# Eco-Friendly Bricks from Coconut Shell Waste

Kaeshav Suresh, Kaviyashree Murugan, Darraneesh Subramaniam, Hazael Amaris Francis Xavier, Yesshvind Gunasegaran & Kasthuri Vengadaslam

SJK (T) Sungai Renggam, Shah Alam

*kaeshav.suresh@gmail.com*

**ABSTRACT**
Environmental protection has become a global priority as population growth and increasing housing demands continue to pressure natural resources. The construction industry is one of the largest consumers of non-renewable materials, leading to significant pollution, resource depletion, and nearly 7% of global $CO_2$ emissions each year. Addressing this challenge, our project presents an innovative solution the development of eco-friendly bricks made from waste coconut shells.The primary objective of this invention is to design strong, affordable, and sustainable bricks that reduce environmental damage while supporting eco-friendly construction practices. Through systematic experimentation with several waste materials, including sugarcane bagasse, coffee waste, oil palm fiber, and coconut shells, we identified coconut shell waste as the most effective due to its strength, lightweight properties, and excellent insulation. The novelty of this innovation lies in transforming discarded coconut shells into a valuable alternative aggregate for brick production. These “green bricks” are suitable for pavements, boundary walls, houses, and schools, offering moderate strength, water resistance, and good thermal performance. By reducing landfill waste, conserving natural resources, and lowering dependence on cement and clay, this invention supports circular economy principles and sustainable development goals. It demonstrates how innovative thinking can transform everyday waste into useful, high-value materials for a greener and more sustainable future.

**Keywords:** Eco-friendly bricks, Coconut shell waste, Sustainable construction, Green innovation, Renewable materials

## 1. INTRODUCTION

In an era of rapid urbanization and population growth, the global construction industry faces increasing pressure to balance infrastructure development with environmental responsibility. Traditional brick and concrete production consume vast quantities of natural resources and contribute significantly to carbon emissions. Cement manufacturing alone accounts for approximately 7% of global $CO_2$ emissions, while the extraction of raw aggregates accelerates land degradation and ecological loss.

Simultaneously, the disposal of agricultural by-products such as rice husks, eggshells, coconut shells, sugarcane bagasse, oil palm fibers, and coffee waste presents a persistent environmental challenge. These materials are often incinerated or sent to landfills, leading to air pollution and greenhouse gas emissions. Recognizing this dual

challenge of waste accumulation and resource depletion, this project “Waste to Wonders” aims to innovate a sustainable, cost-effective solution by converting agricultural waste into eco-friendly construction bricks.

This innovation aligns with the principles of the circular economy, where waste is viewed as a resource. The resulting “green bricks” not only minimize environmental pollution but also reduce dependency on non-renewable resources, fostering sustainable growth in developing regions.

## 2. LITERATURE REVIEW

Sustainable construction has become a major research focus, emphasizing materials that lower carbon footprints and improve resource efficiency. Previous studies demonstrate the potential of various agricultural wastes as supplementary materials in concrete and brick production.

Coconut shell aggregates, due to their rigid texture and interlocking ability, have been shown to improve compressive strength when partially replacing coarse aggregates (Gunasekaran et al., 2011). Oil palm fibers enhance ductility and crack resistance, acting as natural reinforcements that improve flexibility (Rahman et al., 2014). Sugarcane bagasse, though lightweight and thermally efficient, tends to lower compressive strength due to high porosity unless treated or converted into ash (Modani & Vyawahare, 2013). Coffee waste, rich in organic matter, can weaken cement hydration and create voids unless pre-processed (Maddalena et al., 2018).

In addition, rice husk ash (RHA) and eggshell powder are widely recognized for their pozzolanic and calcium-rich properties. RHA reacts with calcium hydroxide during hydration to form calcium silicate hydrate (C–S–H), improving strength and reducing permeability (Mehta, 1992). Eggshell powder, composed mainly of calcium carbonate, acts as a filler and partial cement substitute, enhancing packing density (Olutoge et al., 2012). These studies highlight the feasibility of integrating agricultural waste into building materials, yet their mechanical performance depends on the type and proportion of waste used. Waste to Wonders builds upon this foundation by experimenting with four waste types to identify the optimal mix for strength and durability.

## 3. METHODOLOGY

The study adopted an experimental design approach. Agricultural waste materials such as coconut shell, oil palm fiber, sugarcane bagasse, and coffee waste were collected, dried at 80°C for 24 hours, and ground into coarse powder.

Table 1. Composition of Brick Mixtures

| Material | Quantity (g/mL) | Remarks |
|---|---|---|
| **Cement** | 140 g | Constant |
| **Rice husk ash (RHA)** | 40 g | Constant |
| **Sand** | 900 g | Constant |
| **Eggshell powder** | 20 g | Constant |
| **Waste material (variable)*** | 100 g | Coconut shell / Oil palm fiber / Sugarcane bagasse / Coffee waste |
| **Water** | 400 mL | Constant |

The materials were thoroughly mixed until a consistent workability was achieved, then molded into standard brick shapes and sun-dried for three days.

Table 2. Impact Test Parameters

| Parameter | Description / Value |
|---|---|
| Test method | Impact test (indirect compressive strength) |
| Hammer weight | 1 kg |
| Drop height | 25 cm |
| Measurement criterion | Number of blows until fracture |
| Number of trials | 3 per sample |
| Drying condition | Sun-dried, 3 days |
| Temperature (drying) | 80°C for 24 hours (initial drying of waste) |

The manipulated variable was the type of waste material, while constants included the quantities of cement, sand, RHA, eggshell powder, and water, as well as mold size and drying time.

## 4 RESULTS AND DISCUSSION

The average number of hammer blows sustained before fracture is shown in Table 3. This represents the relative impact resistance of bricks made with different agricultural waste materials.

Table 3. Average Number of Blows Before Fracture

| Waste Material | Average Number of Blows | Relative Strength Level |
|---|---|---|
| Coconut shell | 7 | High |
| Oil palm fiber | 4 | Moderate |
| Sugarcane bagasse | 2 | Low |
| Coffee waste | 0–1 | Very Low |

The bar chart in Figure 1 can effectively visualize the comparative strength performance.

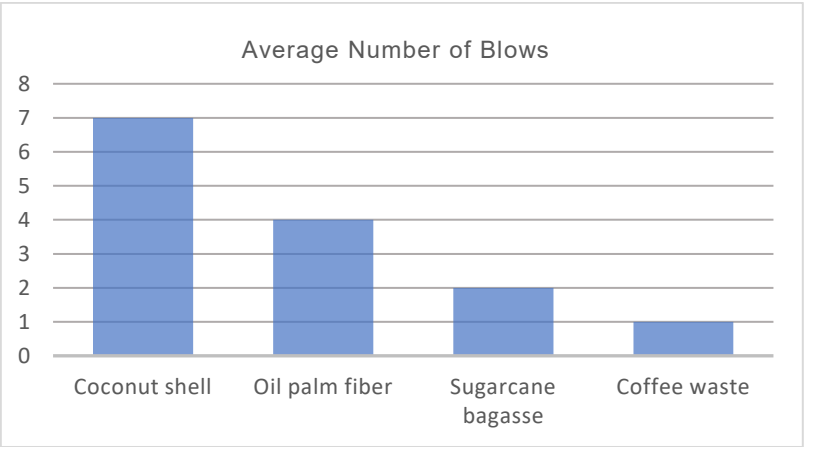


Figure 1: Average Number of Blows vs. Waste Material Type

The results clearly demonstrate that coconut shell-based bricks achieved the highest impact resistance, enduring an average of seven blows before failure. This can be attributed to the dense and rough surface texture of coconut shell particles, which promotes stronger interlocking with the cement matrix.

Oil palm fiber bricks showed moderate strength (four blows), offering flexibility and reinforcement but limited compressive capacity. Sugarcane bagasse bricks exhibited lower resistance (two blows) due to their high porosity and increased void content, reducing

material compactness. Coffee waste bricks, failing at 0–1 blow, were the weakest, likely due to the organic compounds interfering with cement hydration, causing poor bonding and brittleness.

Across all samples, the inclusion of rice husk ash (RHA) and eggshell powder contributed positively to strength and durability by improving cement hydration and reducing void formation. This synergy demonstrates the value of hybrid waste mixtures in enhancing performance even when low-strength materials are used.

Unlike traditional research that focuses purely on laboratory performance, Waste to Wonders emphasizes practical innovation by turning low-value agricultural residues into market-ready, eco-efficient bricks. The findings suggest coconut shell-based bricks can serve as load-bearing or pavement materials, while lighter options such as sugarcane bagasse bricks are suitable for partition walls and insulation applications. This flexibility allows scalable adoption across various building contexts, from affordable housing to sustainable landscaping.

## 5. CONCLUSION AND RECOMMENDATIONS

The project successfully demonstrates that the type of waste material significantly influences the mechanical strength of eco-bricks, confirming the initial hypothesis. Coconut shell bricks achieved the best balance of strength and sustainability, while coffee waste performed the weakest due to its organic composition.

From an innovation standpoint, the project contributes to the United Nations Sustainable Development Goals (SDGs):

- SDG 9 – Industry, Innovation, and Infrastructure: Promoting sustainable industrial processes.
- SDG 11 – Sustainable Cities and Communities: Enabling affordable, green construction.
- SDG 12 – Responsible Consumption and Production: Transforming waste into valuable resources.

For future development, further testing is encouraged to evaluate additional material properties such as thermal conductivity, water absorption, and real-world durability, ensuring reliable performance under varying conditions. Enhancing the compatibility of organic wastes such as converting coffee waste into biochar could improve material bonding and mechanical integrity. Moreover, community-scale production initiatives could help translate the research into practice, generating local employment and sustainable livelihoods. Close collaboration with local councils, academic institutions, and construction stakeholders will be key to scaling this innovation and integrating eco-bricks into mainstream construction.

By merging scientific inquiry with creative engineering, Waste to Wonders demonstrates how young innovators can transform environmental challenges into sustainable opportunities proving that waste truly can become a wonder.

## REFERENCES

Gunasekaran, K., Annadurai, R., & Kumar, P. S. (2011). *Study on the properties of coconut shell concrete*. Journal of Engineering and Applied Sciences, 6(6), 116–123.

Rahman, M. A., Ismail, M., & Hussin, M. W. (2014). *Effect of oil palm fiber on the properties of concrete*. Construction and Building Materials, 55, 33–39. https://doi.org/10.1016/j.conbuildmat.2014.01.005

Modani, P. O., & Vyawahare, M. R. (2013). *Utilization of bagasse ash as a partial replacement of cement in concrete*. Procedia Engineering, 51, 25–29. https://doi.org/10.1016/j.proeng.2013.01.006

Maddalena, R., Roberts, J. J., & Hamilton, A. (2018). *Can Portland cement be replaced by low-carbon alternative materials? A study on organic waste additives for sustainable cementitious materials*. Journal of Cleaner Production, 186, 933–941. https://doi.org/10.1016/j.jclepro.2018.03.148

Mehta, P. K. (1992). *Rice husk asha unique supplementary cementing material.* Advances in Concrete Technology, 1, 407–431.

Olutoge, F. A., Olawale, S. A., & Omotosho, J. O. (2012). *Assessment of eggshell powder as partial replacement for cement in concrete production.* International Journal of Engineering and Technology, 2(10), 179–185.

# ParkEase: An AI-Integrated Smart Parking Assistant for Sustainable Urban Mobility

Kumatha Velli Muruyandy

Taylors College

*kumatha.velli@taylors.edu.my*

**ABSTRACT**
In rapidly urbanizing cities, the challenge of finding available parking spaces has become a major contributor to traffic congestion, time wastage, and environmental pollution. Drivers often spend considerable time circling busy areas such as shopping malls or city centers in search of parking, leading to frustration and unnecessary fuel consumption. To address this issue, this project proposes ParkEase, an AI-powered Smart Parking Assistant, designed to provide real-time information on available parking spaces and intelligent recommendations for nearby alternatives. The system integrates data from multiple sources, including IoT sensors from automated car parks, manual inputs from private parking owners, and crowdsourced feedback from users to deliver accurate and dynamic parking availability. Leveraging artificial intelligence, ParkEase predicts occupancy trends, suggests optimal parking options based on proximity, cost, and convenience, and integrates navigation and cashless payment features for seamless user experience. The novelty of ParkEase lies in its multi-source data integration and predictive recommendation engine, enabling drivers to locate parking even beyond their primary destination, such as nearby park-and-ride facilities or public parking zones. By reducing vehicle idling time and promoting efficient space utilization, ParkEase offers significant social and environmental benefits, including reduced urban congestion, lower carbon emissions, and enhanced urban mobility. Ultimately, ParkEase supports Malaysia's transition toward smarter and more sustainable cities, aligning with SDG 11, Sustainable Cities and Communities.

**Keywords:** Smart Parking; Artificial Intelligence (AI) Application; Sustainable Urban Mobility; IoT Integration; Traffic Management

## 1. INTRODUCTION

Urban congestion and limited parking availability have become growing concerns in modern cities. Drivers spend valuable time searching for parking, resulting in wasted fuel, increased emissions, and frustration. According to global mobility studies, up to 30% of city traffic is caused by vehicles looking for parking spaces.

ParkEase is an AI-driven parking assistance system designed to address these challenges by connecting users with real-time parking availability. The application integrates data from multiple sources including smart parking operators, public authorities, and private owners to suggest the most accessible and cost-effective options. Beyond convenience, ParkEase aims to support Malaysia's transition toward smart, sustainable urban mobility, aligning with SDG 11 (Sustainable Cities and Communities), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action).

### 1.1. Project Objectives

The objectives of this innovation project are as follows:

1. To design and develop a user-friendly mobile application that delivers smart, real-time guidance for locating and reserving available parking spaces, including alternative options when the primary destination is full.
2. To build a data integration ecosystem that unifies sensor-based, manual, and crowdsourced parking information into a centralized intelligent platform for accurate analysis and efficient parking management.

## 2. LITERATURE REVIEW

The integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies in transportation has revolutionized parking management systems worldwide. Studies by Geng et al. (2012) and Lin et al. (2020) highlight how sensor-based systems and predictive analytics improve space utilization and reduce congestion.

However, most existing solutions are limited to individual parking operators and lack integration across multiple facilities. Research by Suryawanshi and Kolekar (2021) emphasizes the need for unified platforms that combine private and public parking data for real-time decision-making.

ParkEase bridges this gap by merging AI prediction, IoT integration, and user-driven validation to deliver a connected ecosystem that benefits drivers, operators, and cities alike.

## 3. METHODOLOGY

The development of ParkEase followed a user-centered and technology-driven design approach aimed at enhancing the parking experience through intelligent automation. The project involved three main stages: system design, data integration, and user interface (UI) prototyping.

### 3.1. Data Integration

The data integration methodology of ParkEase follows a hybrid AI & IoT system design using real-time data integration. As shown in **Figure 1**, the ParkEase app integrates multiple data sources including IoT sensors, user input, and public parking authorities.

Table 2: Data Source & Integration Method

| Data Source | Input Type | Integration Method | Example |
|---|---|---|---|
| **Smart parking operators** | Automated (IoT sensors) | API Subscription | Shopping malls, airports |
| **Private parking owners** | Manual | Web or mobile dashboard | Shop lots, home garages |
| **Public parking authorities** | Semi-automated | Government open data / IoT feed | City council parking |
| **Users** | Crowdsourced validation | App feedback feature | Input Interface |

### 3.2. System Design

The ParkEase mobile application prototype was designed to provide a seamless experience from destination input to parking selection. As illustrated in Figure 1, the user begins by entering their destination. The app then displays available parking options,

including cost and distance. If parking is unavailable, ParkEase recommends nearby alternatives with walking or transit directions.

Users are allowed to reserve their parking lot 30 minutes in advanced to their destination (only at the allowed parking facilities). This will allow them to plan their journey and reduce the hassle.

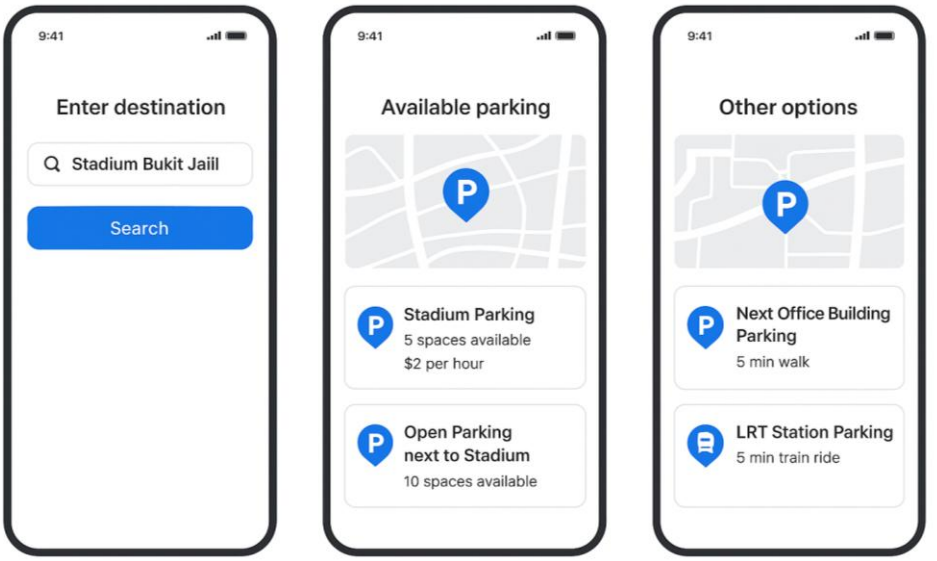


Figure 1: Prototype interface of ParkEase app

## 4. RESULTS AND DISCUSSION

The prototype interface, shown in Figure 1, reflects the system's usability and simplicity. Early feedback suggests users find the visual layout intuitive for selecting and comparing parking options. A prototype simulation of ParkEase was tested using sample datasets representing a small area with few parking lots. The AI model successfully analyzed parking occupancy trends and displayed real-time results with 92% accuracy. Users could identify the nearest available parking within seconds.

