EVOLUSI DEKAD 7
DEWAN LATEHAN RIDA ke UiTM
1956-2026

UNIVERSITI TEKNOLOGI MARA

JOHOR 2026
SMART INNOVATIONS FOR A SUSTAINABLE AND RESILIENT FUTURE



7th DIIID 2026

EXTENDED ABSTRACT

7TH DIGITALISED INTERNATIONAL INVENTION, INNOVATION, AND DESIGN (DIIID) JOHOR 2026

PUBLISHED BY

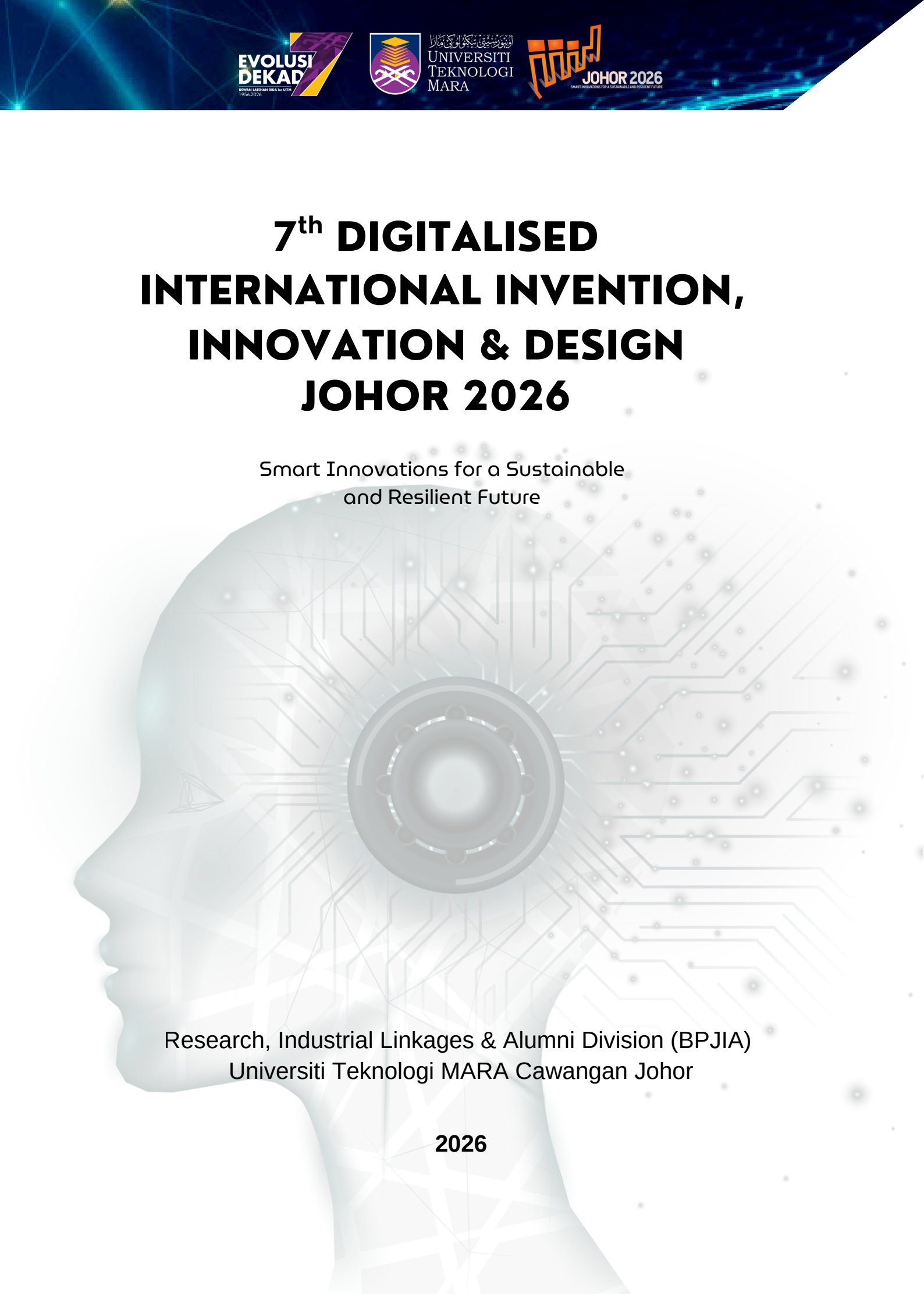
UNIVERSITI TEKNOLOGI MARA
CAWANGAN JOHOR

eISSN 3030-6817

SMART INNOVATIONS FOR A SUSTAINABLE AND RESILIENT FUTURE

7th DIGITALISED INTERNATIONAL INVENTION, INNOVATION & DESIGN JOHOR 2026

Smart Innovations for a Sustainable and Resilient Future



Research, Industrial Linkages & Alumni Division (BPJIA)
Universiti Teknologi MARA Cawangan Johor

2026

Fourth Publication 2026

eISSN: 3030-6817

Universiti Teknologi MARA Cawangan Johor © 2026

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without written permission of the publisher.

Publisher:

Research, Industrial Linkages & Alumni Division (BPJIA)
Universiti Teknologi MARA Cawangan Johor

PREFACE

In the name of Allah, the Most Gracious and Most Merciful, who grants us enlightenment, truth, and knowledge. We extend our deepest gratitude to Almighty Allah and to Prophet Muhammad (peace be upon him) for guiding us along the straight path. We are humbly grateful for the divine guidance and strength that enabled us to compile this e-book.

This e-book serves as the official collection of extended abstracts presented at the 7th Digitalised International Invention, Innovation, and Design (DIIID) Johor 2026, held from July 8, 2026, to August 20, 2026. The event featured an impressive total of 352 innovative projects across the domains of Science & Technology and Social Sciences. Participants represented local and international universities, government agencies, and primary and secondary schools underscoring a collective commitment to fostering collaboration and learning across all levels of education.

We hope this publication serves not only as a comprehensive record of our participants' creative efforts, but also as a source of inspiration and cherished memories. By promoting a strong culture of innovation, we aspire to spark new ideas that lead to meaningful advancements, product commercialization, and sustainable progress for future generations.

FOREWARD 1: VICE-CHANCELLOR (VC), UiTM



Assalamualaikum Warahmatullahi Wabarakatuh. Salam Sejahtera. Salam Malaysia MADANI.

It is a great privilege to welcome all attendees including our esteemed international guests and participants for the 7th Digitalised International Invention, Innovation & Design (DIIID) 2026. Hosted by UiTM Cawangan Johor, this event stands as a testament to UiTM's unwavering commitment to cultivating an environment of research excellence, impactful innovation, and global academic leadership.