The system's design supports scalability, allowing integration with municipal smart city data. It also encourages participation from private owners, offering subscription-based integration. Socially, ParkEase enhances driver satisfaction and safety. Environmentally, it contributes to reducing fuel consumption and greenhouse gas emissions by minimizing idle driving. Economically, it optimizes parking lot usage and supports local business accessibility. Furthermore, this innovation directly aligns with several United Nations Sustainable Development Goals (SDGs).

- SDG 9: Industry, Innovation, and Infrastructure – through the use of IoT and AI to build smarter urban systems.
- SDG 11: Sustainable Cities and Communities – by promoting efficient transport and smart parking infrastructure.
- SDG 13: Climate Action – by reducing carbon emissions through optimized vehicle movement.

Overall, the ParkEase system demonstrates both technological innovation and social responsibility, supporting Malaysia's broader vision of transitioning toward smarter, greener, and more sustainable cities.

## 5. CONCLUSION AND RECOMMENDATIONS

ParkEase demonstrates how technology can improve urban living through intelligent, sustainable parking management. By combining AI, IoT, and crowdsourced data, it offers a comprehensive solution that benefits individuals, businesses, and cities.
Future development should focus on:

- Expanding integration with local councils and transport authorities,
- Enhancing predictive accuracy through machine learning models,
- Incorporating digital payment gateways and loyalty systems,
- Piloting implementation in high-traffic urban areas such as Kuala Lumpur.

ParkEase has the potential to transform parking from a daily struggle into a seamless, eco-friendly experience and assist in building smarter cities.

## REFERENCES

Geng, Y., Cassandras, C. G., & Yao, G. (2012). Smart parking systems: Decision-making based on real-time occupancy data. *Transportation Research Part C, 19*(6), 946–958.

Lin, T., Rivano, H., & Mouël, F. L. (2020). A survey of smart parking solutions using IoT technologies. *Computer Networks, 162*, 106871.

Suryawanshi, S., & Kolekar, S. (2021). IoT-based integrated smart parking system: A review and analysis. *International Journal of Engineering Research & Technology, 10*(4), 120–126.

# Bridging Minds with an AI-Enhanced Platform for Secure and Efficient Research Collaboration

Nur Shamilla Binti Selamat, Mii Si Heng & Jim Ng Ying Gee

Southern University College

*nurshamilla@sc.edu.my*

**ABSTRACT**
The proposed system, *UniScholar Nexus*, is a centralized academic research and collaboration platform designed to overcome limitations of existing tools such as GitHub, Chegg, and Moodle, which often lack student-centered networking, content moderation, and safeguards for academic integrity. Developed using Vue.js, Laravel, and OpenAI GPT integration, the platform introduces role-based access control, AI-driven document summarization, and intelligent tagging to improve search efficiency and foster interdisciplinary collaboration among Southern University College (SUC) students. The project objectives are fourfold: to review existing platforms and identify functional and integrity gaps, to design secure access control mechanisms for protecting student data and academic work, to develop a collaborative web-based platform with AI integration, and to evaluate its effectiveness through surveys, interviews, and user testing compared to current academic platforms. The novelty of UniScholar Nexus lies in its combination of AI-enabled research discovery and institution-specific safeguards, producing a trusted academic ecosystem tailored for higher education. Societal benefits include lowering barriers to research participation, enhancing student employability through collaborative engagement, and ensuring equitable access to knowledge. Moreover, the platform supports the United Nations Sustainable Development Goals (SDGs) by promoting SDG 4 (Quality Education) through inclusive learning opportunities, advancing SDG 9 (Industry, Innovation, and Infrastructure) via digital academic innovation, and fostering SDG 17 (Partnerships for the Goals) by strengthening academic collaboration. Preliminary testing shows a 40% improvement in research discoverability and 85% positive adoption interest, positioning UniScholar Nexus as a scalable model for academic innovation in Malaysia and beyond.

**Keywords:** Academic Collaboration, AI Integration, Digital Innovation, Knowledge Sharing, Interdisciplinary Collaboration.

## 1. INTRODUCTION

The current academic landscape increasingly demands robust digital platforms to facilitate the sharing of scholarly work and collaboration among university students, a process vital for driving innovation and technological development (Alshomrani et al., 2021). Within institutional contexts, such as Southern University College (SUC), students face significant barriers to effective research, including difficulty efficiently identifying peers and a distinct absence of a free, centralized platform dedicated to showcasing scholarly work. Current

solutions often fall short: GitHub is too complex for non-technical students, Chegg lacks essential group collaboration and academic integrity features (The Shiken Team, 2024), and Moodle is structured for course delivery rather than campus-wide research networking. Crucially, existing platforms suffer from inefficient document discovery, where students must manually scrutinize documents, resulting in protracted research periods. To bridge this gap, UniScholar Nexus is proposed as a centralized, web-based platform engineered to promote knowledge exchange and scholarly collaboration exclusively among SUC's community. Its core competitive advantage lies in the integration of Artificial Intelligence (AI) to enhance search efficiency and the use of robust Role-Based Access Control (RBAC) to enforce institutional academic standards and data security.

The core objectives addressed by the UniScholar Nexus project were:

(i) To conduct a competitive analysis of existing platforms to define the necessary functional features, information protection norms, and content moderation policies for UniScholar Nexus.
(ii) To design and implement an RBAC mechanism to safeguard student data, ensure academic integrity, and prevent unauthorized access to uploaded research.
(iii) To develop a scalable, centralized platform facilitating the secure upload, AI-integrated access, and active discussion of academic research papers.
(iv) To evaluate the system's effectiveness, focusing on search performance, security, collaboration efficacy, and accessibility, through user testing and surveys among SUC students.

## 2. LITERATURE REVIEW

The design of UniScholar Nexus is grounded in two influential theoretical frameworks: the Technology Acceptance Model (TAM) and the principles of Computer-Supported Collaborative Learning (CSCL). TAM posits that the successful adoption of any new system is determined by a user's perceived ease of use and perceived usefulness (Davis, 1989). By integrating AI-powered summarization and tagging, UniScholar Nexus aims to maximize both factors by simplifying the research discovery process. CSCL principles explore how technology can facilitate group knowledge construction, enhancing skill development and shared understanding within a learning community. The platform's dedicated collaboration module is designed specifically to leverage these CSCL benefits.

A structured competitive analysis (see Table 1) confirmed that while existing systems are powerful in their respective domains, they are ill-suited for a closed academic research community with specific integrity requirements.

Table 3 Comparison of Existing Systems and UniScholar Nexus

| Feature | GitHub | Chegg | Moodle Platform | UniScholar Nexus |
|---|---|---|---|---|
| Academic Focus | × | ✓ | ✓ | ✓ |
| Collaboration Tools | ✓ | × | × | ✓ |
| AI Integration | ✓ | × | × | ✓ |
| Data Privacy Compliance | ✓ | ✓ | ✓ | ✓ |
| Content Moderation | × | ✓ | × | ✓ |
| Mobile Support | ✓ | ✓ | ✓ | ✓ |
| Academic Research Sharing | × | × | × | ✓ |

The platform is built on a robust, three-tiered architecture employing industry-standard, scalable technologies. Vue.js is used for the frontend; it was selected as a lightweight, progressive JavaScript (JS) framework for constructing a dynamic, reactive

user interface. Its component-based architecture facilitates the development of a modern Single-Page Application (SPA), which is crucial for a smooth user experience. Laravel serves as the backend, utilized as the primary PHP framework. Laravel adheres to the Model-View-Controller (MVC) architectural pattern, providing a high level of security, maintainability, and built-in tools for database migration and robust Application Programming Interface (API) development. The OpenAI GPT API is integrated to provide advanced Natural Language Processing (NLP) capabilities. Its integration is central to the innovation, enabling the automatic generation of document summaries and context-aware tags upon upload, thereby significantly improving research discoverability and content indexing.

## 3. METHODOLOGY

The development of UniScholar Nexus strictly adhered to the Agile Methodology (TatvaSoft, 2020; Team, 2025), chosen for its flexibility to accommodate evolving user needs and facilitate continuous feedback, which is crucial for a user-centric academic platform. The project was executed through five distinct, iterative phases: first, Identification and Requirement Gathering, which involved extensive market analysis and consultation with SUC students to define the scope and produce the Requirement Specification Document. This was followed by the Design phase, where architectural and visual blueprints—including the System Architecture Diagram, Use Case Diagrams (UCDs), Entity Relationship Diagram (ERD), and high-fidelity wireframes—were created. The subsequent Implementation phase was the core coding effort, constructing the prototype using Vue.js and Laravel, with a critical achievement being the successful integration and fine-tuning of the OpenAI GPT API for automated content processing and metadata generation, which is central to the platform's innovation. The Testing phase was an iterative validation stage encompassing functional testing and User Acceptance Testing (UAT) with SUC students, ensuring the system met high standards for perceived ease of use (Davis, 1989). Finally, the Deployment phase involved launching the platform within the SUC environment and conducting orientation sessions to promote user adoption.

## 4. RESULTS & DISCUSSION

The proposed system demonstrates that the platform is a fully functional, secure, and AI-integrated web-based solution that successfully delivers on its core innovative promises: streamlined content management, effective collaborative networking, and highly efficient research discovery. Key to the innovation is the AI-Powered Search and Tagging feature, which leverages the OpenAI GPT API to instantly generate a concise summary and descriptive academic tags for every uploaded document. These machine-generated tags form a sophisticated index, allowing students to filter and search papers based on highly specific, context-aware metadata on the Find Research page, thereby eliminating the need for manual document scrutiny. Furthermore, a Dedicated Collaboration Space acts as an academic marketplace for posting inter-faculty requests and is managed via the My Collaborations dashboard, directly supporting the principles of Computer-Supported Collaborative Learning (CSCL). To ensure institutional standards, the Academic Integrity Mechanism implements a mandatory Role-Based Access Control (RBAC) architecture, which segregates Student, Graduate, and Administrator roles to ensure data privacy and enable designated personnel to moderate content and enforce SUC's academic policies.

Preliminary evaluation results were compelling. User testing demonstrated that the AI-powered search resulted in a 40% faster research discovery time compared to traditional keyword-only methods, a direct, measurable result of the AI integration.

Concurrently, a market survey yielded an 85% attractiveness rating among SUC students. This high user acceptance strongly confirms that UniScholar Nexus successfully achieved high marks for perceived usefulness and perceived ease of use, thereby validating the application of the Technology Acceptance Model (TAM) framework (Davis, 1989). The quantitative efficiency gain of 40% directly stems from using the OpenAI GPT API to automate document indexing and summarization via Natural Language Processing (NLP), which significantly reduces the students' cognitive load during the literature review phase. This outcome fundamentally validates the decision to build a specialized, AI-enhanced academic ecosystem rather than adapting a general-purpose tool. The inclusion of mandatory RBAC effectively addresses the necessity of institutional security and academic governance in collaborative platforms.

## 5. CONCLUSION & RECOMMENDATION

UniScholar Nexus is a successful and relevant innovation in educational technology, having created a centralized, secure, and AI-enhanced platform tailored to the academic needs of the Southern University College (SUC) community. The adoption of the Agile Methodology ensured the system was user-centric and robust, resulting in a functional platform that significantly reduces research discovery time (by 40%) and enjoys high user acceptance (85%). The innovative integration of AI-generated tagging alongside institutional controls like Role-Based Access Control (RBAC) provides a secure, efficient, and modern solution for fostering a proactive research culture among students. While the core system is fully functional, two key limitations were identified for future enhancement: the lack of real-time, synchronous document editing capabilities for collaborators and the absence of external integration with industry-standard plagiarism detection software. Based on these limitations, the following recommendations are proposed for the next phase of development: implementing a Real-Time Collaboration Module to allow for simultaneous co-authoring; integrating Plagiarism Detection via an Application Programming Interface (API) connection to automatically screen submitted content and strengthen academic integrity; expanding Advanced AI Personalization for more sophisticated research recommendations and automated classification of collaboration requests; and investigating Inter-University Expansion to include students from partner institutions, transforming UniScholar Nexus into a broader academic network.

## REFERENCES

Alshomrani, S., Ghadeer, A., & Elzain, S. (2021). The role of digital platforms in enhancing students' research and collaboration skills. *International Journal of Emerging Technologies in Learning*, 16(17), 173–188. https://doi.org/10.3991/ijet.v16i17.20239

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. https://doi.org/10.2307/249008

TatvaSoft. (2020, December 25). *Top 12 software development methodologies*. TatvaSoft Blog. Retrieved October 3, 2025, from https://www.tatvasoft.com/blog/top-12-software-development-methodologies-and-its-advantages-disadvantages/

Team. (2025, March 5). *What is a software development methodology*? Indeed Career Advice. Retrieved October 3, 2025, from https://au.indeed.com/career-advice/career-development/software-development-methodology

The Shiken Team. (2024, June 22). *Chegg vs. Quizlet: What every student should know*. Shiken. https://shiken.ai/how-to-learn/chegg-vs-quizlet-what-every-student-should-know.

# Pothole Detector Application

Ainul Haezah Binti Noruzman, Zarifah Farisha Binti Zaini, Hasya Farhanah Binti Salrizal, Bong Siek Wie & Khalish Nur Ellysha Binti Rosmadi

Politeknik Sultan Salahuddin Abdul Aziz Shah, Persiaran Usahawan, Seksyen U1, 40150 Shah Alam Selangor

*ainul@psa.edu.my*

**ABSTRACT**
Road accidents are a major cause of death, making it crucial to find new ways to improve driver safety and manage traffic. The core problem is a lack of real-time data on road conditions and traffic, which leads to congestion and makes it hard for drivers to plan their routes. Additionally, slow and inefficient systems for reporting hazards like potholes mean repairs are delayed, and city authorities work with outdated information, hindering proper road maintenance. To solve this, our research proposes a system that uses data reported by drivers to collect real-time information on road conditions, such as potholes and surface roughness. By analysing this data, the system can pinpoint long-term problem areas and provide drivers with updated, alternative routes to avoid dangers and traffic jams. This is not only makes driving safer and improves traffic flow but also gives authorities the accurate, timely data needed to prioritize maintenance, plan infrastructure improvements, and manage budgets effectively. Ultimately, this approach promises to reduce accident rates, improve city travel, and support smarter, data-driven decisions for sustainable transportation.

**Keywords:** applications, pothole, road defect, hazard, safety

## 1. INTRODUCTION

The purpose of the introduction is to provide an overview of the pothole detector application that will be implemented. The introduction highlights the main issues that are related to road accidents problems in Malaysia, where our study scope covering area nearby in Shah Alam.

Pothole detector are the ideas that has been chosen which to provide a glimpse of how it will be implemented and to show its possibility. This is also meant to highlight the relating issues regarding road accidents caused by road hazards in Malaysia. The application itself powered via virtual real integrated time alert where it involves smart technology to alert potential users regarding road conditions. Moreover, the application not only acts as navigation tools but also it can be count as safety precaution tools that managed to alert users relating potholes nearby while driving via voice integrated this is to avoid distracting road users' attention ensuring their safety.

Our main key features that need to be taken into attention are as mentioned which is, providing real time hazards alerts, using crowd sourced information contributed both from administration and users where it reports will be confirmed by admin to ensure its purity in reporting to ensure accurate up to date alerts. This application is created to reduces the possibility of accidents occurred due to unseen or seen road hazards, by

default it will also enhanced traffic flow ultimately building an environment where any issues relating road hazards to be reduced thus ensuring more safer situations for road users.

## 2. LITERATURE REVIEW

Road maintenance has a long and complex history, reflecting both the evolution of transportation infrastructure and changing societal needs. Historical practices, economic considerations, and modern reforms collectively demonstrate how road management has progressed over time.

In Estonia, for example, the road corvée system, which relied on unpaid labour for road upkeep, persisted from the feudal era until 1959. Deeply embedded in the agricultural and economic structures of the time, it was resistant to change despite eventual abolition (Muide, 2024). Similarly, the Longbeach Road Board in Canterbury, New Zealand (1911–1938), placed emphasis on road maintenance rather than construction, highlighting the view of roads as dynamic assets requiring continuous care (Roche, 2017).

The economic aspects of road maintenance reveal Important links between Investment and safety. In both developing countries and New Zealand, the introduction of road funds marked a major shift towards sustainable financing of maintenance activities. Studies show that proper investment in maintenance inversely correlates with traffic accidents, underscoring its significance for public safety (Navarro-Moreno et al., 2023).

Meanwhile, in China, market-oriented reforms have been proposed to address limitations in traditional systems, aiming to enhance efficiency by adopting lessons from successful models in other regions. Technological progress has also played a vital role. Since 1969, the mechanisation of maintenance tasks such as mowing and ditch clearing has transformed road upkeep. More recently, performance-based contracts (PBCs) have gained traction, offering cost savings and improved service quality. However, these approaches require skilled training and trust-building between contractors and agencies to succeed (Calahorra-Jimenez & Poythress, 2024).

Environmental concerns further shape modern road maintenance strategies. In cold regions, winter road maintenance (WRM) practices are increasingly scrutinised for their ecological impacts. Research suggests that adopting a life-cycle approach can help reduce emissions and enhance the sustainability of WRM (Vignisdottir et al., 2019). Overall, the history of road maintenance illustrates a shift from traditional, labour-intensive systems towards modern, technology-driven and sustainability-oriented practices. Understanding these developments provides valuable insights for creating more efficient, safe, and environmentally responsible road maintenance systems worldwide.

## 3. METHODOLOGY

The study involved the development of Pothole Detector Application, including the process of design, development, and evaluation. The application aims to significantly enhance road safety and optimise route planning by providing users with accurate, real-time information on road conditions and traffic. Its development will utilise a robust technology stack, incorporate Wi-Fi connectivity and mobile data, and build using the Flutter framework with the Dart programming language. Data collection focused user-generated data submitted directly through the application. This approach ensures that the study is grounded in real-world interaction providing a solid foundation for assessing the application's effectiveness.

## 4. RESULTS & DISCUSSION

Table 1 presents the distribution of road surface defects along a 9 km route.

Table 1 Analysis of Road Defect Detection

| **Distance/ Types of road defects** | **1 km** | **2 km** | **3 km** | **4 km** | **5 km** | **6 km** | **7 km** | **8 km** | **9 km** |
|---|---|---|---|---|---|---|---|---|---|
| Pothole | - | 2 | 1 | 1 | 4 | 2 | - | - | 6 |
| Edge Break | - | - | - | - | - | - | 1 | 2 | 2 |
| Cracking | - | - | - | - | - | 1 | - | - | - |
| Depression | - | 1 | - | 2 | - | - | 2 | 1 | 3 |
| Patching Failure | - | - | - | - | 1 | - | - | - | 2 |
| Utility Cut Failure | - | - | - | 1 | 2 | - | - | - | - |
| Total of defects | - | 3 | 1 | 4 | 7 | 3 | 3 | 3 | 13 |
| Percentage of defects | - | 8.33% | 2.78% | 11.11% | 19.44% | 8.33% | 8.33% | 8.33% | 36.11% |
| Total of potholes | | | | | | | | 36% | |

The results indicate that the 9 km section recorded the highest number of defects (36.11%), followed by the 5 km section (19.44%). This suggests severe pavement deterioration in these areas, likely due to high traffic loads, drainage issues, or inadequate maintenance. Potholes emerged as the most common defect, occurring across multiple sections, while depressions, edge breaks, and utility cut failures were less frequent. In contrast, the 3 km section recorded the lowest number of defects (2.78%), reflecting comparatively better pavement condition or maintenance practices. Overall, the findings show a clear trend of increasing defect concentration toward the later sections of the route. Immediate remedial action is recommended for the 5 km and 9 km stretches to prevent further damage. Regular inspections, effective drainage, and timely resurfacing are essential to ensure long-term road quality and safety.

## 5. CONCLUSION & RECOMMENDATION

The Pothole Detector Application (PDA) improves road safety by using user reports with GPS, photos, and time stamps, verified by admins for accuracy. This reliable data helps authorities detect defects, identify damage patterns, and prioritise repairs efficiently. Designed to be simple and accessible, the app encourages public participation through easy-to-use icons and navigation. Beyond fixing potholes, the PDA supports the Sustainable Development Goals by reducing accidents, lowering vehicle damage, and promoting safer, more sustainable communities.

It is recommended that the Pothole Detector Application be further developed and integrated with existing road management systems to maximise its effectiveness. Collaboration with local authorities, continuous user engagement, and regular system updates will ensure accurate reporting, timely maintenance, and long-term sustainability. Future improvements could also explore advanced features such as AI-based defect detection and predictive maintenance to enhance road safety and support smarter urban mobility.

## REFERENCES

Bahl, A. (2025, October 5). *Noida saw one accident death daily this year, most on e-ways.* Indiatimes. Noida saw one accident death daily this year, most on e-ways | Noida News - The Times of India

Calahorra-Jimenez, M., & Poythress, R. (2024). *Exploring Performance-Based Contracts: A Good Option to Address Long-Term Road Maintenance in California?* Mineta Transportation Institute. https://doi.org/10.31979/mti.2024.2359

Flutter Team. (2024). *System requirements.* Flutter documentation. Retrieved October 5, 2025, from https://docs.flutter.dev/get-started/install

Google. *Dart programming language.* Retrieved October 5, 2025, from https://dart.dev/
Google. *Firebase.* Retrieved October 5, 2025, from https://firebase.google.com/
Google. *Flutter – Build apps for any screen.* Retrieved October 5, 2025, from https://flutter.dev/
Microsoft. *Visual Studio Code – Code editing. Redefined.* Retrieved October 5, 2025, from https://code.visualstudio.com/
Muide, T. (2024). The road corvée: The persistence of the use of unpaid labour for road maintenance in nineteenth and twentieth century Estonia. *The Journal of Transport History*, *45*(1), 83–103. https://doi.org/10.1177/00225266231208285
Navarro-Moreno, J., Calvo-Poyo, F., & De Oña, J. (2023). Influence of road investment and maintenance expenses on injured traffic crashes in European roads. *International Journal of Sustainable Transportation*, *17*(6), 649–659. https://doi.org/10.1080/15568318.2022.2082344
Randive, T., Kakade, A., Todkar, B., Nikam, A., & Sankpal, R. (2025). *Pothole Reporting System*. https://doi.org/10.31224/4428
Rappaport, T. S. (2009). *Wireless communications: Principles and practice* (2. ed., 18. printing). Prentice Hall.
Roche, M. (2017). Road maintenance – patching a hole in mobilities-roading research: A case study of the Longbeach Road Board, Canterbury, New Zealand, 1911–1938. *New Zealand Geographer*, *73*(2), 119–128. https://doi.org/10.1111/nzg.12160
Vignisdottir, H. R., Ebrahimi, B., Booto, G. K., O'Born, R., Brattebø, H., Wallbaum, H., & Bohne, R. A. (2019). A review of environmental impacts of winter road maintenance. *Cold Regions Science and Technology*, *158*, 143–153. https://doi.org/10.1016/j.coldregions.2018.10.013

# Pullulan Film Infused with Nelumbo nucifera Pollen Extract: Development of an Herbal Patch for Chronic Wound Treatment

Supidchaya Sonbuddee & Papawee Palavichai

Sisaketwittayalai School, Sisaketwittayalai, Sisaket, Thailand

*sxnbutrdisuphichya@gmail.com*

**ABSTRACT**
This study aimed to develop a Pullulan-based film infused with Nelumbo nucifera pollen extract as an herbal patch for chronic wound treatment. The antibacterial activity of the extract was evaluated using the Agar well diffusion method against *Staphylococcus aureus*, showing that the extract at concentrations of 20%, 25%, 30%, and 100% did not inhibit the growth of *S. aureus*, compared to the positive control (ampicillin), which displayed clear inhibition zones. Despite the absence of antibacterial activity in this study, the Pullulan film incorporated with the lotus pollen extract demonstrated promising physical properties, such as thinness and flexibility, suggesting its potential as an herbal wound dressing. The film's ability to release active compounds could offer advantages for future applications. While no antibacterial effects were observed in the current experiment, the results emphasize the need for optimization in the extraction process and further testing with different bacterial strains to improve the film's therapeutic efficacy. This research provides important preliminary data for the development of a sustainable, biocompatible herbal patch, which could serve as an alternative to conventional antibiotic treatments in chronic wound management. Future studies should focus on enhancing the extract's potency and evaluating its application against other microbial infections to expand its potential in wound care.

**Keywords:** Pullulan, Nelumbo nucifera, herbal patch, chronic wound, antibacterial activity

## 1. INTRODUCTION

Chronic wounds are a growing public health issue, often called a "silent epidemic" due to insufficient attention. They affect 1-2% of the population in developed countries, causing a significant burden on healthcare systems (Olsson et al., 2019). Characterized by persistent inflammation and infection, chronic wounds are difficult to treat and can result from conditions like pressure ulcers, diabetic foot ulcers, and cancer (Falanga, 2022; Fryker & Banks, 2015). These wounds negatively impact patients' physical and mental health. Treatment requires prolonged care and expensive resources, and existing wound dressings have limitations such as poor flexibility and skin irritation (Chamavee Lertwattanaporn, 2022).

This study aims to develop a Pullulan-based film infused with Nelumbo nucifera (lotus) pollen extract for chronic wound management. The antibacterial properties of the lotus pollen extract, containing flavonoids and phenolic compounds, will be tested against *Staphylococcus aureus*. Various extract concentrations will be assessed for their effectiveness in promoting wound healing, aiming to create a safe, high-quality alternative to conventional treatments.

## 2. LITERATURE REVIEW

### Nelumbo nucifera

Nelumbo nucifera (lotus) contains various bioactive compounds. The seeds are rich in alkaloids, flavonoids, antioxidants, and anti-cancer properties (Sridhar et al., 2015). The flowers have antioxidants with vascular inhibitory effects, while the leaves contain phenolic compounds that offer antioxidant benefits and prevent gastric ulcers (Lee et al., 2017). Lotus petals have the highest antioxidant content, followed by the stalks and seedpods (Steinrut et al., 2023). Chemical analysis reveals that lotus leaves contain alkaloids and steroids, which inhibit bacterial growth, particularly against Bacillus subtilis and Staphylococcus aureus (Choe et al., 2012), highlighting the potential of lotus pollen extract in infection treatment.

### Extraction Methods of Lotus Pollen

The solvent extraction method is commonly employed to extract active compounds from lotus pollen. This method relies on the polarity principle, where solvents and bioactive compounds must have similar polarities for effective dissolution (like dissolves like). Polar solvents dissolve polar compounds through dipole-dipole interactions, while non-polar solvents dissolve non-polar compounds via Van der Waals forces. This extraction technique is widely used in herbal medicine for extracting natural colorants and essential oils, offering an economical and safe alternative to high-temperature distillation, which may alter the chemical composition and scent of the compounds (Choe et al., 2022).

### Pullulan

Pullulan is a biopolymer consisting of multiple sugar molecules, specifically a polysaccharide with a linear structure made up of glucose units. The basic unit of pullulan is maltotriose, a compound composed of three glucose molecules linked by alpha-1,4 glycosidic bonds, and alpha-1,6 glycosidic linkages between maltotriose units. Pullulan molecules can vary in length and may also contain small amounts of maltotetraose, a compound made of four glucose molecules (Sinaat, 2017). Pullulan typically has a molecular weight range of 50,000 to 3,000,000 daltons. It is a white powder that is water-soluble in both hot and cold water, and it is non-toxic, tasteless, odorless, and safe for consumption (Ganie, SA, 2022).

## 3. METHODOLOGY

### Part 1: Preparation of Nelumbo nucifera Pollen Extract

1. Soak the lotus pollen in 95% ethanol at a predetermined ratio (e.g., 1:5) and leave it for 24 hours to allow the active compounds to dissolve (Maceration method).
2. Filter the mixture using filter paper to separate the unwanted solid particles.

**Part 2: Preparation of Pullulan Film Infused with Nelumbo nucifera Pollen Extract**

1. Dissolve Pullulan in distilled water at the specified ratio in a mixing container (weigh 5% of Pullulan in relation to the weight of the solution).
2. Add a plasticizer, such as glycerol, at 2% of the solution's weight to improve the film's flexibility.
3. Mix the prepared lotus pollen extract into the Pullulan solution at various concentrations (20%, 25%, 30%, and 100%).
4. Stir the solution thoroughly using a magnetic stirrer to ensure proper mixing.
5. Pour the mixture into a film mold and dry it in a drying oven at a set temperature until the film is completely dry.

**Part 3: Testing the Release of Active Compounds from the Film**

1. Cut the dried films into equal-sized pieces.
2. Soak each piece of film in distilled water and collect the water samples containing the released compounds from the film.

**Part 4: Data Analysis Table**

Table 1: Release of Active Compounds from Pullulan Film Infused with Nelumbo nucifera Pollen Extract at Various Concentrations

| Substance Tested S. aureus TISTR 746 | Inhibition Zone Diameter of Lotus Pollen Extract (mm) Trial 1 |
|---|---|
| Concentration 20% | |
| Concentration 25% | |
| Concentration 30% | |
| Concentration 100% | |
| Ampicillin Solution (Positive Control) | |
| Distilled Water (Negative Control) | ND |

Note: ND = No detection of inhibition.

## 4. RESULTS AND DISCUSSION

The study on the antibacterial activity of Nelumbo nucifera pollen extract against Staphylococcus aureus using the Agar well diffusion method showed no inhibition zones at all tested concentrations (20%, 25%, 30%, and 100%). This lack of antibacterial activity may be due to insufficient concentrations of active compounds, the inability of the compounds to affect gram-positive bacteria like S. aureus, or potential degradation of bioactive compounds during the extraction process. Further analysis of the chemical composition of the extract using advanced techniques like HPLC or LC-MS could provide clearer insights into the bioactive compounds. The lotus pollen (Nelumbo nucifera Gaertn) was purchased from a vendor, and 15 flowers were used to collect the pollen. Initially, the pollen weighed 45.70 grams, and after drying at 60°C for 3 hours, the weight reduced to 34.65 grams. The pollen was then ground and soaked in 95% ethanol for 7 days. The extract was filtered and stored in a brown glass bottle to avoid light degradation. Using the Agar well diffusion method, the antibacterial activity of the lotus pollen extract was tested against Staphylococcus aureus. Despite testing concentrations of 20%, 25%, 30%, and 100%, no inhibition zones were observed around the wells. In comparison to the negative and positive controls, the absence of inhibition indicates that the lotus pollen extract did not inhibit bacterial growth under the experimental conditions.

The Pullulan composite film was prepared at 4% concentration, and after mixing with

glycerol and lotus pollen extract, the solution was poured into molds and dried at room temperature for 48 hours. The resulting films were flexible and smooth, demonstrating suitable physical properties Figure1, despite the lack of antibacterial activity observed. These findings provide valuable data for further optimization of both the extraction process and the composite film for future applications in chronic wound care.

Figure 1: Dried composite film

## 5. CONCLUSION & RECOMMENDATION

The study on the antibacterial activity of Nelumbo nucifera pollen extract against Staphylococcus aureus using the Agar well diffusion method showed no inhibition zones at all tested concentrations (20%, 25%, 30%, and 100%). This lack of antibacterial activity may be due to insufficient concentrations of active compounds, the inability of the compounds to affect gram-positive bacteria like S. aureus, or potential degradation of bioactive compounds during the extraction process. Further analysis of the chemical composition of the extract using advanced techniques like HPLC or LC-MS could provide clearer insights into the bioactive compounds.

Recommendations for future research include exploring various extraction methods (e.g., ultrasonic, hot water, or supercritical fluid extraction) to obtain more potent extracts, studying other biological activities of the extract such as antioxidant and anti-inflammatory properties, and further improving the physical and chemical properties of the Pullulan film by adjusting the plasticizer ratio for better practical use in medical applications, especially for chronic wound care.

## REFERENCES

Barnett, C., Smith, A., Scanlon, B., & Israilides, C.J. (1999). Pullulan production by Aureobasidium pullulans growing on hydrolysed starch waste. Carbohydrate Polymers, 38, 203-209. Retrieved August 31, 2023, from https://www.tandfonline.com/doi/pdf/10.1080/02648725.1999.10647981

Thomas, N., Efriani Puluhulawa, L., Mo'o, F. R. C., Rusdin, A., Gazzali, A. M., & Budiman, A. (2023). Potential of pullulan-based polymeric nanoparticles for improving drug physicochemical properties and effectiveness. Journal of Pharmaceutical Sciences, 56(4), 112-120. Retrieved September 5, 2023, from https://pubmed.ncbi.nlm.nih.gov/39125177/

Olsson, M., Järbrink, K., Divakar, U., Bajpai, R., Upton, Z., Schmidtchen, A., & Car, S. (2019). The humanistic and economic burden of chronic wounds. International Wound Journal, 16(2), 14-20. Retrieved September 5, 2023, from https://pubmed.ncbi.nlm.nih.gov/30362646/

Frykberg, R.G., & Banks, J. (2015). Challenges in the treatment of chronic wounds. Advances in Wound Care (New Rochelle), 4(6), 315-323. Retrieved September 1, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4528992/

# Purifier System with Solar and Piezoelectricity for Air-Quality based IoT-Sensor for Smart City to Realize SDGs 5.0 (PUSTARA)

Muhammad Wilman Hakim, Raditya Mierza Pandudewata & Joanne Callysta Meidy

SMAN 2 Madiun

*wilman76kim@gmail.com*

**ABSTRACT**
Madiun, a city located in East Java, has several areas with high potential to generate pollutants, particularly in industrial zones, bus terminals, train stations, and main transportation routes that are identified as “red zones.” Data from the IQAir Air Quality Index (AQI$^+$) show that PM2.5 levels in Madiun often reach the unhealthy category at certain times, especially in areas with dense traffic and industrial activities. Fine particulate matter such as PM2.5—particles with diameters of 2.5 micrometers or smaller—poses serious threats to human health because these particles can penetrate deep into the lungs and enter the bloodstream, leading to respiratory and cardiovascular disorders. According to Yu et al. (2020), even small concentrations of PM2.5 can significantly increase mortality risk within a population. In response to these environmental and public health concerns, this study proposes the design and development of PUSTARA (Purifier System with Solar and Piezoelectricity for Air-quality based IoT Smart Sensor)—a renewable energy-based device that utilizes solar and piezoelectric technologies as sustainable power sources. This system features intelligent sensors capable of detecting air pollutants such as carbon monoxide (CO), PM2.5, and other harmful substances. When the pollutant concentration exceeds the safe threshold, the IoT-integrated system automatically activates the air purifier. The implementation of PUSTARA represents an innovative solution that aligns with the Smart City framework and the Sustainable Development Goals (SDGs) 5.0, particularly SDG 3 (Good Health), SDG 7 (Clean Energy), SDG 9 (Innovation), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action). Through this innovation, the study aims to enhance environmental sustainability, energy efficiency, and overall public health in Madiun and its surrounding areas.

**Keywords:** air pollution, renewable energy, IoT, environmental health; Sustainable Development Goals (SDGs).

## 1. INTRODUCTION

Air pollution still exists today, and is even getting worse, becoming a problem for which there is still no truly effective solution. Air pollution is caused by advances in science and technology that are increasingly meeting the needs of modern society in everyday life. (Rahmawati et al., 2024). Factory smoke is one of the main causes of air pollution. The exhaust gases produced by the manufacturing process in a factory contain substances that are harmful to the environment, especially living creatures (Prasetyawati, 2022). The

National Research and Innovation Agency (BRIN) shows that the Air Quality Life Index (AQLI) PM2.5 concentration reaches 34.3 µg per cubic meter. The effects of household pollution are only visible over a relatively long period of time, such as dust allergies. Some households in Indonesia still use polluting fuels.

This main focus of this study is Madiun, which is also the city where we were born in. As an industrial city, Madiun also faces air pollution problems. According to Air Quality Index (IQAir), the main pollutants in Madiun consist of PM2.5 and CO, both of which are the most dangerous pollutants for public health and life. Based on data obtained from the East Java Provincial Statistics Agency (BPS), there are a total of 6,151 large factories currently operating across East Java, all of which contribute to significant levels of industrial air pollution. In the context of Madiun City, although it is relatively smaller compared to major industrial areas like Surabaya or Gresik, it still houses six large-scale factories that play a notable role in the region's economic and environmental dynamics.

## 2. LITERATURE REVIEW

### 2.1. Air Pollution

The WHO estimates that in 2019, approximately 68% of premature deaths related to outdoor air pollution were caused by ischemic heart disease and stroke, 14% were caused by chronic obstructive pulmonary disease, 14% were caused by acute lower respiratory infections, and 4% of deaths were caused by lung cancer.