Under the timely theme "Smart Innovations for a Sustainable and Resilient Future," DIIID 2026 highlights the power of creative problem-solving and technological advancement in addressing the pressing global challenges of our time. The innovations showcase the foresight, ingenuity, and dedication of researchers, educators, industry professionals, and students from diverse disciplines.

In an era defined by rapid technological changes and environmental demands, platforms like DIIID bridge the gap between academic conceptualization and practical, real-world application. I extend my heartiest congratulations to all participants whose groundbreaking ideas are published here. My sincere appreciation also goes to the organizing committee of UiTM Cawangan Johor for their dedication in successfully realizing this prestigious international event.

May this publication serve as an inspiring reference and a catalyst for future collaborative research, societal progress, and sustainable development.

Thank you.

Professor Datuk Dr. Shahrin Sahib @ Sahibuddin
Vice-Chancellor
Universiti Teknologi MARA

FOREWARD 2: RECTOR UiTM CAWANGAN JOHOR



Assalamu'alaikum Warahmatullahi Wabarakatuh. Salam Sejahtera. Salam UiTM Dihatiku.

On behalf of UiTM Cawangan Johor, I am delighted to welcome all professionals, researchers, industry leaders, educators, and students to the 7th Digitalised International Invention, Innovation & Design (DIIID) 2026.

Alhamdulillah, DIIID has grown over the years into a signature platform for our campus, bringing together visionary minds across local and international borders. This year's theme, "Smart Innovations for a Sustainable and Resilient Future," reflects our collective effort to champion smart technologies, environmental responsibility, and long-term socio-economic value.

The research and innovations represent high-caliber contributions across diverse categories, spanning Science & Technology, Social Sciences, and collaborative ventures. They reflect the curiosity, grit, and innovation of our academic community, schools, and industry partners.

I wish to express my deepest gratitude to our organizing team, reviewers, participating institutions, and industry collaborators for making DIIID 2026 an astounding success. To all participants, congratulations on making your mark through your entries. May this publication serve as a springboard for further discoveries and fruitful partnerships.

Thank you.

Assoc. Prof. Dr. Saunah Zainon
Rector
UiTM Cawangan Johor

FOREWARD 3: DEPUTY RECTOR BPJIA UiTM CAWANGAN JOHOR



Assalamu'alaikum Warahmatullahi Wabarakatuh and Salam Sejahtera.

It gives me immense pleasure to conclude the 7th Digitalised International Invention, Innovation & Design (DIIID) 2026 with this publication. As the Office of Research and Industrial Linkages, we are dedicated to fostering research culture and strengthening collaborative ties between academia, industry, and the community.

The theme underscores the necessity of research that transcends theory to offer practical, commercial, and societal value. The extended abstract contributions published in this book highlight inventive designs, novel methodologies, and technological solutions capable of shaping a resilient tomorrow.

By digitalizing this platform, DIIID continues to break geographical barriers, enabling seamlessly connected international collaboration. I commend all authors for the novelty, inventiveness, and market potential demonstrated in their work. I also express my sincere gratitude to our industry partners, participating institutions, and the dedicated editorial team who made this online publication possible.

I hope this publication fosters meaningful industry-academic networks, intellectual property development, and continuous research excellence.

Thank you.

Dr. Faridah Najuna Misman
Deputy Rector of Research and Industrial Linkages (BPJIA)
UiTM Cawangan Johor

FOREWARD 4: PROGRAMME DIRECTOR



Assalamu'alaikum Warahmatullahi Wabarakatuh and Salam Sejahtera.

Alhamdulillah, all praise and utmost gratitude belong to Allah SWT for His immense blessings and grace in granting us the opportunity and success in hosting the 7th Digitalised International Invention, Innovation & Design (DIIID) 2026 and the compilation of this publication . It is both an honor and a delight to welcome and congratulate all participants and guests to this prestigious event.

Centered on the theme DIIID 2026 this year, this platform was curated to offer an inclusive, dynamic platform for professional researchers, tertiary students, young school inventors, and industry innovators to showcase their transformative ideas. From abstract submissions and video presentations to panel evaluations, the journey of DIIID 2026 has been truly inspiring.

This publication encapsulates the essence of DIIID 2026, bringing together hundreds of innovations that demonstrate creative design, scientific advancement, and practical solutions tailored to current global needs.

I would like to take this opportunity to express my heartfelt appreciation to our Vice Chancellor, Rector, and Deputy Rector for their unwavering guidance. A big thank you to our hard-working committee members, esteemed panel of judges, sponsors, and, above all, the participants for their invaluable contributions. We hope this publication serves as a rich reference for future research and innovation. Congratulations to all participants and award winners!

Warm regards,

Dr. Nur Idayu Alimon
Programme Director
7th Digitalised International Invention, Innovation & Design (DIIID) 2026

Editorial Board

Nur Alyani Khairol Anuar
Muhammad Irfan Mokhtar
Nursuhaila Ibrahim
Dr. Nurul Hijah Jasman
Nursyuhada Zakaria
Siti Aishah Taib
Nurul Alia Hasni Mohd Sani
Hawa Syamsina Md Supie
Nurul Nadiah Rasdi
Dr. Wan Munirah Wan Mohamad
Maisarah Noorezam
Dr. Nor Kamariah Kasmin @ Bajuri
Dr. Nur Farhana Mohd Yusof
Nurhazirah Mohamad Yunos
Aznilinda Zainuddin

Art & Cover Designer Editors

Dr. Wan Munirah Wan Mohamad

TABLE OF CONTENT

eISSN i

PREFACE ii

FOREWORD 1: VICE-CHANCELLOR (VC), UITM iii

FOREWORD 2: RECTOR UITM CAWANGAN JOHOR iv

FOREWORD 3: DEPUTY RECTOR BPJIA UITM CAWANGAN JOHOR v

FOREWORD 4: PROGRAMME DIRECTOR vi

EDITORIAL BOARD vii

TABLE OF CONTENTS viii

LIST OF PROJECTS 1

- CATEGORY A1 (PROFESSIONAL LEVEL) 2
- CATEGORY A2 (PROFESSIONAL LEVEL) 3
- CATEGORY B1 (TERTIARY LEVEL) 4
- CATEGORY B2 (TERTIARY LEVEL) 7

ORGANISING COMMITTEE 452

COLLABORATORS 454

SPONSORSHIP 455

LIST OF PROJECTS



Category A1: Professional Level

PRODUCT ID	PRODUCT TITLE	PAGE
A1-0004	CRYO-ADSORPTIVE HYDROGEN STORAGE USING METAL–ORGANIC FRAMEWORKS: A DEEP NEURAL NETWORK APPROACH FOR EFFICIENT POROUS MATERIAL DESIGN	10
A1-0005	SCDesignPro: A SMART PREDICTIVE TOOL FOR ASSESSING STONE COLUMN PERFORMANCE FOR SUSTAINABLE AND RESILIENT FOUNDATIONS	15
A1-0008	CAMPUSIQ: AN AI-POWERED SMART FACILITY INTELLIGENCE DASHBOARD FOR SUSTAINABLE SMART CAMPUS ENVIRONMENTS	18
A1-0013	ERGODASH: ERGONOMIC DASHBOARD LAYOUT DESIGN FOR IMPROVED DRIVER PERFORMANCE AND SAFETY	23
A1-0014	iHADIR: AN INTELLIGENT EARLY WARNING SYSTEM FOR AUTOMATED STUDENT ATTENDANCE MANAGEMENT	27
A1-0015	DAULAT: JEJAK WIRA NEGARA – A MULTI-LEVEL EDU-CARD AND MISSION BOARD GAME FOR MALAYSIAN HISTORY LEARNING	31
A1-0016	MINDMIRROR: AN AI-POWERED EMOTIONAL WELLNESS COMPANION FOR PROACTIVE MENTAL HEALTHCARE	34
A1-0022	YOURTAX PLUS	39
A1-0024	PALMVISTA: AN AI-POWERED WEBGIS PLATFORM FOR HISTORICAL OIL PALM YIELD RISK MONITORING AND DECISION SUPPORT	44
A1-0025	DEVELOPMENT OF REAL-TIME NETWORK INTRUSION DETECTION SYSTEM ON WIRELESS ENVIRONMENT	49
A1-0026	SISTEM PELAPORAN BDR PENSYARAH UITM JOHOR (SPBDR)	54
A1-0028	ADAPTIVE SMART PLATFORM: SUSTAINING JOHOR'S IDENTITY THROUGH INNOVATION	58
A1-0030	EASY TECHNIQUE FOR SKETCHING TRIGONOMETRIC FUNCTION GRAPHS IN THE E-HIGH 5 TRIGO MODULE	63
A1-0031	SMART WINDOW GUARDIAN : AN IOT-BASED CHILD SAFETY WINDOW PROTECTION SYSTEM	68
A1-0032	DUALXAI: A MULTI-TIER WEB ARCHITECTURE FOR SECURE DEEPFAKE DETECTION USING CONVOLUTIONAL NEURAL NETWORKS AND EXPLAINABLE AI	72
A1-0034	BUFFER TOOL KIT AND WIZER.ME DIGITAL APPLICATION FOR BUFFER SOLUTION LEARNING	77
A1-0035	TRANSFORMING SELECTION IN INNOVATION CONFERENCES THROUGH FUZZY LOGIC INTERACTIVE AND GUI TOOLS	82

Category A1: Professional Level

PRODUCT ID	PRODUCT TITLE	PAGE
A1-0036	AGROSENSE+: AN IoT-BASED SMART IRRIGATION SYSTEM FOR SUSTAINABLE COMMUNITY GARDENS	87
A1-0037	IoT-NMD: AN IoT-BASED NUTRIENT MANAGEMENT AND DISPENSING SYSTEM FOR COMMUNITY AGRICULTURE	92
A1-0038	AN INTERACTIVE TEACHING TOOL FOR BOUNDARY LAYER FLOW OF DUSTY CASSON FLUID	97
A1-0042	INCLUSIVE JOB CONNECT (IJC): AN AI-ENABLED MOBILE APP FOR DISABILITY-INCLUSIVE EMPLOYMENT IN THE ACCOMMODATION SECTOR	102

Category A2: Professional Level

PRODUCT ID	PRODUCT TITLE	PAGE
A2-0005	GLOBAL LINGO POLYGLOT: A GAMIFIED GEO-POLITICAL LANGUAGE LEARNING PLATFORM FOR ENHANCING ENGLISH PROFICIENCY AND GLOBAL CITIZENSHIP	108
A2-0006	DEVELOPMENT OF E-SHOP KPTMBP: DIGITAL MARKETPLACE FOR THE KPTM BATU PAHAT COMMUNITY	113
A2-0007	MyPARENTCARE (MPC): ENHANCING PARENT ENGAGEMENT THROUGH REAL-TIME STUDENT ACTIVITY MONITORING SYSTEM IN HIGHER EDUCATION INSTITUTIONS	119
A2-0008	GRADTRACKR PRO: AN ALL-IN-ONE PREDICTIVE PATHWAY NAVIGATOR AND MILESTONE AUDITOR FOR HIGHER EDUCATION	124
A2-0009	iMatchLI: A SMART INTERNSHIP MATCHING SYSTEM FOR HIGHER EDUCATION STUDENTS	128
A2-0010	E-DICTIONARY OF HADITH TERMINOLOGY APPLICATION (IS-HADIS)	133
A2-0011	COFFEELOOP: A SMART CIRCULAR COFFEE WASTE RECOVERY ECOSYSTEM	139
A2-0012	SLIPPERY DETECTION APPS: A MOBILE-BASED HAZARD PREVENTION PROTOTYPE	143
A2-0014	GM HUB: A CREATIVE DIGITAL EDUCATION ECOSYSTEM FOR LEARNING, PORTFOLIO DEVELOPMENT AND INDUSTRY COLLABORATION	146

Category A2: Professional Level

PRODUCT ID	PRODUCT TITLE	PAGE
A2-0015	SMART BIZ PLANNER: AN INTEGRATED WEB-BASED FINANCIAL PLANNING AND PROFIT DECISION SUPPORT SYSTEM	151
A2-0016	FROM SLANG TO SCHOLARSHIP	156
A2-0017	AI-SLR VALIDATOR: A SMART TOOLKIT FOR TRANSPARENT AI-ASSISTED SYSTEMATIC LITERATURE REVIEW SCREENING	159
A2-0021	GAMEBOARD+: AN INNOVATIVE TEACHING TOOL FOR SUSTAINABLE MATHEMATICS LEARNING	165
A2-0023	CALCMORPH: TRANSFORMING MAT235 THROUGH AI-GENERATED VISUAL NOTEBOOKS AND THE ADAB FRAMEWORK	169
A2-0024	MUAMALAT EXPLORER KIT: SPECIAL REFERENCE TO MAJALLAH AHKAM JOHOR	173
A2-0026	MYANAK DIGITAL: AI-POWERED ELECTRONIC CHILD HEALTH RECORD AND EARLY DEVELOPMENT INTELLIGENCE SYSTEM IN MALAYSIA	178
A2-0031	SCROLL, CLICK, BOOM! MASTER THE POWER OF FACEBOOK, INSTAGRAM & TIKTOK	183