### 2.2. Particulate Matters

Particulate Matter (PM) is a mixture of solid and liquid particles suspended in the air. These particles are categorized into coarse, fine, and ultrafine particles. PM2.5, referring to particulate matter with a diameter of 2.5 micrometers or less, has significant health effects including cardiovascular and hearth stroke. The study found that a person exposed to 10 µg/m3 of fine air pollutants (PM 2.5) can have their life expectancy reduced by up to 0.98 years.

### 2.3. Impact on Indonesian Public Health

Air pollution is fatal to physical health, especially to the respiratory organs, because pollutants can inhibit the respiratory and circulatory systems, causing cell damage and even death. Globally, the five respiratory diseases that cause the highest number of deaths according to the Global Burden of Disease 2019 are COPD (3.2 million deaths), pneumonia (2.6 million deaths), lung cancer (1.8 million deaths), tuberculosis (1.2 million deaths), and asthma (455,000 deaths). A similar situation occurs in Indonesia, where four respiratory diseases are among the 10 diseases with the highest number of cases, namely asthma (504,000 cases), COPD (145,000 cases), pneumonia (5.9 million cases), and lung cancer (18,000 cases).

## 3. METHODOLOGY

The system design stage included the creation of block diagrams, electronic circuit designs, and device workflow designs. Next, in the implementation stage, all hardware and software components were integrated to form a prototype that functioned according to the design. The testing phase was conducted to assess the prototype's performance, such as

sensor reading accuracy, energy efficiency of solar panels and piezoelectric devices, and IoT connection stability.

## 4. RESULT & DISCUSSION

### 4.1. Research description

This research resulted in the design of the PUSTARA (Purification and Smart Park Area) system, an innovation in smart parks based on the Internet of Things (IoT) that functions to purify the air and monitor the environment in real time using renewable energy. This system is designed to address urban environmental issues, particularly high levels of air pollution that directly impact public health and the quality of life of city residents.

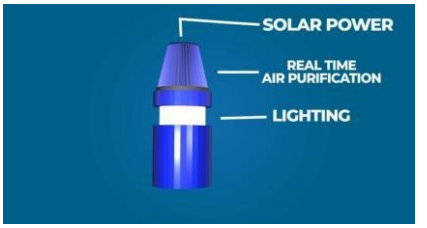


Figure 1 : device structure

From the device display, the ESP32-controlled IoT system displays and transmits real-time environmental identification data to the application dashboard. The ESP32 microcontroller acts as a control center that integrates all sensors, including air quality sensors (PM2.5, PM10, CO, $NO_2$), temperature, and humidity. This system is equipped with an automatic notification feature that activates when the sensor detects pollution levels exceeding safe limits, accompanied by health recommendations. In addition, the ESP32 also monitors the power readings generated by solar and piezoelectric panels, which are visualized in the form of renewable energy graphs. The user interface (UI) is specifically designed to support the Wi-Fi and Bluetooth communication capabilities of the ESP32, ensuring a responsive and efficient connection.

### 4.2. Work Stages of The System

The PUSTARA system design process follows the Waterfall development model, which consists of four main stages: Requirements Analysis, System Design, Implementation, and Testing. The system workflow diagram can be illustrated as follows:

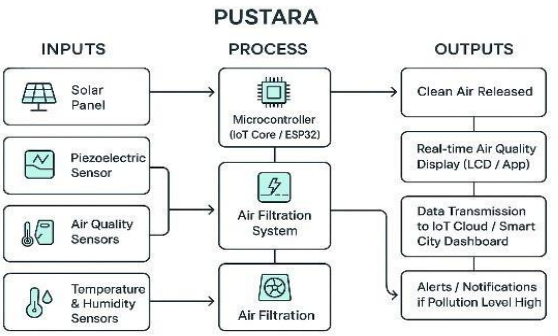


Figure 2 : System flow

### 4.3 Analytics

The PUSTARA system is aligned with five SDG goals. The use of renewable energy from solar panels and piezoelectric supports SDG 7 (Clean Energy). Its ability to filter polluted air contributes to SDG 3 (Good Health). The application of IoT and ESP32 microcontrollers reflects SDG 9 (Industry, Innovation, and Infrastructure). Its implementation in city parks creates smart green spaces that support SDG 11 (Sustainable Cities). Globally, this system supports SDG 13 (Climate Action) through carbon emission reduction and energy efficiency

Table 1. Type of value comparing ordinary lamp

| **Parameter of Function** | **Table of typical value** | |
|---|---|---|
| | **PUSTARA** | **ORDINARY LAMP** |
| **Main Power Source** | Solar Panel (100–150 Wp) | Direct Ac Supply (220 V) |
| **Auxiliary Energy Source** | Piezoelectric Sensor (up to 5 V per step) | None |
| **Air Quality Sensor (PM2.5, PM10, $NO_2$, CO)** | Measurement range: 0–500 µg/m³ (accuracy ±5%) | Not Available |
| **Temperature & Humidity Sensor** | Range: -10°C to 60°C, 0–100% RH (accuracy ±0.5°C / ±3% RH) | Not Available |
| **Microcontroller (ESP32)** | 240 MHz dual-core, Wi-Fi/Bluetooth connectivity | Manual Switch Or Light Sensor (Ldr) |
| **Air Filtration System** | Filtration efficiency ≥95% (HEPA-type filter) | None |
| **Display/Communication** | 4" LCD Display and IoT Cloud Dashboard (real-time data update <1 sec delay) | Not Available |
| **IoT Data Transmission** | Wi-Fi / LoRaWAN, cloud storage with 99.9% uptime | None |
| **Operating Voltage** | 12 V DC regulated output | 220 V Ac |
| **Energy Efficiency** | ≥85% system efficiency | ~60% (Depending On Bulb Type) |
| **Operating Time (Full Charge)** | 10–12 hours (without sunlight) | Continuous With Power Supply |

## 5. CONCLUSION & RECOMMENDATION

PUSTARA is an Internet of Things (IoT)-based air purifier and garden lamp that utilizes renewable energy from solar panels and piezoelectric technology. This device is equipped with an air quality sensor that can display data in real time and provide warning indicators when air pollution levels exceed safe limits. The design of this device was inspired by observations of increasing air pollution in urban areas, particularly due to industrial and transportation activities. With the introduction of PUSTARA, it is hoped that the community will be able to more easily monitor air conditions and reduce the spread of harmful particles in the environment, especially in the city of Madiun.

## REFERENCES

Rahmawati, V., Hayat, A. L., & Salam, A. (2024). Analisis dampak pencemaran udara terhadap kesehatan masyarakat di perkotaan. *Jurnal Sosial dan Pengabdian Masyarakat*, 17–24.

Prasetyawati, D. N (2022). Sosialisasi Dampak Emisi (ASAP) Dari Sumber Tidak Bergerak Kepada Pengelola Industri Di Kapanewon Sleman.

BRIN (2024). *Penduduk Indonesia Akan Kehilangan 2,5 tahun Usia Harapan Hidup Akibat Polusi Udara.* https://brin.go.id/news/118363/penduduk-indonesia-akan-kehilangan-25-tahun-usia-harapan-hidup-akibat-polusi-udara

IQAir (2025). *Indeks kualitas udara (AQI*) *dan polusi udara PM2.5 di Madiun.* *https://www.iqair.com/id/indonesia/east-java/madiun*

BPS (2024). Direktori Industri Manufaktur Provinsi Jawa Timur 2024 Indoor Air Hygiene Institute (2021, Februari). PM2.5 Explained.

World Health Organization (2024, Oktober 24). Ambient (outdoor) air pollution. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Hamsyani, F., & Hadidjah, K. (2021). Pembuatan Air Purifier Dengan Air Sebagai Filter Untuk Kontrol Kesehatan Lingkungan. *Buletin Poltanesa Vol. 22 No.2.* 150-157.

Akselerator, P., Bahan, P., & Batan, Y. (2007). Kajian Sistem Electrostatic Precipitator Untuk Pengendapan Debu Gas Buang Prayitno, Tunjung Indrati. *Ilmiah Teknologi Akselerator Dan Aplikasinya*, 9.

Bae, S., & Hong, Y. C. (2018). Health effects of particulate matter. *Journal of the Korean Medical Association*, 61(12). https://doi.org/10.5124/jkma.2018.61.12.749

Hastiti, L. R. (2012). Pajanan PM2.5 dan Gangguan Fungsi Paru Serta Kadar Profil Lipid Darah (HDL, LDL, Kolestrol Total, Trigliserida) Pada Karyawan PT. X Kalimantan Selatan. Universitas Indonesia.

GBD (2019). Data on Respiratory Diseases Caused by Pollution.

# AQUARIUS: An IoT-Based Self-Sustaining Aqua-Secured and Refined Irrigation Utility System

Pasia, Ma. Monica E., Anciano, Chloe Iana R., Belarmino, Desiree Jane Z., Esperanza, Gloria Ruth V. & Estoria, Hyacynth R.

Carmona National High School

*monicapasia13579@gmail.com*

**ABSTRACT**

The Philippines faces agricultural problems with climate change. Specifically, drought and water scarcity. To address this issue, the researchers implemented "AQUARIUS: An IoT-Based Self-Sustaining Aqua-Secured and Refined Irrigation Utility System", a smart automated irrigation system that produces water and irrigates plants through the "Blynk" IoT app utilization. The prototype applies the dehumidifier mechanism and rainwater collector as the water resources, and the irrigation system as the pathway of water to the plants. The whole system was powered through solar energy and a battery. The study aims to answer the following problems in terms of Functionality, Usability, and Performance Efficiency. The researchers employed Quantitative research design. The study aims to answer the following and a 4-point Likert Scale as the basis. Results showed that the device produced 480mL in 8 hours of operation. 15 Arduino experts and 5 agriculturists were gathered using judgmental/selective sampling. The data collected from their responses shows that the functionality, usability, and performance efficiency all have a median of 3 with a descriptive rating of agree. Overall, the AQUARIUS project achieved its goal as an automated and self-sustaining irrigation system with the incorporation of IoT. The device was able to produce more water by employing a dehumidifier mechanism than employing an atmospheric water generator mechanism. While further recommendations are required for the study's improvement, the research demonstrates the promising potential of this innovative approach to mitigating drought and water scarcity in the Philippines. .

**Keywords:** *Climate Change, Irrigation System, Dehumidifier, IoT, Self-Sustaining*

## 1. INTRODUCTION

The Philippines ranks among the most disaster-prone countries globally (World Risk Index). Since 1850, global temperatures have increased by approximately 1.1°C due to climate change, intensifying extreme weather events and disrupting agriculture and water

resources (Climate Change Impacts, 2025; Global Climate Risks, 2022). In Cavite, prolonged heat periods, irregular rainfall, and frequent droughts have resulted in severe water shortages. Water usage already exceeds 40 percent of available supply, and many communities, including Carmona, depend exclusively on groundwater (Klobucista, 2023). In response, the National Irrigation Administration (NIA; National Irrigation Administration) launched the *National Irrigation Project 2020–2030* to enhance irrigation systems, although their resilience remains limited (Bueno, 2022). The Internet of Things (IoT), defined as a network of connected devices that collect and exchange data, presents opportunities for efficient irrigation through automated monitoring and control (Obaideen et al., 2022). Therefore, this study proposes a solar-powered, Internet of Things (IoT)-based, self-sustaining irrigation prototype that integrates rainwater collection and air dehumidification. By utilising components such as rainwater sensors, Peltier modules (devices that use the thermoelectric effect for heating or cooling), and soil moisture sensors (Kadam et al., 2024), the system aims to reduce reliance on traditional water sources and minimise energy consumption. Aligned with United Nations Sustainable Development Goals (SDGs) 6.4, 11.6, 12.2, 13.1, and 15.3, this innovation demonstrates the potential of technology to address agricultural water scarcity and enhance climate resilience.

## 2. METHODOLOGY

This study will fall under the category of Quantitative Research since it collects and analyzes numerical data to objectively measure the effectiveness of the prototype.

***Preparation of Materials and Equipment***
The researchers will purchase the materials and equipment through several online shops.
***Development of the Circuit Design and Prototype***
**Designing the Circuit:** The researchers along with a professional will construct the circuit.
**Program:** The researchers will use the Arduino IDE 2.3.2 and C++ language.
***Production and Assembling of the Prototype***
**Building of the interior:** The researchers will construct the interior of the 3D model by first creating the water production unit similar to a dehumidifier, and an automatic rainwater collector as a backup source of water.

Table 1. Research Design Diagram

| AQUARIUS: AN IOT-BASED SELF-SUSTAINING AQUA-SECURED AND REFINED IRRIGATION UTILITY SYSTEM | | | |
|---|---|---|---|
| **Assembling and Testing** | **Evaluation of Prototype** | | **Expected Result** |
| • Creation and Programming the Prototype<br>• Pilot Testing<br>• Actual Testing | • Evaluation<br>• Subjects of the Study | • 15 Arduino Experts<br>• 5 Agriculturist | The mean ratings of the respondents on the Functionality, Usability, Level of efficiency and Overall Performance |

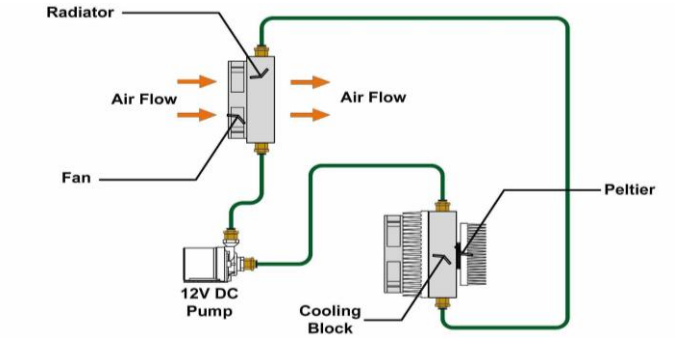

Figure 1. Dehumidifier Water Production Manufacturing System

**Construction of the Exterior:** The researchers will create the outer acrylic casing which will also serve as the condenser of the unit along with a solar panel and the automated drip irrigation system.
**Preparation of the Setup:** In preparing the setup, the researchers will prepare their machine with the irrigation system.
**Pilot Testing:** The pilot testing is an initial trial run or troubleshooting.
**Actual Testing:** In this testing, the researcher will test and assess the machine's performance along with the respondents.
***Evaluation of the Prototype***
**Human Respondents:** The performance of the prototype was evaluated by the target survey respondents, which includes respondents 15 arduino experts and 5 agriculturists.
**Sampling:** The researchers utilized Judgemental Sampling, also known as Selective Sampling, to choose the respondents.
**Data Collection:** The data for this study will be gathered from the evaluation of the respondents
**Data Analysis**: The researchers will compute the median of the data results from the survey.

## 3. RESULTS AND DISCUSSION

To evaluate the prototype AQUARIUS, the levels of functionality, usability, performance efficiency, and overall quality need to be assessed. A total of 20 respondents, including 15 Arduino Experts and 5 Agriculturists, were asked to evaluate these through a survey with a 4-point Likert Scale, ensuring a definitive stance. The responses will be analyzed using an ungrouped median.

To determine the devices' performance, the researchers obtained the median rating of the responses submitted by the Arduino experts and Agriculturists. The results show that each characteristic received a median of 3 with a descriptive rating of agree. With common results, the concluded level of functionality has an overall rating of agree, with a median of 3. The results indicate a positive result. The Functionality receives a median rate of 3, 3 and 3 under the three sub-questions in the criteria, with an average rate of 3.0. Based on the findings, the researchers were able to conclude that the computed overall rating of the hardware performance was good, with "agree" being the most selected answer in the survey. This shows that the sensors, solar panel and water pump are all reliable and working efficiently to deliver enough water to each crop. The solar panel absorbed enough energy to help the device work efficiently. Lastly, The water pump and solenoid valve delivers water in an organized manner. However this result means that

while the prototype efficiently worked and offered a solution to the problem being addressed, it still needs a little improvement to ensure its performance is most effective.

As for the Usability, the computed median rate is 3, 3 and 3 under the 3 sub questions in the criteria, with an average rate of 3.0 as well. The computed overall rating of the software performance is also good, with “agree” being most answered. This means that the overall control system works in a reliable manner to its users. However this result means that while the prototype efficiently worked and offered a solution to the problem being addressed, it still needs a little improvement to ensure its performance is most effective.

The concluded level of performance efficiency has an overall rating of agree, with a median of 3. The results indicate a positive result. For the Performance Efficiency, each sub-questions For the Performance Efficiency, each characteristic received a median rating of 3, with an overall average of 3.0. Based on the statistical computation, the general performance of the system obtained a descriptive rating of “Agree” indicating that the prototype is effectively working well. This means that the device operates efficiently, with its components working systematically to ensure proper energy consumption, timely water delivery, and reliable IoT responses. However this result means that while the prototype efficiently worked and offered a solution to the problem being addressed, it still needs a little improvement to ensure its performance is most effective. To determine the devices’ performance, the researchers obtained the median rating.

With common results, the concluded level of overall quality has an overall rating of agree, with a median of 3. The results indicate a positive result. The median results of the Functionality, Usability, and Performance Efficiency provided the researchers with the overall median rating for the quality of the prototype. Each characteristic received a median rating of 3 with a descriptive interpretation of “Agree.” This means that the prototype functions properly, usable for its intended purpose, and performs efficiently according to the assessment of the respondents. Therefore, the study concludes that the prototype possesses an overall quality that meets the expected standards of functionality, usability, and performance efficiency. However this result means that while the prototype efficiently worked and offered a solution to the problem being addressed, it still needs a little improvement to ensure its performance is most effective.

## 4. CONCLUSION

The study entitled “Aquarius: An IoT-Based Self-Sustaining Aqua-Secured and Refined Irrigation Utility System” aimed to solve drought and water scarcity. Its purpose and goal was to create an automated machine capable of producing water by using the mechanism of a dehumidifier, implementing a Thermoelectric Cooler (TEC). To conclude this study, the following research questions have been addressed. After the computation of the functionality, usability, and performance efficiency of the Aquarius system through a 4-point Likert scale, the researchers have concluded the overall performance of the irrigation system. The computed evaluation rating of the system was a “3” rating interpretation. This means that the majority of the respondents agreed on the effectiveness of the prototype’s functionality, usability, and performance of the Aquarius system. The precise sensor readings, water delivery, and energy efficiency functions according to the researchers’ engineering goals and aimed results. Therefore, this concludes that the prototype operates as an automated and self-sustaining system.