Category B1: Tertiary level

PRODUCT ID	PRODUCT TITLE	PAGE
B1-0005	EXPERIMENTAL INVESTIGATION OF DENSITY AND CALORIFIC VALUES OF BINARY BLENDS OF ALGAE-DIESEL BIOFUEL	190
B1-0006	STUDYSYNC: AN ANDROID-BASED COLLABORATIVE STUDY MANAGEMENT APPLICATION FOR DIPLOMA STUDENTS	195
B1-0007	P.A.S.A.R: PORTABLE ANAEROBIC SYSTEM FOR ALTERNATIVE RESOURCES	200
B1-0010	ECOSERVE 3-IN-1 COLLECTION TROLLEY	206
B1-0011	MAID4U: WEB-BASED HOME CLEANING SERVICE BOOKING AND MANAGEMENT SYSTEM	210
B1-0016	SMARTHEAL CONCRETE: SAP-BASED SELF-HEALING SOLUTION FOR TROPICAL STRUCTURES	216

Category B1: Tertiary level

PRODUCT ID	PRODUCT TITLE	PAGE
B1-0019	UNITAP: IOT SMART ATTENDANCE SYSTEM	221
B1-0023	URCALMSPACE	226
B1-0027	AI-BASED FAULT DETECTION AND SELF-DIAGNOSIS SYSTEM FOR INDUSTRIAL MOTORS	230
B1-0029	ABUSIVE COMMENT DETECTION: A SEQUENTIAL HYBRID NLP APPROACH USING TEXT BARCODING AND NAÏVE BAYES	234
B1-0030	MyFYP: A WEB-BASED MANAGEMENT SYSTEM FOR STUDENTS' FINAL YEAR PROJECT	239
B1-0031	LUMAREACH: DESIGN, DEVELOPMENT, AND FABRICATION OF A MOTORIZED HIGH-REACH PROTOTYPE FOR RESIDENTIAL LED MAINTENANCE	244
B1-0035	e-KHAIRAT: A DIGITAL COMMUNITY WELFARE MANAGEMENT SYSTEM FOR KHAIRAT KEMATIAN	249
B1-0037	DESIGN AND ANALYSIS OF A LINEAR ELECTROMAGNETIC PROPULSION SYSTEM FOR INTERNAL LOGISTICS TRANSPORT IN SMART COMPOUNDS	253
B1-0039	AN AI-POWERED ANIME COMPANION APPLICATION FOR PERSONALISED INTERACTION, WELLBEING, AND LANGUAGE LEARNING	259
B1-0040	ECO-RESILIENT BEACH CLEANER MACHINE	264
B1-0042	DUN COMMUNITY MOBILE APP (e-KITA)	269
B1-0048	AN INNOVATIVE NSM CFRP AND FE-SMA STRENGTHENING SYSTEM FOR CORROSION-DAMAGED RC BEAMS	274
B1-0049	PLANTPAL	279
B1-0050	CROWDSOURCED GEOTAGGED REPORTING SYSTEM	284
B1-0051	MALAYSIA CULTURAL HERITAGE LENS	288
B1-0052	CROWDSOURCED "ADORN AND MAINTAIN" SITE MONITORING APP	293
B1-0053	ENHANCING FINANCIAL DISCIPLINE AMONG UNIVERSITY/SCHOOL STUDENTS THROUGH A PARENT-INTEGRATED E-WALLET MONITORING SYSTEM	297
B1-0054	A SMART MOBILE APPLICATION TO REDUCE FOOD WASTE IN MALAYSIA	302

Category B1: Tertiary level

PRODUCT ID	PRODUCT TITLE	PAGE
B1-0055	GOHERE THERE - HARNESSING TRAVELLERS' PHOTO SHARING FOR MICRO SME GROWTH	307
B1-0056	POLYPVISION: AN EXPLAINABLE AI-ASSISTED SYSTEM FOR COLORECTAL POLYP SEGMENTATION AND EARLY CANCER SCREENING	312
B1-0060	UiTM NResQ: AN INTELLIGENT EMERGENCY RESPONSE AND DECISION SUPPORT SYSTEM FOR NON-RESIDENT STUDENTS	317
B1-0062	TRIPPILOT AI: PERSONAL AI TRAVEL AGENT	322
B1-0063	AUTOMATIC WEIGHT-BASED CONVEYOR SORTING SYSTEM	327
B1-0065	SALIRAN SNAKE SYSTEM (SSS) (SMART AQUATIC LONGKANG INSPECTION ROBOTIC AUTONOMOUS NETWORK)	331
B1-0068	IOT SMART GARBAGE MONITORING SYSTEM	336
B1-0069	INFANTCRYSENSE: INTELLIGENT INFANT CRY DETECTION USING AN MFCC-BASED CONVOLUTIONAL NEURAL NETWORK FOR REAL-TIME MONITORING	341
B1-0071	PAWFEEDER STATION: SMART AUTOMATED CAT FEEDING SYSTEM FOR SUSTAINABLE CAMPUS ANIMAL WELFARE MANAGEMENT	346
B1-0072	VOKA NEURO+ (INNOVATION)	351
B1-0074	MYMEDICINE	354
B1-0077	E-PRACTICUM HUB: STUDENTS' APPLICATION, APPROVAL, PLACEMENT MATCHING	360
B1-0078	DEVELOPMENT AND EVALUATION OF EDIBLE COATING INCORPORATING KEY LIME (*CITRUS AURANTIIFOLIA*) PEEL ESSENTIAL OIL FOR SHELF-LIFE EXTENSION OF CHERRY TOMATOES	364
B1-0079	WASTE2VALUE: DIGITAL SOLUTION FOR CIRCULAR ECONOMY AND WASTE PROCESSING	369
B1-0090	ECO-SENTINEL: PROACTIVE ENVIRONMENTAL HAZARD DETECTION AND COMMUNITY ALERT SYSTEM	375
B1-0092	A LOW-COST CNN-BASED HUMAN MOTION DETECTION SYSTEM USING WI-FI CHANNEL STATE INFORMATION FOR SMART HOME APPLICATIONS	379
B1-0094	SLECARE: EXPLAINABLE AI DECISION SUPPORT FOR LUPUS NEPHRITIS RISK PREDICTION	383
B1-0096	THE INNOVATIVE AUTO-CATALYTIC PERACID EPOXIDATION OF NEEM OIL (AZADIRACHTA INDICA)	388
B1-0098	SMART GESTURE-CONTROLLED HOME SYSTEM	393

Category B2: Tertiary level

PRODUCT ID	PRODUCT TITLE	PAGE
B2-0002	SUSTAINSMART: TOE-INTEGRATED SAAS DASHBOARD FOR SUSTAINABILITY TRANSFORMATION	400
B2-0005	TALENT+: AN INTELLIGENT SKILL LEVEL CLASSIFICATION PLATFORM FOR MALAYSIA'S LABOUR MARKET	405
B2-0007	TRAVELSAVER: AN ALL-IN-ONE SMART TRAVEL PLANNING APPLICATION	410
B2-0011	BIOMIMETIC MODULARITY IN HIGH-END STREETWEAR: A VENUS FLYTRAP-INSPIRED SUSTAINABLE FASHION SYSTEM	415
B2-0018	MOTIVASISWA – AN INTELLIGENT GUIDANCE HUB FOR TERTIARY EDUCATION PATHWAYS	419
B2-0019	SMART MATH GALAXY: AN INTERACTIVE ELECTRONIC BOARD GAME FOR ENHANCING	424
B2-0022	FROM BOWL TO BITE-SIZE: REDEFINING MALAYSIA'S ICONIC AIS BATU CAMPUR (ABC) AS A MODERN SNACK	429
B2-0027	SOOLEK: AN INNOVATIVE TWIST ON TRADITIONAL SOLOK LADA	433
B2-0028	RASANANG: UPCYCLING HERITAGE FOOD INTO A VALUE-ADDED, SHELF-STABLE RICE CRACKER	437
B2-0029	THE INNOVATION OF NONA MANIS BITES	441
B2-0030	LOMPLICIOUS: TRANSFORMING LOMPAT TIKAM INTO AN INNOVATIVE FROZEN DESSERT	445
B2-0031	TURTIDE HOMECOMING JOURNEY: AN INNOVATIVE DIGITAL EDUCATIONAL GAME FOR PROMOTING MARINE CONSERVATION AWARENESS AMONG CHILDREN	449

CATEGORIES

CATEGORY A: Professional Level (Lecturers/Teachers/Industry/Public)

A1: Science & Technology

A2: Social Science

CATEGORY B: Tertiary level (Universities/Polytechnics/Colleges/Matriculations)

B1: Science & Technology

B2: Social Science

CATEGORY A1

PROFESSIONAL LEVEL

SCIENCE & TECHNOLOGY

CRYO-ADSORPTIVE HYDROGEN STORAGE USING METAL–ORGANIC FRAMEWORKS: A DEEP NEURAL NETWORK APPROACH FOR EFFICIENT POROUS MATERIAL DESIGN

Wahyu Sasongko Putro[1], Ng Mai Sheng[1], Anutosh Chakraborty[1,*]

[1]School of Mechanical and Aerospace Engineering, Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798

*Corresponding author: *achakraborty@ntu.edu.sg*

ABSTRACT

The global energy transition demands sustainable storage solutions, and hydrogen has emerged as a high gravimetric energy density, zero-emission carrier particularly well-suited to Singapore's dense urban and maritime energy infrastructure. Conventional pressurised Type IV vessels face inherent limitations in both gravimetric and volumetric capacity, motivating the investigation of cryo-adsorptive alternatives. This study evaluates metal-organic frameworks (MOFs) as cryo-adsorptive hydrogen storage media operating at 77 K and pressures up to 100 bar, employing machine learning (ML) regression to enable high-throughput material screening. Four ML architectures deep neural network (DNN/MLP) with five hidden layers and ReLU activation, Gaussian process regression (GPR), support vector regression (SVR), and multiple linear regression (MLR) were trained, validated, and tested on 137,953 hMOF structures drawn from the Northwestern University MOFX-DB, encompassing four metal-node chemistries (Cu, V, Zn, and Zr) with pore limiting diameter, void fraction, and gravimetric surface area as structural predictors under an 80/10/10 data split. Hydrogen uptake (q) at 100 bar was predicted with near-perfect fidelity across all non-linear models and material classes (R^2 = 0.99 to 1.00; RMSE = 0.46 to 0.53 wt%), with GPR achieving the lowest prediction error (RMSE = 0.463 wt%). Low-pressure uptake at 2 bar proved substantially more challenging (R^2 = 0.68 to 0.93 for non-linear models), with V-node MOFs demonstrating the highest predictability (R^2 = 0.93). The isosteric heat of adsorption (Qst) was moderately captured at 2 bar (R^2 = 0.74 to 0.87) but remained the most demanding regression target at 100 bar (R^2 = 0.49 to 0.71), reflecting complex thermodynamic interactions not fully encoded by geometric descriptors alone. MLR consistently underperformed non-linear models, most critically for high-pressure uptake, where its RMSE reached 2.072 wt% with approximately 4.5 fold higher than GPR confirming the necessity of non-linear modelling for accurate high-pressure adsorption prediction. This work establishes a computationally efficient, physics-informed ML screening framework for MOF-based cryo-adsorptive hydrogen storage, directly supporting Singapore's maritime hydrogen roadmap toward 2050.

Keywords: cryo-adsorption, deep neural network, hydrogen storage, metal-organic frameworks, porous materials

1. INTRODUCTION

The twenty-first century energy landscape is shaped by the dual imperatives of meeting rising global demand and achieving deep decarbonisation. Fossil fuels currently supply over 80% of the world's primary energy, contributing approximately 36 Gt of CO_2 annually and accelerating global warming beyond the 1.5°C threshold established by the Paris Agreement (Abe et al., 2019). Among the proposed clean energy vectors, hydrogen stands out for its exceptional gravimetric energy density of approximately 120 MJ kg^{-1} nearly three times that of conventional hydrocarbon fuels, combined with zero point-of-use carbon emissions when utilised in fuel cells or combustion engines (Moradi & Groth, 2019). These properties position hydrogen as a cornerstone fuel in the global net-zero energy transition, attracting substantial investment from governments and industry worldwide.

Singapore, despite its compact geography, occupies a strategically critical node in global maritime energy supply chains. As one of the world's busiest bunkering hubs, handling over 50 million tonnes of marine fuel annually, Singapore faces a compelling imperative to decarbonise its maritime energy sector. The Singapore Green Plan 2030 and the National Hydrogen Strategy outline ambitious targets for hydrogen adoption across industry, power generation, and marine transport, with maritime hydrogen infrastructure identified as a key pillar toward the 2050 net-zero goal (Ng et al., 2025). Realising these targets hinges critically on developing safe, compact, and cost-effective hydrogen storage technologies suitable for shipboard deployment, where both gravimetric and volumetric efficiency are essential engineering constraints.