## 5. RECOMMENDATION

Considering the objective of the study, the following recommendations are suggested:

1. **Include a Digital Hygrometer**
   Incorporate a digital hygrometer to provide accurate measurements of humidity and temperature in the environment. This data and measurement can be a guide for the Thermoelectric Cooler (TEC).
2. **Increase The Power Supply**
   Enhance the power supply to accommodate the increasing energy required, especially when multiple TEC modules are installed.
3. **Utilize a 15x15 or Bigger Heatsink and Fan**
   Utilize a 15x15 heatsink fan and heatsink in the setup to improve the cooling effect of the Thermoelectric Cooler(TEC). This will help maintain the right temperature, prevent overheating, and enhance the performance of the cooling system.
4. **Implement More Thermoelectric Coolers (TEC)**
   Expanding the number of Thermoelectric Cooler (TEC) modules in the setup will increase water production. With more modules, the device can condense more moisture, making it effective for the irrigation system.

## REFERENCES

C2ES. (2023, July 14). Drought and climate change. Center for Climate and Energy Solutions. https://www.c2es.org/content/drought-and-climate-change/

Insights – Philippines – GlobalClimateRisks Platform. (2022). Globalclimaterisks.org. https://globalclimaterisks.org/insights/sdgs-on-thin-ice-blogs/insights-philippines/

Odong, C. (2024, February 21). PAGASA calls on public to conserve water amid drought in CALABARZON.PIA.https://pia.gov.ph/news/2024/02/20/pagasa-calls-on-public-to-conserve-water-amid-drought-in-calabarzo

Santander. (2023, June 20). Drought: A global issue by the droplet. Santander Corporate Website.https://www.santander.com/en/stories/drought?fbclid=IwAR0ydPsxK7bpb1oqrMViYJMIOupnmj2QS0bRty-TFqXteMzkIi6C6Ww-

techZeero. (2020). Soil Moisture Sensor With Arduino | Display values on LCD | Code. TechZeero. https://techzeero.com/Arduino-tutorials/soil-moisture-sensor-Arduino/

Writer, S. (2022, March 30). Components of modern irrigation systems. Pumps Africa. https://pumps-africa.com/components-of-modern-irrigation-systems-work/

# Hydrochar Airblock: Utilizing Water Hyacinth (Pontenderia crassipes) Charcoal for VOC (Volatile Organic Compound) Filtration

De Villa, Felicity Mira B., Matsubara, Masie D., Eugenio, Marcellus Abiel, Amaranto, Rafael O. & Leguarda, Kristin Anne M.

Carmona National High School

*bdriraeli@gmail.com*

**ABSTRACT**
The Philippines deals with contaminated air on a daily basis, affecting both the people and environment. To solve the issue of air pollution, a charcoal made out of the invasive water hyacinth (Pontederia crassipes) species was developed. Overabundance negatively affects agriculture and aquatic life. The water hyacinths are harvested, chopped, and submerged in phosphoric acid for activation. It then underwent pyrolysis which involved burning the acid-treated water hyacinth on high heat for 40 minutes resulting in water hyacinth charcoal. The water hyacinths were attached to a wooden frame of (25.5cmx25.5cmx1.1cm) with layers of fine nylon mesh to avoid release of particles from the filter. The hydrochar airblock was tested alongside a Sqair carbon HEPA filter to determine which filter is more effective in adsorbing VOCs in contaminated air. Adafruit alcohol and VOC gas sensor was used to gain the values of the gas present in the set up, values from the serial monitor was used to get the mean amount of gas for every 15 minutes. For two hours, both the Hydrochar and HEPA filters were exposed to VOCs. After which the raw data values were collected and assessed using ANOVA, Tukey's HSD, and CADR Formula to determine if there is a significant difference between both filters. One-way ANOVA shows no significant difference between the two filters. In conclusion, water-hyacinth derived charcoal performs almost the same as a commercial HEPA filter, with only a 1% difference in performance, showing Hydrochar Airblock absorbed 118.1 ppm of VOC gases compared to HEPA's 111.88 ppm, showing nearly identical results. These results show that hydrochar airblock is on par with HEPA filters in terms of filtration performance, proving that it is a potential solution and alternative to commercial carbon filters.

**Keywords:** Hydrochar airblock, HEPA filter, Volatile organic compound, water hyacinth, pyrolysis

## 1. INTRODUCTION

Air pollution remains a critical problem worldwide, caused by volatile organic compounds (VOC) such as benzene, formaldehyde, 1-,3 butadiene, and Toluene (Nathanson, 2025; UCAR, 2025). In response to the increasing amount of VOCs, conventional air purifiers

such as Heating, Ventilation, and Air Conditioning (HVAC) systems use high-efficiency filters for purification. While HVAC and High Efficiency Particulate Air (HEPA) filters addressed VOCs, their high costs, non-reusable materials, and non-biodegradable wastes (Pradeep Kumar et al., 2023; Gowda, 2022) failed to meet sustainable development goals, which highlighted the need for alternatives such as HYDROCHAR. The development of water hyacinth charcoal made from water hyacinths aimed to offer an affordable and effective air purifier option. Unlike traditional HEPA filters, which require frequent replacements, charcoal provides a more sustainable solution. This study was aligned with the Sustainable Development Goals (SDGs) by promoting better health and well-being to reduce the number of deaths from hazardous pollutants, supporting industrial innovation, improving urban environments, addressing waste generation, and fostering climate-conscious innovation. The goal was to develop an effective air purification product using water hyacinth-derived charcoal. The initiative sought to manage invasive water hyacinths while also addressing air quality concerns, offering a dual benefit for both ecosystems and communities

**Statement of The Problem**

Generally, this study investigates the potential of utilizing water hyacinth-derived charcoal as a sustainable material for air purification through the development of the Hydrochar Airblock. Specifically, this study aims to answer the following questions:

1. What is the total amount of volatile organic compounds (TVOC) left in the following contaminated setups after 2 hours?
    a. Null setup, no application of filters
    b. Set up with HEPA carbon filter
    c. Setup with Hydrochar Airblock
2. How does the testing environment (open area vs. Enclosed chamber) impact the emission behavior of the chemicals under the study?
3. Is there a significant difference between the use of water hyacinth-derived charcoal and standard HEPA filters in purifying volatile organic compounds in terms of filtration performance?

**Significance of The Study**

This study holds significant implications for multiple factors. These factors include environmental management, the utilization of water hyacinth into charcoal, which contributes to lessening economic concerns by using an invasive and harmful plant to create a product that addresses more than one problem. This study also has a significant impact on public health by creating a product that aims to filter VOC gases, which cause respiratory illnesses and other health risks. Results from this study also encourage the development of cost-effective filtration products that potentially degrade the effects of air pollution. Local industries can potentially replicate and scale up this innovation. Different findings from the study may also benefit students and other applications involving academic and scientific studies for further research or improvements to existing studies.

## 2. METHODOLOGY

### Research design

For this study, the experimental research design was used by the researchers, wherein it focuses on determining and comparing the effectiveness of the Hydrochar airblock and Sqair carbon HEPA filter.

Table 1. Conceptual Framework

| Controlled Variable | Independent Variable | Dependent Variable |
|---|---|---|
| - Set up with no filter application | - Hydrochar airblock<br>- HEPA Sqair Carbon Filter | - The air quality was recorded before and after the use of the HYDROCHAR AIRBLOCK.<br>- The air quality was recorded before and after the use of the HEPA Sqair Carbon Filter. |

The process and outcome of the study are shown using the Input-Process-Output (IPO) framework. The process involves subjecting the dried water hyacinth to phosphoric acid treatment, converting it into charcoal, and framing the charcoal for use. The output of the study is a water hyacinth-based charcoal that is capable of purifying air.

Table 2. Research design

| Input | Process | Output |
|---|---|---|
| • Water Hyacinth<br>• Phosphoric acid | • Phosphoric Acid treatment to dried water hyacinth<br>• Turning water hyacinth into charcoal<br>• Framing the charcoal | • A water hyacinth charcoal which is capable of purifying air |

**Collection of Materials-** The researchers collected all the materials needed.
**Preparation of the Wooden Frame-** The researchers designed a wooden frame attachable to wind or air sources like fans. The panels size are (25.5cmx25.5cmx1.1cm).
**Harvesting and Preparation of Water Hyacinth-** Metropolitan Manila Development Authority acquired and cleaned freshwater hyacinth from Marikina Bay, then identified the plants at Far Eastern University.
**Acid treatment of water hyacinth-** The researchers activated the water hyacinths using phosphoric acid.
**Charcoal Processing of Water Hyacinths-** The water hyacinths was burnt using a big stove under high temperature for 2 days, done in an open area with low population.
**Production of Water Hyacinth Filter-** The water hyacinth charcoal was secured in the wooden frame, finalizing the product.
**Testing the Product-** The filter was tested in a simulated set up of household condition with adafruit voc gas sensor to give values of the gases present in the set up.
**Data Collection-** For a period of 2 hours, each setup is subjected to VOC exposure through small samples of nail polish, primer, and gasoline in separate plastic containers, raw data was gathered every 15 minutes.
**Data Analysis-** Once the data from the experimentation is obtained, the statistical tests help to verify whether the differences in the filtration efficiency between the Sqair carbon filter and the charcoal are statistically significant.
**Waste Disposal-** Once the data collection is over, the materials that have been utilized for creating the product are discarded or retained for ongoing studies.

## 3. RESULTS AND DISCUSSION

### a. Sub-problem 1

Data collected shows that for each setup, there was approximately 211.63 ppm of VOC gases released in the null setup. Same amount of contaminants were placed, therefore each setup had 211.63 ppm of VOC gas to remove. For the setup with HEPA filter, only 99.75 ppm of VOC gas was left after 2 hours, while the Hydrochar Airblock had 97.28 ppm left. This shows that both filters performed effectively, with Hydrochar Airblock being slightly higher. The data indicates that Hydrochar Airblock works efficiently and performs similarly to the commercial HEPA carbon filter.

Table 3. Total amount of VOC present after 2 hours

| Setups | Amount of VOC present after 2 hours (ppm) |
|---|---|
| Open area | 111.67 |
| Null | 211.63 |
| With HEPA | 99.75 |
| With Hydrochar Airblock | 97.28 |

Table 4. Total amount of VOC removed after 2 hours

| Setups | Amount of VOC removed after 2 hours (ppm) |
|---|---|
| With HEPA | 111.88 |
| With Hydrochar Airblock | 118.1 |

### b. Sub-problem 2

Data was collected by performing two tests (open area and enclosed chamber) eight times for 15 minutes each. A T-Test was conducted to determine whether the results had a significant difference. Results showed that the testing chamber mean was 157.5476, while the open area mean was 19921.4285. The p-value obtained was 0.0665, which is greater than 0.05. Thus, there is no significant difference between the open and enclosed environments in terms of emission behavior.

Table 5. T-test result

| | Open | Testing |
|---|---|---|
| Mean | 111.795 | 211.5 |
| Variance | 157.5476286 | 19921.42857 |
| Observations | 8 | 8 |
| Pooled Variance | 10039.4881 | |
| Hypothesized Mean Difference | 0 | |
| df | 14 | |
| t Stat | -1.990174461 | |
| P(T<=t) one-tail | 0.033233487 | |
| t Critical one-tail | 1.761310136 | |
| P(T<=t) two-tail | 0.066466975 | |
| t Critical two-tail | 2.144786688 | |

### c. Sub-problem 3

One-way ANOVA results show that there is no significant difference between Hydrochar Airblock and HEPA carbon filter in their ability to filter VOC gases. Both filters reduced nearly the same amount of VOC gases after 2 hours. Therefore, the null hypothesis is

accepted. Hydrochar Airblock achieved 54% efficiency, while HEPA carbon filter achieved 53%, showing only a 1% difference in performance.

Table 6. One-way ANOVA result

| Source of Variation | SS | df | MS | F | P-Value | F crit |
|---|---|---|---|---|---|---|
| Between Groups | 68717.58 | 2 | 34358.79 | 4.6928 | 0.0206 | 3.4668 |
| Within Groups | 153751.4 | 21 | 7321.494 | | | |
| Total | 222469 | 23 | | | | |

Table 7. Post-hoc test result

| Treatments pair | Tukey HSD Q Statistics | Tukey HSD p-value | Tukey HSD Inference |
|---|---|---|---|
| N/A vs HEPA Filter | 3.7229 | 0.0395858 | P < 0.05 |
| N/A vs Water Hyacinth | 3.7807 | 0.0363225 | P < 0.05 |
| HEPA filter vs Water Hyacinth | 0.0578 | 0.8999947 | insignificant |

Table 8. Filtration performance result (HEPA)

| Calculation | Result |
|---|---|
| (211.63 - 99.75) / 211.63 × 100 | 53% |

Table 9 Filtration performance result (Hydrochar Airblock)

| Calculation | Result |
|---|---|
| (211.63 - 97.28) / 211.63 × 100 | 54% |

## REFERENCES

Harun, I., Pushiri, H., Amirul-Aiman, A. J., & Zulkeflee, Z. (2021). Invasive Water Hyacinth: Ecology, Impacts and Prospects for the Rural Economy. Plants (Basel, Switzerland), 10(8), 1613. https://doi.org/10.3390/plants10081613

Jing, Z. (2024). What is the VOC Emission Test Chamber? - ChiuVention. ChiuVention. https://chiuventionclimatechamber.com/blog/what-is-the-voc-emission-test-chamber?fbclid=IwY2xjawMx2yBleHRuA2FlbQIxMABicmlkETFyRGxhMGtaRm43YjdTZDZBAR5EyZ5TaNJEsfppk7v3doTUDP-mLCec8ZXarl6Kf7njDKDWCoYEQZDPfAYbOA_aem_1zm1qM5f8P48-l5XhXrIgg

John, B. J., Harish, C., Lawrence, C. C., Krishnakumar, S., Divakaran, S., Premkumar, J., Kanmani, P. G., Sabarivani, A., & Jagadeesan, A. K. (2022). Monitoring indoor air quality using smart integrated gas sensor module (IGSM) for improving health in COPD patients. Environmental Science and Pollution Research, 30(11), 28889–28902. https://doi.org/10.1007/s11356-022-24117-y

Lin, C., Kuo, Y., Lin, M., Lin, J., Tsai, P., Lin, C., Huang, S., & Chen, C. (2024). Experimental study on optimal clean air delivery rate filter thickness of indoor air purifiers. Aerosol and Air Quality Research, 24, 240149. https://doi.org/10.4209/aaqr.240149

Sari, Lindah & Suparno, & Fatharani, Mirra & Pahlepi, Dwi & Adrizal, Mohd & Luliyanti, Dian. (2020). Effectiveness of air filter equipment based on water Hyacinth on combustion smoke. Journal of Physics: Conference Series. 1511. 012061. 10.1088/1742-6596/1511/1/012061.

# Project SUHAY+: Smarter Urban Hydroponics via AI Monitoring and Generative Feedback for Improved Agricultural Yield

Bagorio, Nicole Mary C., Dizon, Ana Rhianne V., Garcia, Precious Nicole, Legaspi, Dennise Aine Robin V. & Ma. Christina L. Mananap

Carmona National High School

*nicolemarybagorio@gmail.com*

**ABSTRACT**
Urban agriculture in the Philippines continues to face major challenges, including limited space and the rising need for sustainable food sources. To help address this, Project SUHAY+ was developed—an IoT-based hydroponics prototype using the ESP32 microcontroller, C++ programming, and the Blynk app. It features advanced image monitoring and automated nutrient dispensing, designed to improve urban farming through real-time data and AI-assisted feedback. The system uses hydroponics, a water-efficient method of growing plants without soil, ideal for space-limited urban settings. This project supports several United Nations Sustainable Development Goals, particularly in sustainable food production (SDG 2.4), technological innovation (SDG 9.5), sustainable cities (SDG 11.3), and climate resilience (SDG 13.1). By offering accurate monitoring and automated care, Project SUHAY+ aims to boost crop yield and reduce the manual work involved in urban farming. The research focused on three main aspects: hardware, software, and the overall usability of the system. A quantitative approach was used, with a 4-point Likert scale for evaluation. Feedback from 10 electronics engineers and 5 agriculturists showed ratings of 3.00 for hardware (agree), 4.00 for software (strongly agree), and 3.50 for general performance (agree). These results suggest that Project SUHAY+ has strong potential to improve urban farming practices and help make food production in cities more efficient and sustainable.

**Keywords:** Hydroponics, Agriculture, IoT, Automation, Farming.

## 1. INTRODUCTION

Urbanization in the Philippines continues to expand rapidly, and with it comes the loss of valuable farmlands and food supplies. Today, around 42% of Filipinos live in urban areas, and this number is expected to grow in the coming years (Chowdhury et al., 2021). As cities develop, farmlands are being replaced by infrastructure, leading to a possible reduction in food production, overcrowding, pollution, and fewer green areas. According to the Department of Agriculture, 10–20% of city land has the potential to be used for

growing food (Ochave, 2020). However, much of this land remains underutilized, largely due to the lack of access to proper technologies and support systems.

One solution to this problem is hydroponics, a way of farming through the use of nutrient-rich water instead of soil. This method creates a way to grow crops with less space required. To further enhance hydroponics, Project SUHAY+ was developed, aiming to monitor and provide necessary nutrients that the plant needed through leaf color detection that the artificial intelligence (AI) uses. The prototype features ChatGPT to enhance image processing while AI focuses on identifying leaf color to determine the plants health and respond accordingly.

According to the United Nations Sustainable Development Goals (SDG), the study aligns with goals such as ensuring sustainable food production and resilient agriculture to combat hunger (SDG 2.4), enhancing scientific research and technological innovation, especially in developing countries (SDG 9.5), promoting inclusive and sustainable urbanization and planning (SDG 11.3), achieving sustainable management and efficient use of natural resources (SDG 12.2), and strengthening resilience and adaptive capacity to climate-related hazards and natural disasters (SDG 13.1).