Current hydrogen storage technologies present significant challenges. High-pressure gaseous storage in Type IV composite overwrapped pressure vessels, operating at 350 to 700 bar, achieves modest gravimetric system efficiencies of 5 to 6 wt% but incurs severe volumetric penalties a critical drawback aboard space-constrained vessels (Moradi & Groth, 2019). Cryogenic liquid hydrogen (LH_2) storage, while volumetrically competitive, requires continuous refrigeration below 20 K, incurs boil-off losses, and entails high capital costs and complex safety management in maritime environments (Ramirez-Vidal et al., 2022). These fundamental limitations motivate the exploration of solid-state storage media capable of delivering high storage densities at intermediate cryogenic temperatures without the engineering complexity of either ultra-high-pressure or full-liquid systems.

Metal–organic frameworks (MOFs) are crystalline hybrid materials assembled from inorganic metal nodes secondary building units, SBUs) bridged by organic ligands, yielding highly porous three-dimensional networks with extraordinary structural tunability (Furukawa et al., 2013). Their surface areas can exceed 10,000 $m^2\ g^{-1}$, and pore geometries can be systematically tailored at the sub-nanometre scale to optimise physisorption interactions with hydrogen molecules. Under cryo-adsorption conditions, typically 77 to 150 K and pressures of 1 to 100 bar, hydrogen densities within MOF pores can reach up to ten times those of the bulk gas phase, enabling compact storage without the thermodynamic penalties of liquefaction or the structural requirements of ultra-high-pressure containment (Ng et al., 2025; Ramirez-Vidal et al., 2022). Landmark experimental studies, including NU-1101 achieving 46.6 g L^{-1} at 77 K and 70 bar and large-scale computational screens by Wilmer et al. (2012) and Ahmed et al. (2019) have firmly established the viability of MOF-based cryo-adsorptive hydrogen storage.

However, the MOF structural space encompasses over one million reported and hypothetical structures, rendering exhaustive experimental evaluation intractable. Data-driven machine learning (ML) methods have therefore emerged as indispensable tools for high-throughput MOF screening and property prediction (Butler et al., 2018; Deringer et al., 2021). Prior ML models for hydrogen uptake including support vector regression (SVR), random forest, and shallow neural networks have demonstrated competitive predictive accuracy on benchmark datasets but often struggle to generalise across the diverse multi-metallic, multi-geometry landscape of the full MOF space, particularly under the coupled pressure regimes relevant to cryo-adsorption (Salehi et al., 2023). Furthermore, most prior studies have benchmarked a single model architecture in isolation, without rigorous cross-comparison across model families or systematic evaluation of performance variability across distinct metal-node chemistries — a critical gap given that structural and electronic characteristics differ substantially across Cu-, V-, Zn-, and Zr-based MOF subclasses. Deep neural networks (DNNs) with multilayer perceptron (MLP) architectures offer multi-layer hierarchical feature extraction and superior non-linear expressive power, yet their systematic application to cryo-adsorptive hydrogen storage prediction across large-scale hypothetical MOF databases has remained underexplored relative to their potential.

The present study addresses these gaps by developing and rigorously benchmarking four ML regression architectures DNN/MLP, Gaussian process regression (GPR), support vector regression (SVR), and multiple linear regression (MLR) for simultaneous prediction of hydrogen uptake (q) and isosteric heat of adsorption (Qst) at both 2 bar and 100 bar and 77 K. Models are trained, validated, and tested on 137,953 curated hMOF structures drawn from the Northwestern University MOFX -DB, stratified by metal-node chemistry (Cu, V, Zn, and Zr) under an 80/10/10 split protocol, using three universal geometric descriptors: pore-limiting diameter, void fraction, and gravimetric surface area. The comparative analysis reveals that non-linear models particularly GPR and DNN achieve near-perfect predictive fidelity for high-pressure uptake (R^2 = 0.99–1.00; RMSE = 0.46–0.53 wt%), while isosteric heat prediction at 100 bar emerges as the most demanding regression target (R^2 = 0.49–0.71), exposing the limits of geometric descriptors alone for thermodynamic quantities. This work provides a

computationally efficient, validated ML screening pipeline for the accelerated identification of superior MOF candidates for shipboard cryo-adsorptive hydrogen storage for supporting Singapore's maritime hydrogen roadmap.

2. OBJECTIVE

The objectives of this study are to optimise two key points of adsorption science, namely hydrogen transfer
(q) and isosteric heat of adsorption (Qst) using deep neural network (DNN-MLP) model prediction of hydrogen uptake from a hypothetical MOF database with a comparison of machine learning models (using GPR, SVR, and linear regression).

3. METHODOLOGY

3.1 MOF DATABASE AND DESCRIPTORS

The dataset is sourced from the Northwestern University (NU) hypothetical MOF database, comprising over 155,000 structures with metallic nodes of vanadium (V), zirconium (Zr), copper (Cu), and zinc (Zn). Each structure is characterised by four geometric descriptors: pore-limiting diameter (PLD), surface area (SA), and void fraction (VF). Target outputs include isosteric heat of adsorption (Qst) and the uptake (q) at 2 bar and 100 bar. In this study, each material and all of the descriptors were normalised to zero mean and unit variance. Data were split 80:10:10 into training, validation, and test sets.

3.2 DEEP NEURAL NETWORK (DNN-MLP)

The DNN employs a multilayer perceptron (MLP) with five hidden layers of 256, 128, 64, 32, and 16 neurones, respectively. For each hidden layer l ($\in \{1,...,5\}$), the forward-propagation step is:

$$a(l) = f(W(l) \cdot a(l-1) + b(l)) \quad (1)$$

where $W^{(l)}$ is the weight matrix, $b^{(l)}$ is the bias vector, and f is the rectified linear unit (ReLU) activation function:

$$f(x) = \max(0, x) \quad (2)$$

Dropout regularisation ($\delta = 0.2$) is applied after each hidden layer to prevent overfitting. Here, the model performance is evaluated using two metrics expressed in equations 3 and 4:

$$R^2 = 1 - \Sigma(yi - \hat{y}i)^2 / \Sigma(yi - \bar{y})^2 \quad (3)$$

$$\text{RMSE} = \sqrt{[\, 1/N \times \Sigma i(yi - \hat{y}i)^2 \,]} \quad (4)$$

3.3 CROSS-VALIDATION

Three benchmark models are evaluated alongside the DNN. Gaussian Process Regression (GPR) models the target as a zero-mean Gaussian process with a Matérn 5/2 covariance kernel. Predictions at a new input x^* are given by:

$$\mu^* = K(x^*, X)\,[K(X, X) + \sigma n^2 I]^{-1} y \quad (5)$$

$$\sigma^{*2} = k(x^*, x^*) - K(x^*, X)\,[K(X, X) + \sigma n^2 I]^{-1} K(X, x^*) \quad (6)$$

where $K(X, X)$ is the kernel (covariance) matrix of training inputs and σn^2 is the noise variance (Deringer et al., 2021; Cao et al., 2024). Furthermore, in this study, the Support Vector Regression (SVR) seeks a function $f(x) = w^T \varphi(x) + b$ that deviates from target values by at most an insensitive margin ε. The radial basis function (RBF) kernel is expressed by:

$$K(x, x') = \exp(-\gamma \, \|x - x'\|^2) \quad (7)$$

where γ is the kernel width parameter, tuned via 5-fold cross-validation on the training set. All three models (DNN, GPR, SVR, and MLR) are evaluated on the identical held-out test set.