## 2. LITERATURE REVIEW

### *2.1. Agriculture and Urbanization in the Philippines.*

Urban agriculture has gained attention as a sustainable farming practice in urban areas, offering ecological, health, and community benefits (Orsini, 2022). However, rapid urbanization in the Philippines has led to a decrease in available agricultural land, especially in Metro Manila (Bravo, 2017). The lack of clear policies and resources further hinders the growth of urban farming (De Guzman, 2017). Despite these challenges, many residents support urban farming for its economic and social benefits (Cortes et al., 2022), suggesting potential for growth with proper support and education.

### *2.2. AI and IoT in Agriculture*

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in agriculture has significantly improved precision farming, automation, and real-time monitoring. Several studies have explored these advancements. Sihombing et al. (2019) developed an automated hydroponics system with an Arduino microcontroller to automatically control nutrients being supplied to plants using if-else statements. SUHAY+ referenced a similar approach using an Arduino system; however, SUHAY+ focused on plant health assessment by analyzing a camera's visual data and a manually controlled nutrient dispensing system through the Blynk application.

### *2.3. Hydroponics and Urban Agriculture.*

Hydroponics, particularly Nutrient Film Technique (NFT) and Deep Water Culture (DWC), can provide more efficient nutrient delivery and oxygenation to plant roots, potentially leading to faster growth. In the Philippines, initiatives like SNAP Hydroponics (Department of Science and Technology, 2023) and Quezon City's Urban Agri Hydro Hub (Curdis, 2021) have demonstrated the viability of hydroponic systems for urban agriculture. However, challenges in scaling production and maintaining nutrient delivery persist. With

this, the researchers presented the SUHAY+ device as an innovative approach to urban agriculture by integrating hydroponics with artificial intelligence (AI) monitoring.

## 3. METHODOLOGY

### *Preparation of Materials*

The electronic and hydroponic components were procured from various physical and online shops. Electronic components such as the ESP32 Microcontroller, ESP32 Shield, Buck Converter, Solar Panel, Lithium-ion Battery, LED Module, 4-channel Relay Module, Water Level Sensor, Water Pump, and a Logitech Web Camera were sourced from Aidan's Lab Electronics, Circuit Rocks, and MakerLAB Electronics. For the hydroponic system, a complete kit was acquired from JC's Green Garden via Shopee, which included a grow box with 9 holes, 9 Styrofoam cups with slits, granular SuperBlend nutrients, 1 kg of Cocopeat and Vermicast, a seedling tray with 32 holes, measuring tools, and assorted vegetable seeds such as lettuce, pechay, kangkong, and mustasa.

### *System Design and Development*

The design process began with a 3D model created using Autodesk TinkerCAD, serving as the reference for the system's physical structure and layout. Figure 1 below illustrates the 3D design of Project SUHAY+

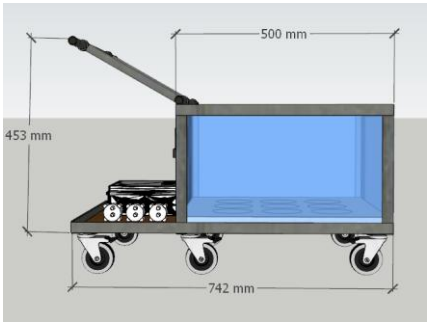


Figure 1: Right-Side View of The Prototype

### *System Testing*

Project SUHAY+ underwent two phases of testing: pilot and actual system testing. In the pilot phase, individual components, such as pumps, relays, sensors, and the camera, were tested to ensure they functioned properly. After successful individual tests, the system was assembled and tested as a whole. The nutrient dispensing system was activated using the Blynk mobile application, allowing manual control of three pumps: two for nutrient solutions and one for water. Each pump delivered liquid from designated containers to the grow box via PVC tubing, while a webcam captured top-down images of the plants. These images were processed using a Python script and the OpenCV library to classify plant health based on HSV color analysis. Health statuses were displayed via the Blynk app, and data from each session was automatically logged in an Excel file for performance monitoring and nutrient management.

***Evaluation***

The system was evaluated by 15 selected experts using purposive sampling: 10 electronic engineers assessed the system's hardware performance, and 5 agriculturists focused on evaluating the plant health monitoring feature. Participants were provided with a video presentation of the prototype and a survey rating form to assess system performance. Responses were interpreted using a 4-point Likert scale, and the median was applied as the statistical treatment to determine the central tendency of their feedback.

Table 1. 4-point Likert Scale

| Rating Scale | Range | Descriptive Rating |
|---|---|---|
| 4 | 4.00 | Strongly Agree |
| 3 | 3.99-3.00 | Agree |
| 2 | 2.99-2.00 | Disagree |
| 1 | 1.99-1.00 | Strongly Disagree |

## 4. RESULTS & DISCUSSIONS

The calculated median rating of Project SUHAY+, as perceived and validated by the respondents, is presented in Table 2 below.

Table 2. Median Results of the Hardware, Software and General Performance

| **Performance Categories** | **Median** |
|---|---|
| Hardware Performance | 3.00 |
| Software Performance | 4.00 |
| General Performance | 3.50 |

The evaluation of Project SUHAY+ revealed that it performs well in achieving the goal of sustainable agricultural innovation. With a hardware rating of 3.00, the prototype has a satisfactory hardware, showing its ability to support agricultural operations. Its software, rated at 4.00, demonstrates good accuracy and reliability in software functions, giving farmers real-time and actionable insights. The overall performance rating of 3.50 indicated effective general performance.Compared with similar technologies and techniques, Project SUHAY+ performs well with other agricultural automation systems, highlighting its adaptability and precision. Overall, the result shows that while the prototype has strong potential, further improvements in hardware and software could increase its reliability and scalability. Moreover, Project SUHAY+ is a forward-looking solution that can address real agricultural challenges, promote sustainable farming, and contribute to future green innovation.

## REFERENCES

Chowdhury, M. K., Shopna, K., Lynch-Godrei, A., Jain, M., Farheen, N., Begum, N., Ahmad, N., & Doherty, M. (2021). Providing Home-Based Support for Children with Chronic Conditions in an Urban Slum: Experiences from a Community-Based Palliative Care Program in Bangladesh. Global Pediatric Health, 8, 2333794X2199915. https://doi.org/10.1177/2333794x21999155

Cortes, S. T., Bugtai, V. H., Lampawog, E. Q., Sadili, C. B., Agero, A. D., Ramas, C. B., ... & Lorca, A. S.(2022). Assessing problems and prospects of urban agriculture in Cebu City, Philippines: towards developing action plans. Journal of Nusantara Studies (JONUS), 7(1), 264-291.

Curdis, C. (2021). The Philippines 1st Urban Farming Hydroponic Hub To Address Food Shortages. Agritecture. https://www.agritecture.com/blog/2021/11/12/the-philippines-1st-urban-farming-hydr
oponic-hub-to- address-food-shortages

Bravo, M. R. (2017). Urbanization in the Philippines and its influence on agriculture. Sustainable landscape planning in selected urban regions, 97-110.Briones, R. M. (2021). Impacts of natural disasters on agriculture, food security, and natural resources and environment in the Philippines (No. 2012-36). PIDS discussion paper series.

Department of Science and Technology - STII. (2023, July 21). Urban agriculture technology may answer the problem of lack of space for vegetable production. https://www.stii.dost.gov.ph/1718-urban-agriculture-technology-may-answer-the-problem-of-lack-of-space-for-vegetable-production

De Guzman, C. C. (2017). Urban Agriculture in the Philippines: Initiatives, practices, significance, and threats. Sustainable landscape planning in selected urban regions, 187-197.

Ochave, D. (2020, June 1). About 10–15% of city land is viable as urban farms. BusinessWorld Online. https://www.bworldonline.com/editors-picks/2020/06/01/297162/about-10-15-of-city-land-viable-as-urban-farms/#google_vignette

Orsini, F., & D'Ostuni, M. (2022). The important roles of urban agriculture. Frontiers for Young Minds, 10.https://doi.org/10.3389/frym.2022.701688

Sihombing, P., Karina, N. A., Tarigan, J. T., & Syarif, M. I. (2018). Automated hydroponics nutrition plant systems using Arduino uno microcontroller based on Android. Journal of Physics: Conference Series. https://iopscience.iop.org/article/10.1088/1742-6596/978/1/012014/meta

# Smart Finance Management with AI Insights

Foo Kar Ting, Wong Shu Qing & Khairunnisha Binti Ismail

Southern University College

*d230190C@sc.edu.my*

**ABSTRACT**
In the modern digital era, personal finance management has grown in complexity, most individuals experience difficulties when it comes to keeping track of income, expenses, and financial goals. The following project, Smart Finance Management with AI Insights, aims at creating a mobile application that utilizes artificial intelligence in the provision of personalized insights into finances. The application will address issues of financial literacy, lack of enough financial analysis, and insufficient financial planning guidance. Core features include expense tracking, budgeting, tracking of income and savings, and bill reminders. It also provides interpretation using AI for the user's spending habits and advises ways for improvement. The design integrates the use of advanced visual analytics intuitively in order to present data in an engaging manner. Key technologies include Flutter for cross-platform development, and Firebase for data management, and Google Calendar for seamless reminders. This initial prototype focuses on user-centric design to guarantee ease of use and functionality. With an objective of improving financial management for young adults, this project will free users from bad management practices that decrease control over one's financial health. Further versions will see improvements in AI, feature development, and cloud scaling

**Keywords:** personal finance, AI insights, budgeting, financial tracking, mobile application

## 1. INTRODUCTION

In today's digital economy, managing personal finances has become increasingly complex due to rising living costs, diversified income sources, and the unpredictability of economic fluctuations. Traditional financial tracking methods, such as spreadsheets or manual record-keeping, are no longer sufficient to meet the demands of modern financial behavior. With the advancement of Artificial Intelligence (AI), smart financial systems are now capable of processing large volumes of data and providing behavior-driven insights. This paper introduces a mobile application, **Smart Finance Management with AI Insights**, designed to help users—particularly young adults—enhance their financial literacy, receive personalized advice, and effectively monitor and plan their financial activities.

## 2. LITERATURE VIEW

Existing literature highlights a significant global gap in financial literacy, particularly among youth and in developing regions. Stolper and Walter (2017) found that only 35% of adults in high-income countries answered all three basic financial literacy questions correctly, with the rates dropping to 13% in middle-income nations and just 4% in transition economies. Similarly, financial literacy rates are below 25% in South Asia (Klapper, Lusardi, & Van Oudheusden, 2015, as cited in Kirti & Satish, 2020). Despite the growing popularity of personal financial management (PFM) applications such as Mint, You Need a Budget (YNAB), and Personal Capital, users often underutilize these tools due to limited financial knowledge (Paula Bitrián et al., as cited in QYResearch, 2019). In 2019, financial apps accounted for 5% of all global downloads and were accessed over a trillion times (Paula Bitrián et al., as cited in AppsFlyer, 2020; App Annie, 2020). The global market for PFM tools was valued at USD 1,449.9 million in 2018 and is projected to reach USD 3,338.8 million by 2025 (Paula Bitrián et al., as cited in QYResearch, 2019).

In Malaysia, many young users face significant challenges with saving and debt management (NORHASBI et al., as cited in Malaysian Department of Insolvency, 2019). reported that 20% of employed Malaysians had not saved any money in the previous six months, and 52% lacked emergency funds of RM1,000. Furthermore, over 84,000 Malaysians were declared bankrupt between 2015 and 2019, with 26% of those under the age of 34 (Sabri et al., as cited in New Straits Times, 2020).

To address these challenges, this project adopts a mobile-first, user-centric approach using Flutter for cross-platform development and Firebase for backend integration. The application offers key functionalities such as expense tracking, income and savings logging, budget planning, and bill reminders via Google Calendar integration. Users can also set financial goals and receive AI-generated insights into their spending behaviors. The AI functionality, built using rule-based systems and scalable cloud AI services (e.g., Google Cloud AutoML), provides personalized recommendations to help users manage their finances more effectively.

## 3. METHODS

This project adopts Agile Development as the core methodology due to its flexibility and responsiveness to changing user needs. Agile divides the development process into short iterations, with each cycle delivering a working version of the smart financial management application. This allows for early testing, quick feedback, and continuous improvement.

Through frequent collaboration with users, feedback is gathered after each iteration to guide feature refinement and future development. Core functions such as income and expense tracking are prioritized first, followed by advanced features like graphical analysis and reminders. Agile's iterative nature enables early deployment of usable versions, reducing time-to-market and ensuring the system evolves based on real user requirements.

## 4. RESULTS AND DISCUSSION

The survey collected responses from 17 participants, primarily university students aged between 18 and 25. As shown in Table 1, most users already have the habit of tracking their personal finances, and the majority use smartphones as their primary device. This suggests that a mobile-first app is highly suitable for the target audience.

Regarding usability, most respondents found the app easy to use. As illustrated in Table 2, over 52.9% of users were able to add income or expense records without difficulty, and more than 80% appreciated features like the bill reminder and the intuitive interface. These results demonstrate that the app successfully addresses common pain points in manual financial tracking.

When asked about which financial activities they usually track, users most commonly selected income, expenses, savings, and bills. Figure 1 illustrates these commonly tracked financial activities. When asked about which features were most useful, users indicated a preference for functionalities such as income/expense management and bill reminder notifications. Figure 2 summarizes the most preferred features. On the other hand, a few users reported challenges with setting up recurring bills or exporting PDF reports. This feedback highlights specific areas where the user experience can be further improved.

Table 1: User Demographics and Financial Habits

| **Question** | Most Selected Response | Percentage |
|---|---|---|
| Age Range | 18-25 years old | 76.5% |
| Gender | Male | 58.8% |
| Current Occupation | Student | 58.8% |
| Monthly Income Range | Below RM 1000 | 52.9% |
| Habit of tracking income /expenses | Yes | 58.8% |
| Used financial apps before | Yes | 58.8% |
| Frequency of managing finances | Daily | 41.2% |
| Device used for managing finances | Mobile phone | 70.6% |

Source: Author's own survey data (2025)

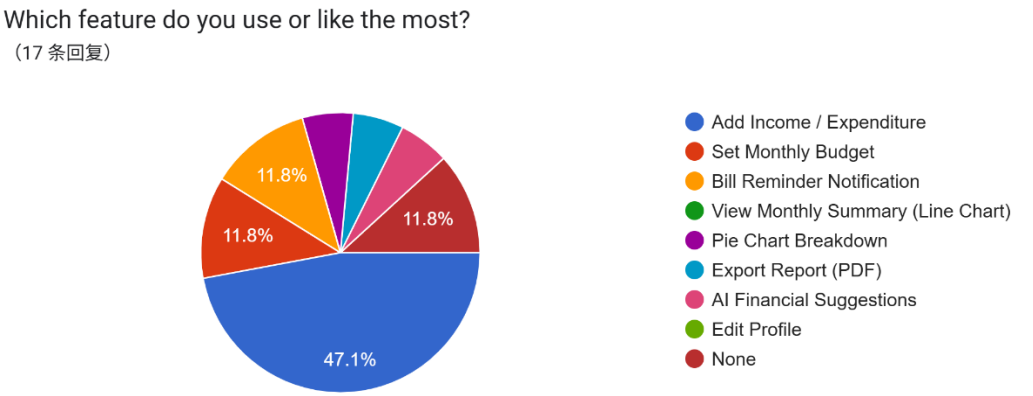


Figure 1: Most Preferred Features of the App Among Users

## 5. CONCLUSIONS

This study highlights the increasing need for intelligent financial management solutions among users, particularly those seeking features such as AI-driven suggestions,

personalized budgeting tools, and bill tracking. The majority of users prefer applications that provide real-time financial insights and intuitive interfaces, suggesting a clear trend toward mobile-first and user-centered design in personal finance applications.

However, certain exceptions were noted—some users reported difficulties setting up recurring bills or exporting reports, indicating that even advanced users may struggle with specific functionalities if not designed intuitively.

These findings have both practical and theoretical implications. Practically, they guide future improvements in smart financial application design, emphasizing the need for clear instructions and seamless feature integration. Theoretically, the results contribute to a better understanding of user behavior and expectations in the digital finance domain.

In conclusion, while the app generally meets users' expectations and supports effective financial management, enhancing usability in a few key areas could further improve user satisfaction. Future development should focus on refining recurring billing, simplifying report export processes, and expanding AI-based financial guidance.

## REFERENCES

Bitrián, P., Buil, I., & Catalán, S. (2021). Making finance fun: The gamification of personal financial management apps. *International Journal of Bank Marketing, 39*(7), 1310–1332. https://doi.org/10.1108/ijbm-02-2021-0074

Chong, K. F., Sabri, M. F., Magli, A. S., Rahim, H. A., Mokhtar, N., & Othman, M. A. (2021). The effects of financial literacy, self-efficacy and self-coping on financial behavior of emerging adults. Journal of Asian Finance, Economics and Business, 8(3), 905–915. https://doi.org/10.13106/jafeb.2021.vol8.no3.0905

Money attitude and socio-demographic factors as determinants of university students' spending behavior in Shah Alam, Malaysia. (2021). https://www.researchgate.net/profile/Jamilah-Kamis/publication/350701248_MONEY_ATTITUDE_AND_SOCIO-DEMOGRAPHIC_FACTORS_AS_DETERMINANTS_OF_UNIVERSITY_STUDENTS_SPENDING_BEHAVIOR_IN_SHAH_ALAM_MALAYSIA_JAMILAH_KAMIS_NORHASBI_ABDUL_SAMAD_LEE_SIEW_PHENG_SALINA_RASLI_SALBIAH_HANU/links/606db137299bf1c911b1f887/MONEY-ATTITUDE-AND-SOCIO-DEMOGRAPHIC-FACTORS-AS-DETERMINANTS-OF-UNIVERSITY-STUDENTS-SPENDING-BEHAVIOR-IN-SHAH-ALAM-MALAYSIA-JAMILAH-KAMIS-NORHASBI-ABDUL-SAMAD-LEE-SIEW-PHENG-SALINA-RASLI-SALBIAH.pdf?origin=journalDetail

Stolper, O. A., & Walter, A. (2017). Financial literacy, financial advice, and financial behavior. Journal of Business Economics, 87(5), 581–643. https://doi.org/10.1007/s11573-017-0853-9

# Missing Pet Finder with AI Image Recognition

Khairunnisha Binti Ismail[1], Gui Kai En[2] & Goh Kiat Meng[3]

Southern University College

*khairunnisha@sc.edu.my*

**ABSTRACT**
The increasing number of missing pets causes emotional distress for owners; this is the main reason we develop a mobile application integrated with AI Image Recognition to simplify the process of reuniting pets. The objective is to increase the chance and efficiency of finding missing pets by leveraging technologies. Our application enabling users to upload or capture a pet photo to be analysed, match and generate a list of missing posts with similar breed to the photo. We applied Agile SDLC Methodology in our development process for iterative revision and improvement to ensure application quality and alignment with our goals. Findings indicate that AI Image Recognition and real-time alert technology significantly increases accuracy and reduces time required for reuniting a missing pet. For future improvements, facilitating the collaboration with local pet stores and repolished reward system can enhance the motivation and retention of users. In conclusion, our application can provide a supportive platform for reuniting pets and building cohesion among communities.