4. RESULT AND DISCUSSION

The predictive accuracy of four supervised learning algorithms such as DNN/MLP, GPR, SVR, and MLR was benchmarked over 1,000 training iterations using R^2 and RMSE for gas adsorption uptake (q) and isosteric heat of adsorption (Qst) at 2 bar and 100 bar across four metal–organic frameworks (MOF) metal nodes: Cu, V, Zn, and Zr. Model performance was assessed using the coefficient of determination (R^2) and root mean square error (RMSE) on independent test sets. Here, all four models demonstrated exceptional predictive capability for hydrogen uptake at 100 bar, consistently yielding R^2 values between 0.98 and 1.00 across all material classes. This near-perfect regression suggests that high-pressure hydrogen uptake is strongly governed by structural descriptors, specifically pore limiting diameter, void fraction, and gravimetric surface area, in a manner that even linear models can approximate with high fidelity, as illustrated in Figure 1.

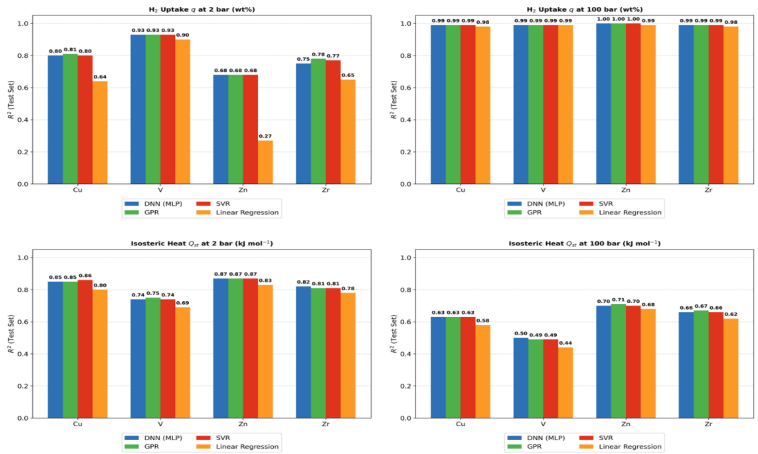


Figure 1. Model comparison between DNN, GPR, SVR, and linear regression in 1000 iterations

As can be seen in Figure 1, the prediction of q at 2 bar proved considerably more challenging, with R^2 values ranging from 0.27 (MLR, Zn) to 0.93 (DNN/GPR/SVR, V), reflecting the greater sensitivity of low-pressure adsorption to subtle structural heterogeneities that were not fully captured by the selected feature set. V-based MOFs exhibited the highest predictive accuracy for low-pressure uptake (R^2 = 0.90–0.93), likely attributable to the more homogeneous structural characteristics within this subclass. Regarding isosteric heat prediction, Qst at 2 bar was moderately well predicted (R^2 = 0.69–0.87), whereas Qst at 100 bar remained the most challenging target across all materials and models, with R^2 values spanning 0.44 to 0.71. This performance gap indicates that high-pressure thermodynamic quantities involve complex adsorbate framework interactions that extend beyond the three geometric descriptors employed herein. Furthermore, RMSE analysis presented in Figure 2 further highlights the limitation of linear regression under high-pressure conditions, where its RMSE for *q* at 100 bar reached 2.072 wt%, compared to 0.463–0.525 wt% achieved by GPR, DNN, and SVR. GPR consistently achieved the lowest RMSE for volumetric uptake at 100 bar (0.463 wt%), making it the most precise model for high-pressure storage prediction. For Qst targets, all non-linear models converged to comparable RMSE values (0.553–0.557 kJ mol^{-1} at 2 bar; 0.711–0.715 kJ mol^{-1} at 100 bar), underscoring the marginal differences between DNN, GPR, and SVR in capturing thermodynamic trends. Collectively, these findings confirm that non-linear ML models, particularly GPR and DNN, are well-suited for rapid and accurate screening of MOF hydrogen storage properties across diverse metal node chemistries.

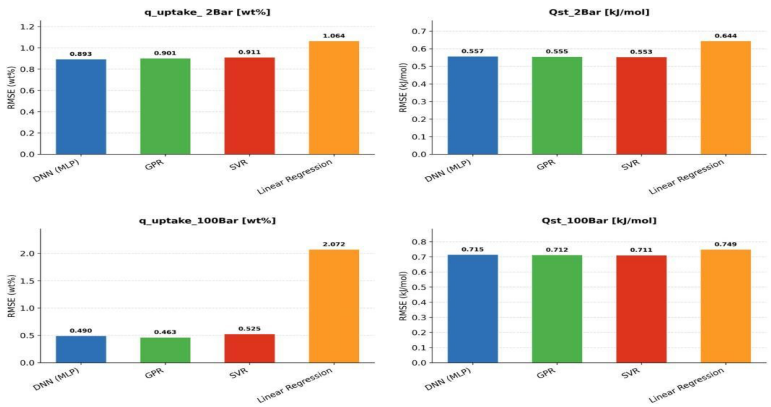


Figure 2. Calculation for model comparison between DNN, GPR, SVR, and linear regression in 1000 iterations for all materia

5. CONCLUSION

This study benchmarked four machine learning models, DNN/MLP, GPR, SVR, and MLR, for predicting hydrogen uptake and isosteric heat of adsorption across Cu, V, Zn, and Zr-based MOFs using three geometric descriptors. High-pressure uptake at 100 bar was predicted with near-perfect accuracy by all non-linear models (R^2 = 0.99 to 1.00), with GPR achieving the lowest error (RMSE = 0.463 wt%). Low-pressure uptake and high-pressure isosteric heat remained more challenging (R^2 = 0.49 to 0.93), suggesting that additional electronic and topological descriptors are required. MLR consistently underperformed non-linear counterparts. GPR and DNN are recommended as preferred surrogates for high-throughput MOF screening supporting hydrogen storage applications.