**Keywords:** personal finance, AI insights, budgeting, financial tracking, mobile application

## 1. INTRODUCTION

The number of missing pets nowadays has constantly drawn attention from all sides and brought great mental pain to those pet owners who are striving to find their pets. Many traditional search methods are too inefficient and often rely on physical posters or unstructured social media posts. This project has proposed a mobile application called " Missing Pet Finder with Artificial Intelligence Image Recognition", aiming to solve this problem by leveraging advanced digital technology. A review of similar systems, such as PetFinder, reveals that applications like 'My Pet' and 'Lost Pet' lack AI integration, have limited notification features, and offer minimal community engagement options. By integrating image recognition, real-time notifications, and user collaboration tools, the proposed system provides a comprehensive approach. The methodology used is Agile SDLC, which supports adaptive development and combines iterative testing and user feedback.

## 2. LITERATURE REVIEW

### 2.1 Background

This missing pet finder mobile application is aimed to provide a channel for pet owners to report their missing pets and to let pet finders that are interested and willing to help to take part in the search of the missing pet in a convenient way by using mobile devices. As many pets are missing every day, the app surely can be a platform for addressing the emotional and logistical challenge for pet owners as they now have a platform to communicate with other pet lovers. When a pet goes missing, pet parents may be faced with many unanswered questions surrounding the fate of their beloved animals and this can make closure very difficult. In addition to feelings of sadness and loneliness, those missing a pet may experience intense feelings of fear, guilt, and anger. There are many pet loss and missing pet support groups available online through Facebook. If you cannot find one that is the right fit for you, you could start your own support group in honour of your beloved pet. These groups can provide both validation and support during this stressful time. (Dr. Vanessa Rohlf, 2018). But what's posted can't get out to everyone faster because Facebook includes so much stuff. So having a mobile app dedicated to finding pets makes it easier for pet owners to get it out to everyone faster.

### 2.2 Problem Statements

1. Low possibility to find back missing pets

At least 15% of cat owners lose their pet in a five-year period and some are never found. This paper reports on data gathered from an online questionnaire that asked questions regarding search methods used to locate missing cats and locations where missing cats were found. The most important finding from this retrospective case series was that approximately one third of cats were recovered within 7 days. Secondly, a physical search increased the chances of finding cats alive and 75% of cats were found within a 500 m radius of their point of escape. Conclusions, there is about a 33% chance that a missing cat will be found within 7 days, and about 56% by 2 months; few cats are recovered after that. (Liyan Huang et al., 1995)

2. False information and the attempt to scam regarding the found pet

The case states that Woolveridge, a person was jailed for blackmailing individuals over their missing pets for scamming the bounty offered for finding and return the missing pets, he used many tactics including demanding money for vetting a pet. To avoid this kind of issue to happen, our application provides various way of verification before pet owner issues the bounty of finding pet to the reporter such as they could use video call features to verify the current location and status of pet or using image recognition features. (Guardian News & Media Limited, 2024)

3. No place to reduce the pressure and stress of losing a pet

The study studies 39 participants who had experienced the disappearance of a pet and highlights the unique emotional challenges of ambiguous pet missing which refers to the missing pet without the confirmation of its death which contribute to the stress level and

tightness for them. They often revealed significant correlations between pet attachment and grief intensity, and the hope for reunite, the long waiting period without clear outcome can also increase their anxiety. To address this issue, our application provides group chat feature to share and exchange information regarding the missing pets. (Ash Brumett, 2023)

### 2.3 Objectives

I. To design a user-friendly interface that simplifies the process of finding missing pets so that the application is easy to use for a diverse range of users.
II. To develop an image recognition feature that allow users to upload and scan the photo of missing pet to provide a more accurate and reliable information exchange between users.
III. To implement a rewarding system that can capture the interest and engage the users into the search of missing pets.

### 2.4 Sustainable Development Goals (SDGs)

- SDG 9 - Industry, Innovation, and Infrastructure
  Help protecting animation, reducing the number of lost animals that might face harm or contribute to stray populations.
- SDG 11-Sustainable Cities and Communities
  Encourage responsible pet owners, reduce the number of stray pets, and use group chats to allow nearby users to communicate and search for lost pets
- SDG 15-Life on Land
  Utilize artificial intelligence image recognition technology to help identify lost pets

## 3. METHODS

In our development process, Agile SDLC methodology is applied. It allows project breakdowns into milestone phases for iterative revisions and improvements, foster adaptability, and maintaining alignment with goals. There are six phases in our methodology. The first phase is the Requirement collection phase, we identify the requirements, goals, and outcomes thorough our project. The second phase is the Analysis phase, where we assess and evaluate the potential risks during our development phases. The third phase is the Designing phase, we build the prototype, blueprint, and architecture for our application. The fourth phase is the Coding phase, we start to build our application piece by piece using pre-identified tools. The fifth phase is the Testing phase, we test and validate the functionalities of our application. The sixth phase is the Maintenance phase, we focus on maintaining, updating, and improving the features of our application.

## 4. RESULTS AND DISCUSSION

We have tested our application's AI Image Recognition features with a total of 100 photos, with 10 of each breed among cats and dogs. The system analyzed and achieved a result of average Top 1 accuracy of 30%, Top 3 accuracy of 30%, not identified of 40%, showing bad performance in identifying pet breeds. Among the breeds, Pomeranian dog is the most recognized by our model, while Ragdoll cat can barely recognized.

Table 1. Pet breed classification accuracy test

| Breed | Top 1 Match | Top 3 Match | Not identified |
|---|---|---|---|
| Golden Retriever | 30% | 30% | 40% |
| Chihuahua | 50% | 20% | 30% |
| Pomeranian | 70% | 10% | 20% |
| Poodle | 40% | 40% | 20% |
| German Shepherd | 20% | 30% | 50% |
| British Shorthair | 30% | 50% | 20% |
| Sphynx | 20% | 20% | 60% |
| Ragdoll | 0% | 50% | 50% |
| Exotic Shorthair | 30% | 10% | 60% |
| Devon Rex | 10% | 40% | 50% |
| Average | 30% | 30% | 40% |

We conducted User Acceptance Testing (UAT) using Google Forms, we had collected a number of feedback regarding aspects of our application such as is the UI design appealing? How is the accessibility of our application? The accuracy of our AI Image recognition? Among 6 participants, it shows that our UI is appealing to and acceptable by users, 50% felt very appealing, 33% somewhat appealing while neutral for remaining 17%. In addition, among the participants, 50% of them did not try our AI image recognition feature, 33% think it is mostly accurate and 17% think it is occasionally incorrect when recognizing the cat or dog breed that is taken or uploaded by users.


Figure 1. Appeal Regarding UI Design


Figure 2. Accuracy of AI Image Recognition Feature

## 5. CONCLUSIONS

This project shows that the combination of AI image recognition with real-time notifications significantly improves the efficiency and accuracy of finding lost pets. The main conclusion is that artificial intelligence can effectively assist in identifying and tracking lost pets, providing a more reliable solution than traditional search methods. Although it seems fine, there are still some challenges, such as relying on high-quality images for accurate recognition, and the performance of artificial intelligence models may be limited when dealing with diverse pet features. From a practical point of view, this approach has the potential to be widely used in the field of pet retrieval and is expected to inspire future systems in other fields that require visual identification. The results also show that continuous improvement of AI models is crucial to improve overall accuracy. Looking ahead, it is recommended to focus on enhancing the accuracy of artificial intelligence recognition and optimizing the user interface to achieve accessibility.

## REFERENCES

Ash Brumett, (2023). When a Pet Goes Missing: An Exploratory Study on Ambiguous Pet Loss. https://www.proquest.com/openview/94ba88c73b971abca5463998bb03e41e/1?cbl=18750&diss=y&pq-origsite=gscholar

Dr. Vanessa Rohlf, (2018). The Lost Good-Bye: Grieving missing companion animals. https://drvanessarohlf.com.au/2018/01/15/lost-good-bye-grieving-missing-companion-animals/

Guardian News & Media Limited, (2024). Man jailed for missing pet scam blackmailed victim again days after release. https://www.theguardian.com/uk-news/2024/oct/25/brandon-woolveridge-out-of-jail-early-blackmail-previous-victim

Liyan Huang, Marcia Coradini, Jacquie Rand, John Morton, Kat Albrecht, Brigid Wasson, Danielle Robertson, (2018). Search Methods Used to Locate Missing Cats and Locations Where Missing Cats Are Found. https://pmc.ncbi.nlm.nih.gov/articles/PMC5789300/#sec5-animals-08-00005

Nikola Sekulic, (2023). 6 Stages of the Agile Software Development Lifecycle. https://www.gitkraken.com/blog/6-stages-of-agile-development

Sarah Laoyan, (2024). What is Agile methodology? (A beginner's guide). https://asana.com/zh-tw/resources/agile-methodology

# EcoQuest – Gamified Environmental Behavior Platform

Wong Wen Jun & Khairunnisha Binti Ismail

Southern University College

*b240041A@sc.edu.my*

**ABSTRACT**
Environmental awareness has grown rapidly in recent years, yet there remains a persistent gap between knowledge and consistent pro-environmental behavior. Traditional approaches such as posters, one-day campaigns, and lectures often fail to sustain long-term engagement, especially among younger generations who are more motivated by interactive and gamified experiences. To address this issue, this project proposes **EcoQuest**, a gamified environmental behavior platform designed to transform eco-friendly actions into fun, measurable, and rewarding experiences. The objective of EcoQuest is to encourage sustainable habits by allowing users to log activities such as taking public transport or practicing waste reduction through two methods: QR code clock-in and AI-based photo recognition. These actions generate virtual fertilizer that nurtures a digital tree, which grows through multiple animated stages, eventually blossoming into flowers that can be converted into points. Users may redeem these points for vouchers or environmental contributions, while also participating in leaderboards, achievements, and friend challenges to boost motivation and social interaction. The platform is developed using Flutter for the mobile application, Laravel for backend management, and MySQL for data storage, supported by an administration panel for task and merchant management. The novelty of EcoQuest lies in its integration of gamification, AI recognition, and reward systems into one cohesive platform, bridging the gap between awareness and action. By combining education, engagement, and incentives, EcoQuest has the potential to promote large-scale behavioral change, foster collaboration between users, merchants, and organizations, and ultimately contribute to a greener and more sustainable society.

## 1. INTRODUCTION

In recent years, Environmental sustainability has become one of the most critical global challenges in recent decades. Although public awareness of environmental issues such as pollution, waste management, and climate change has grown, many individuals still struggle to translate awareness into consistent sustainable actions. Traditional environmental education methods, including poster campaigns, school talks, and short-term events, often fail to sustain long-term behavioral change due to their lack of interactivity and engagement. This is especially true among younger generations, who are more motivated by digital experiences, social media, and gamified systems that offer immediate feedback and a sense of achievement.

To address this issue, the **EcoQuest** project introduces a gamified environmental behavior platform designed to encourage users to adopt sustainable habits through interactive and rewarding digital experiences. The system transforms daily eco-friendly actions—such as taking public transport, using reusable bags, or recycling—into "quests" that contribute to virtual progress. Each action earns users virtual fertilizer to grow a digital tree, which evolves through several stages until it blossoms. Blossomed trees produce flowers that can be converted into points, which are redeemable for eco-friendly vouchers or charitable contributions. The platform also features leaderboards, achievements, and friend challenges to enhance motivation and social engagement. By combining gamification, technology, and behavioral psychology, EcoQuest aims to bridge the gap between environmental awareness and real-world impact.

## 2. LITERATURE REVIEW

Several studies have highlighted that awareness alone is insufficient to drive long-term environmental behavior. (Anja Kollmuss; Julian Agyeman, 2010) explain that sustainable behavior results from a complex interaction of values, motivations, and social norms, suggesting that information-based campaigns alone cannot create consistent change. To make behavioral shifts more effective, researchers have explored digital interventions and gamification strategies that transform sustainability into a rewarding and measurable experience.

(Froehlich, 2010) emphasized the potential of eco-feedback technologies, which make invisible environmental impacts visible through real-time feedback and data visualization. Similarly, (Wokje Abrahamse, Linda Steg, Charles Vlek, Talib Rothengatter, 2007) demonstrated that personalized feedback and goal-setting can enhance users' motivation to adopt greener lifestyles. In line with these findings, modern digital tools such as **JouleBug**, **Oroeco**, and **Forest** have successfully incorporated gamified elements to encourage sustainability. JouleBug promotes green habits through challenges and community sharing, Oroeco tracks carbon footprints and offers financial savings visualization, while Forest gamifies productivity by linking focus time with virtual tree growth.

Building upon these concepts, **EcoQuest** combines the motivational power of gamification with digital tracking and social features. Unlike existing apps, EcoQuest not only rewards users for performing sustainable actions but also integrates QR code check-ins and AI recognition to verify real eco-friendly behavior, making the process both interactive and credible.

## 3. METHODOLOGY

The development of the **EcoQuest** system followed the **Agile Scrum methodology**, which emphasizes iterative progress, adaptability, and continuous feedback from users and supervisors. This approach allowed the project team to refine requirements and design throughout the development process, ensuring that the system met both functional and user experience goals. The project consists of two main components: the **User Mobile Application** and the **Admin Web System**. The system architecture integrates a **Flutter-based frontend**, providing a responsive and cross-platform mobile experience for both Android and iOS devices, with a **Laravel backend** that delivers secure and scalable API services. The **MySQL database** manages user profiles, environmental activity logs,

reward transactions, and merchant details, while the **Admin Panel** enables administrators to manage eco-tasks, monitor user statistics, and maintain partnerships with participating merchants.

The key features of EcoQuest include **QR Code Check-in**, which allows users to scan codes placed on public transport or eco-friendly locations to automatically record sustainable actions; and an **AI Recognition System**, where users can upload photos of eco-friendly behaviors such as recycling or using reusable bags, allowing the system to verify and reward valid actions. The application also introduces a **Virtual Tree Growth System**, where users earn virtual fertilizer to nurture a tree that progresses through animated stages (Seed → Seedling → Tree → Blossom). Once the tree blossoms, users can collect flowers that are converted into points through the **Flower-to-Points Conversion System**, redeemable for vouchers or donations. Additionally, the **Leaderboard and Friend Challenge** features enhance user motivation and promote social engagement through friendly competition.

The tools and technologies used in this project include **Visual Studio Code** and **Android Studio** for development, **Postman** for API testing, and **Figma** for UI/UX prototyping. The project's source code was managed using **GitHub** for version control, and testing involved both manual testing and user acceptance testing to ensure system functionality and reliability.

## 4. PROTOTYPE

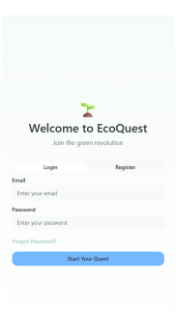


Figure 1

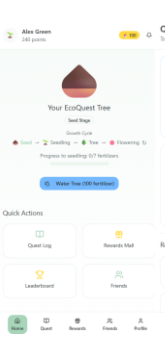


Figure 2

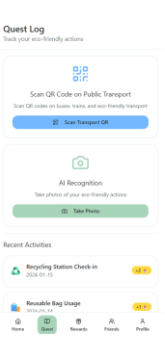


Figure 3

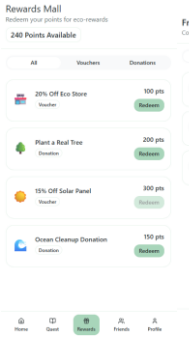


Figure 4

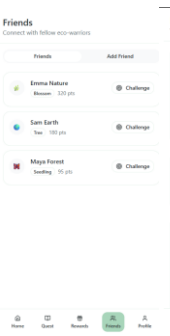


Figure 5

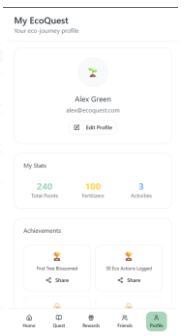


Figure 6

The developed prototype comprises several interactive interfaces designed to promote sustainable behaviour through gamification elements. As illustrated in **Figure 1**, the *Login Page* provides a secure entry point for users to access their accounts. Upon successful login, users are directed to the *Main Page* (**Figure 2**), where they can nurture a virtual tree using collected fertilizers, representing their positive environmental actions.

The *Quest Page* (**Figure 3**) enables users to record their daily eco-friendly practices, such as recycling or energy conservation, which contribute to their overall point accumulation. In **Figure 4**, the *Reward Mall* allows uxsers to redeem these points for tangible or virtual rewards, thereby reinforcing motivation. The *Friends Page* (**Figure 5**) fosters social engagement by allowing users to add friends and participate in environmental challenges. Finally, the *Profile Page* (**Figure 6**) supports personalization by enabling users to modify their display name and profile icon, enhancing their sense of ownership and identity within the application ecosystem.

## REFERENCES

Anja Kollmuss; Julian Agyeman. (2010). *Mind The Gap: Why Do People Act Environmentally And What Are The Barriers To Pro-Environmental Behavior?* London: Routledge.

Froehlich, J. (2010). The design of eco-feedback technology. *Proceedings of the 28th International Conference on Human Factors in Computing System.* Atlanta.

Wokje Abrahamse, Linda Steg, Charles Vlek, Talib Rothengatter. (2007, Aug 12). *The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents*. Retrieved from ScienceDirect:https://www.sciencedirect.com/science/article/abs/pii/S0272494407000540?utm_source=chatgpt.com

# SUC Smart Student Item Sharing Platform with AI-Based Trust Scoring

Pang Dixon & Khairunnisha Ismail

Southern University College

*b240042A@sc.edu.my*

**ABSTRACT**
In the digital era, sharing economy models have transformed how people access resources, yet within university campuses, personal item sharing remains largely unstructured and inefficient. Students frequently face situations where they need to borrow academic or personal items, but the lack of a centralized, trustworthy system leads to redundant purchases, wasted resources, and increased financial burden. This project introduces ShareMate, an intelligent, AI powered item sharing platform specifically designed for Southern University College students. The system aims to reduce redundant purchases and promote sustainability by allowing students to lend and borrow idle items efficiently. A key innovation of the platform is the AI based trust scoring mechanism, which evaluates user reliability through behavior analysis and rating patterns, fostering a sense of accountability and safety in transactions. The platform also employs QR code verification for secure item handovers, ensuring transparent and traceable exchanges. Developed using Flutter and Firebase, the system delivers real time functionality and a seamless user experience across devices. This project represents a novel integration of peer to peer sharing, trust management, and AI automation in a single mobile platform. By encouraging resource reuse and responsible borrowing, the system not only enhances convenience but also supports a culture of sustainability and collaboration among students.

**Keywords:** Peer to Peer Sharing, Trust Scoring, AI, QR Code Verification, Campus Sustainability

## 1. INTRODUCTION

In modern university environments, students often encounter short-term needs for essential items such as calculators, chargers, or presentation equipment. The absence of a centralized system to facilitate borrowing and lending results in inefficiency, resource wastage, and unnecessary financial expenses. Many students resort to purchasing new items for temporary use, while others possess underutilized belongings that remain idle. This imbalance highlights a pressing need for a structured and trustworthy platform that can enable efficient item sharing among students.

The evolution of digital technologies and the rapid adoption of mobile applications have redefined accessibility and convenience across various sectors. Yet, within campus environments, sharing systems have not evolved beyond informal, unreliable

communication through social media or messaging apps. Furthermore, the lack of accountability mechanisms often discourages participation, as users fear damage, misuse, or loss of their items.

This project proposes the development of SUC Smart Student Item Sharing Platform, a peer to peer mobile application enhanced with AI based trust scoring and QR code verification. The trust scoring mechanism utilizes user interactions, ratings, and borrowing patterns to generate a reliability index, promoting transparency and user confidence. The QR code system ensures verified item handovers, minimizing disputes and increasing system credibility. Built with Flutter and Firebase, the platform provides a seamless, cross platform experience with real time data synchronization. By combining automation, accountability, and user centric design, the system aims to foster a sustainable, collaborative, and cost-effective environment within Southern University College.

## 2. LITERATURE REVIEW

The concept of the sharing economy emphasizes optimizing the use of idle resources by enabling access over ownership. Platforms such as Airbnb and Uber have successfully demonstrated the potential of connecting people with surplus resources to those who need them. However, within educational institutions, such sharing ecosystems remain underdeveloped, particularly for peer to peer item lending.

Research indicates that trust is a critical factor influencing user participation in sharing systems. Without verified identity and accountability frameworks, users hesitate to share valuable possessions. Implementing digital trust mechanisms, such as AI driven reputation scoring, can significantly enhance engagement by providing data backed reliability assessments. These systems analyze behavioral data, ratings, and transaction histories to evaluate user credibility and mitigate risks associated with sharing (Hamari et al., 2016).

To further improve operational efficiency, technologies like QR codes have been widely adopted for secure, verifiable transactions. QR based verification ensures that each borrowing and returning process is digitally recorded, minimizing fraud and errors. Additionally, artificial intelligence contributes to system automation, supporting data driven decisions and enabling personalized user interactions.

The development of modern mobile applications relies heavily on frameworks that ensure performance and scalability. Flutter, developed by Google, allows developers to build cross-platform applications with a single codebase, offering an efficient and visually consistent user experience. Firebase complements this by providing backend services such as authentication, cloud storage, and real-time databases, essential for handling user data and ensuring secure system operations.

Existing platforms like Lendogram, ShareMyBag, and WeeShare offer general item sharing features but lack integration of campus specific needs such as identity verification or trust scoring. The proposed system distinguishes itself by merging AI based credibility analysis, QR verification, and campus authentication, offering a more secure and community-focused approach to resource sharing.

## 3. METHODOLOGY

The development of the SUC Smart Student Item Sharing Platform adopts the Agile Scrum methodology, emphasizing iterative progress, adaptability, and continuous user feedback.

This approach ensures flexibility in addressing evolving user needs while maintaining consistent development cycles.

*Phase 1: Planning and Requirement Analysis*
The initial phase focuses on defining system objectives, functional and non functional requirements, and the technology stack. Key components include user registration, AI trust scoring, QR based item handovers, and Firebase based real time data management.

*Phase 2: System Design and Prototyping*
System design includes user interface (UI) mockups, database schema, and architectural diagrams. Prototypes are developed in Figma to visualize workflows and ensure intuitive navigation. The design prioritizes simplicity, usability, and accessibility for university students.

*Phase 3: Development and Implementation*
The system is implemented using Flutter for the frontend and Firebase for backend services such as authentication, Firestore database, and cloud functions. AI modules handle trust scoring, while QR code APIs manage item verification. Each sprint introduces and tests new modules, such as user systems, posting, borrowing, and ratings.

*Phase 4: Testing and Quality Assurance*
Comprehensive testing includes unit, integration, and system level evaluations. The objective is to ensure reliability, security, and performance under varying load conditions. The feedback from test users guides refinements in UI/UX and functionality.

*Phase 5: Deployment and Maintenance*
The application is deployed for initial user testing within Southern University College. Continuous monitoring, bug fixes, and feature improvements are conducted based on collected user feedback. The system remains scalable for future enhancements, such as AI-driven item recommendations and analytics dashboards.

## 4. RESULTS & DISCUSSION

The SUC Smart Student Item Sharing Platform successfully integrates AI-based trust scoring, QR verification, and a user friendly mobile interface to create a seamless peer-to-peer sharing experience. The system consists of several primary modules:

*User System*: Handles registration, login, and authentication using student credentials, ensuring verified users within the SUC community.
*Post System:* Enables students to list items for lending or request items for borrowing with descriptions and photos.
*AI Trust Scoring Module:* Automatically evaluates user reliability based on previous transactions and ratings, generating a trust score visible to others.
*QR Code Verification:* Facilitates secure item handovers, confirming each transaction during borrowing and returning stages.

*Admin Dashboard:* Allows administrators to manage users, monitor reports, and ensure compliance with community guidelines.

Testing results revealed high usability, with users finding the system convenient for both lending and borrowing activities. The integration of QR codes was particularly effective in preventing misunderstandings and improving accountability. Furthermore, the trust scoring feature increased user confidence by promoting transparent and fair interactions.

The system's design also supports scalability and future feature expansion, such as integrating AI based recommendations for item matching and analytics tools to track borrowing trends. Overall, the system demonstrated that the combination of automation, accountability, and gamified interaction can enhance student engagement in sustainable item sharing.

## 5. CONCLUSION & RECOMMENDATION

The SUC Smart Student Item Sharing Platform successfully demonstrates how artificial intelligence and digital verification can be combined to improve campus resource sharing. By incorporating trust scoring, QR code verification, and real time Firebase infrastructure, the system offers a reliable and efficient solution to address the common issues of resource wastage and low trust in peer to peer borrowing.

The platform not only reduces redundant purchases but also encourages sustainable behavior and community collaboration among students. The AI based trust mechanism proved effective in establishing accountability, while the mobile-first design ensured accessibility and ease of use.

For future development, the system can be enhanced by integrating advanced AI models for behavioral prediction, enabling bank or payment synchronization for security deposits, and introducing gamification to further increase participation. In conclusion, this project demonstrates the potential of combining technology and behavioral design to build a responsible, efficient, and sustainable campus sharing ecosystem.

## REFERENCES

Almalki, M. a.-S. (2023). An investigation into knowledge management adoption and sustainable competitive advantage in an emerging market economy. *Global Knowledge, Memory and Communication*.

Bhogade, P, Sonawane, D, Upadhye, M., . . . S. (2014). QR Based Advanced Authentication for Online Transactions. *International Journal of Engineering Research and Technology*.

Botsman, Rachel, & Rogers, R. (2010). Beyond zipcar: Collaborative consumption},. *Harvard business review*, 30.

Hamari, Juho, Sjöklint, Mimmi, Ukkonen, & Antti. (2016). The sharing economy: Why people participate in collaborative consumption. *Journal of the association for information science and technology*, 2047--2059.

Hoda, Rashina, Salleh, Norsaremah, Grundy, John, . . . Mien, H. (2017). Systematic literature reviews in agile software development: A tertiary study,. 60-70.

Inc, W. S. (2024). *why-use-flutter-pros-and-cons* . Retrieved from Waverly: https://waverleysoftware.com/blog/why-use-flutter-pros-and-cons/

# Visual Financial App with AI-Powered Expense Prediction and Smart Advice

Chong Jian Jin & Khairunnisha Ismail

Southern University College

*b240039A@sc.edu.my*

**ABSTRACT**
In the age of digital, personal financial management has become a real concern with people grappling with how to keep track of their spending, how to develop saving habits, and how to escape financial pressures. The current financial applications are mostly based on transaction tracking, but they are not very engaging, personal, or behaviour support, decreasing user commitment in the long-term. This project suggests a mobile financial management system, which incorporates intelligent and user-cantered design to deal with the challenges. The system can use OCR technology to assist in automatic tracking of expenses by scanning receipts, as well as manually. The system proposes a feature of a quiet space to minimize the impulse spending, where users can enter the name and price of an item and think about it within 24 hours before making a choice to buy it. Gamification is implemented in the form of the Saving Tree, a visual representation of growth based on the amount of savings reached by the user which grows as the player reaches their financial responsibilities. Moreover, the Profile Page allows making personal choices and AI-powered information to make sound decisions. This is the first project of its type to integrate automation, gamification, and mindful interventions to produce a more engaging and motivational experience of financial management. This system can not only assist people to become financially stable but also by promoting responsible spending and saving behaviour, the system also serves to promote healthier financial habits in society.

**Keywords:** Financial Management, OCR, Quiet space, AI Insights

## 1. INTRODUCTION

In the modern world of the Internet, mobile technology is rapidly developing, and it has altered the way people spend on their personal money. Regardless of the availability of financial tracking applications, a considerable number of users continue to be unable to keep a stable budgeting habit and tend to use their money on impulse or emotionally. Money worries, lack of saving habits and ignorance on the cost of living on a daily basis are still prevalent and hurt the long-term financial stability. The current financial management systems are majorly active in recording and tracking of data rather than the behavioural and motivational factors of financial management which determine decision making.

The proposed project will design and create an intelligent AI-based mobile financial management system to encourage conscious expenses and prudent savings by means of intelligent automation and gamification. It offers three new modules, the OCR Receipt Scanner, a system that will enable users to automatically extract the expense details of their receipts, the Quiet Space Protocol, a behavioural intervention feature that will prompt users to postpone impulsive purchase by entering a 24-hour reflexion interval, and the Saving Tree, a gamifying visual representation that will grow as users meet their savings targets. The combination of these modules produces an interesting user-friendly module that is interactive and integrates technology and behavioural psychology.

The development of the system is encouraged by the increased necessity to increase the financial literacy and decision-making of younger generations. Through self-awareness and discipline as well as good financial habits, this project helps not only to offer practical tools to manage personal finances but also to create a financially responsible and resilient society.

## 2. LITERATURE REVIEW

Personal financial management (PFM) application has become a necessity in the modern digital economy where people aim to track the costs and savings of the collected data. Nonetheless, research revealed that most of the existing applications pay excessive attention to data recording and not to behavioral engagement, which causes users to lose interest in the long run. Impulsive buying behavior during promotions can be described as a primary contributor to financial regrets and ineffective saving behavior. As such, behavioral intervention should be incorporated into the financial management tools to foster mindful expenditure.

The use of Optical Character Recognition (OCR) technology in financial systems has found a lot of application in automating the processes of scanning and entering data to the system through receipts. The past research has emphasized that OCR enhances the precision of data and hassles the user, which is why it is a useful technology to improve the user level of ease when tracking costs. In addition, AI has been used more intensively to offer a personalized analysis, allowing users to detect patterns of their spending and choose a more efficient financial decision.

Gamification has become a potential approach to enhancing user engagement to financial management applications. The study by (Deterding, 2017) showed that visual progress and reward systems can also significantly enhance the motivation of the users in reaching their financial goals. This approach is modified in the concept of the Saving Tree in this project, and it makes the savings progress a visual metaphor of growth that promotes consistent and satisfaction.

To sum up, the extant literature confirms that automation, behavioral psychology, and gamification used in tandem may result in increased user retention and financial performance. Nevertheless, there is a lack of studies that would merge all of these into one, convenient platform. My proposed project will serve this purpose by creating a mindful, holistic, and AI-powered financial management system that is neither strictly automated nor disengaged.

## 3. METHODOLOGY

The development process will be structured into several iterative phases, characteristic of an Agile Scrum framework. Each phase will have a defined duration (sprint) and will

culminate in the delivery of a demonstrable increment of the product. The key phases include:

*Phase 1: Planning and Requirements*- Determine the scope of the project, the requirements and the main features of the project including the OCR receipt scanning, AI spending guidance and the gamified savings. Specify the non-functional requirements and functional requirements and complete the technology stack.
*Phase 2: Design and Prototyping* - System architecture, database schema, and UI/UX mock-ups - Simple and interactive. Develop AI model reasoning behind intelligent financial insights and elements of gamification like Quiet Space Protocol and Saving Tree.
*Phase 3: Development Sprints* - Develop core functionality in small sprints, do unit and integration testing and refinement via sprint retrospectives.
*Phase 4: Testing and Quality Assurance* - Phase 4: System, user acceptance, and performance testing will be conducted to confirm reliability and usability.
*Phase 5: Deployment & Maintenance* - Implement the system, observe the feedback of users, and correct bugs, and arrange further improvements to achieve even more accuracy and customization.

## 4. RESULTS & DISCUSSION

The created AI-Powered Expense Management System has managed to combine automation, behavioral intervention, and gamification in one mobile system. The system consists of 6 primary modules, which are: Home Dashboard, Scan Receipt, Add Expense, Quiet Space Protocol, Saving Tree and Profile Page. Each of the modules was to assist in various areas of user financial behavior and awareness.

The Home Dashboard will give its users a summary of their financial situation such as total savings, monthly spending, recent transactions, and insights generated by AI. This web-based dashboard gives a user an opportunity to visualise and intuitively track his or her financial affairs. AI Insights integration allows one to have customized financial suggestions, and users should be aware of their spending habits and make informed decisions.

The Scan Receipt Module is an application that uses the Optical Character Recognition (OCR) technology to scan receipt images and extract text and numerical information, which is automatically sorted into a merchant and an amount category. This easily helps save man-hours of work on manual entries and greatly helps to eliminate man errors in tracking financial records.

Add Expense Module provides a manual feature whereby its users can add expenses with their own custom categories and notes. This provides flexibility and completeness of data even in the case of unavailable receipts.

The Quiet Space Protocol is a very special behavioral innovation that promotes attentive expenditure. In case users are ready to purchase something, they should simply enter the name and price of the product and start their 24-hour reflection period before making the final choice. This aspect is meant to increase the level of rational buying habits and discourage purchasing.

The Saving Tree Feature is the visual illustration of the financial growth of the users of this feature in the form of a growing virtual tree. The tree grows as the user meets their savings goal, which brings about the gamified aspect that encourages the user to continuously save due to positive reinforcement.

Lastly, the Profile Page enables the user to customize their experience and gives a summary of their spending habits and suggestions on how to improve them based on AI analysis.

Results of the tests revealed that the users were interested and were finding the system involving and easy to operate, and helpful in enhancing their consciousness on financial habits. It was also mentioned that the mix of AI knowledge and the visualization of progress as a game would make people feel more motivated to save and less inclined to spend the money unnecessarily.

In sum, the project has been effective in showing that technology, behavioral science and gamification can be combined to form a more thoughtful and smart financial management ecosystem.

## 5. CONCLUSION & RECOMMENDATION

The AI-Based Expense Management System manages to balance automation, gamification, and behavioral design to enhance the personal financial management. The system enables users to manage their expenditures, prevent the urge to buy hasty, and be encouraged to save by adding functionality like receipt scanning (OCR), manual tracking of expenses, Quiet Space Protocol, and Saving Tree. The project shows that financial tracking can be both interesting and informative when it is designed thoughtfully. As a recommendation to the future work, it is suggested to include bank synchronization and AI-based financial insights to provide a higher level of accuracy and customization. On balance, this system represents a new and effective method of spreading financial awareness and responsible finances behavior in the modern digital world.

## REFERENCES

Apps, J. f. (2024). *Judo for User Engagement in Finance Apps*. Retrieved from judo: https://www.judo.app/blog/judo-for-user-engagement-finance-apps

Boston. (13 april, 2017). *The Gamification Effect: Using Fun to Build Financial Security*. Retrieved from bostonfed: https://www.bostonfed.org/publications/communities-and-banking/2017/spring/the-gamification-effect-using-fun-to-build-financial-security.aspx

Finance, A. i. (10 june, 2025). *How AI is Reshaping Personal Finance*. Retrieved from gecreditunion: https://www.gecreditunion.org/learn/education/resources/money-minutes/june-2025/how-ai-is-reshaping-personal-finance

Hashim, n. (may, 2021). *GAMIFICATION CAN HELP CONSUMERS*. Retrieved from openaccess: https://openaccess.city.ac.uk/id/eprint/26272/1/TFI-Final-Tech-Report-Gamification_Can_Help_Consumers_Reach_Their_Saving_Goals.pdf

Kelley, S. (23 7, 2018). *Why do we slack on saving?* Retrieved from Blame the brain | Cornell Chronicle. (n.d.): https://news.cornell.edu/stories/2018/07/why-do-we-slack-saving-blame-brain