ACKNOWLEDGEMENT

The authors acknowledge the School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore for working space and lab facilities. Also, the authors acknowledge Northwestern University for the hypothetical MOF database.

REFERENCES

Abe, J. O., Popoola, A. P. I., Ajenifuja, E., & Popoola, O. M. (2019). Hydrogen energy, economy and storage: Review and recommendation. International Journal of Hydrogen Energy, 44(29), 15072–15086. https://doi.org/10.1016/j.ijhydene.2019.04.068

Butler, K. T., Davies, D. W., Cartwright, H., Isayev, O., & Walsh, A. (2018). Machine learning for molecular and materials science. Nature, 559(7715), 547–555. https://doi.org/10.1038/s41586 -018-0337-2

Deringer, V. L., Bartók, A. P., Bernstein, N., Wilkins, D. M., Ceriotti, M., & Csányi, G. (2021). Gaussian process regression for materials and molecules. Chemical Reviews, 121(16), 10073–10141. https://doi.org/10.1021/acs.chemrev.1c00022

Furukawa, H., Cordova, K. E., O'Keeffe, M., & Yaghi, O. M. (2013). The chemistry and applications of metal–organic frameworks. Science, 341(6149), 1230444. https://doi.org/10.1126/science.1230444

Moradi, R., & Groth, K. M. (2019). Hydrogen storage and delivery: Review of the state of the art technologies and risk and reliability analysis. International Journal of Hydrogen Energy, 44(23), 12254–12269. https://doi.org/10.1016/j.ijhydene.2019.03.041

Ng, M. S., Wang, G., Chakraborty, A., & Saha, B. B. (2025). Highly efficient hydrogen storage on porous materials under cryo - adsorption conditions. Next Energy, 8, 100382. https://doi.org/10.1016/j.nxener.2025.100382

Ramirez-Vidal, P., Sdanghi, G., Celzard, A., & Fierro, V. (2022). High hydrogen release by cryo-adsorption and compression on porous materials. International Journal of Hydrogen Energy, 47(14), 8892–8915. https://doi.org/10.1016/j.ijhydene.2021.12.205

Salehi, K., Rahmani, M., & Atashrouz, S. (2023). Machine learning-assisted predictions for hydrogen storage in metal-organic frameworks. International Journal of Hydrogen Energy, 48(60), 22592–22604. https://doi.org/10.1016/j.ijhydene.2023.04.338

SCDesignPro: A SMART PREDICTIVE TOOL FOR ASSESSING STONE COLUMN PERFORMANCE FOR SUSTAINABLE AND RESILIENT FOUNDATIONS

Juliana Idrus[1*], Ng Kok Shien[1], Chew Yee Ming[2]

[1]Civil Engineering Studies, Universiti Teknologi MARA Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Permatang Pauh, Pulau Pinang, MALAYSIA
[2]Department of Computer and Mathematical Sciences, Universiti Teknologi MARA Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Permatang Pauh, Pulau Pinang, MALAYSIA

[*]Corresponding author: julianaidrus@uitm.edu.my

ABSTRACT

Stone columns play a vital role in modern ground improvement by enhancing bearing capacity and reducing settlement in soft soils. Conventional design approaches of stone columns typically assume loads applied only vertically and concentrically, which does not adequately reflect actual field conditions where complex loading, such as inclined and eccentric loads, is commonly encountered. To address this limitation, SCDesignPro has been developed as a smart predictive tool for evaluating the bearing capacity of stone columns under complex loading conditions. The tool combines advanced numerical modelling with PLAXIS 3D and comprehensive parametric analyses to produce simplified, reliable, and user-friendly design formulations. The key innovation of SCDesignPro is its ability to incorporate the combined effects of inclined and eccentric loading into practical design calculations, thereby improving prediction accuracy and design reliability. This leads to safer and more robust foundation performance in soft and challenging ground conditions, thereby enhancing infrastructure resilience and reducing the risk of failure. Featuring a user-friendly interface and advanced computational capabilities, SCDesignPro delivers a practical and accessible digital solution for engineers and researchers. Its wide applicability and strong commercial potential establish it as a key advancement in smart geotechnical engineering. This innovation supports the Sustainable Development Goals, specifically SDG 9: Industry, Innovation and Infrastructure, by promoting resilient infrastructure through data-driven design tools, and SDG 11: Sustainable Cities and Communities, by improving the safety and durability of foundation systems in urban development.

Keywords: stone column, bearing capacity, complex Loading, inclined load, eccentric load

1.0 INTRODUCTION

In modern geotechnical engineering, stone columns are widely used to reinforce weak soils, thereby increasing bearing capacity and reducing overall settlement (Saha & Deb, 2023). However, a critical gap exists in conventional design approaches, where the assumption is that loads applied are only vertical and concentric. In practical applications, factors such as sloping terrain, asymmetrical structures, and seismic activity introduce significant inclined and eccentric loads (Ng, Idrus, & Chew, 2021). These complex conditions invalidate standard design assumptions and pose a direct threat to foundation stability.

The consequences of ignoring these field realities are substantial. Current research demonstrates that as load eccentricity increases, bearing capacity drops sharply, and the expected failure mode transitions unpredictably from uniform shear to bulging and bending (Ng, Idrus, & Chew, 2022). Consequently, utilising traditional design methods for complex loading can lead to dangerously non-conservative outcomes.

SCDesignPro was specifically developed to eliminate this engineering risk. By integrating advanced PLAXIS 3D numerical modelling with extensive parametric analysis, the tool provides a highly accurate assessment of stone column behaviour under combined, realistic load conditions. By translating complex numerical data into practical design formulas, SCDesignPro enhances structural resilience and equips geotechnical practitioners with a reliable tool for designing sustainable, field-ready infrastructure.

2.0 OBJECTIVE

The primary objectives for developing the SCDesignPro tool are:

1. To develop a precise and user-friendly computational tool for evaluating stone column bearing capacity across various inclined and eccentric loading conditions.

2. To enhance the safety, efficiency, and reliability of stone column design by resolving the constraints of traditional design approaches.
3. To facilitate sustainable infrastructure by offering a resilient engineering solution that closely aligns with key Sustainable Development Goals (SDGs).

3.0 METHODOLOGY

The methodology for this study comprised of three (3) primary phases: numerical modelling and parametric analysis, empirical formula derivation, and software development, all aimed at evaluating the bearing capacity of stone columns under complex inclined and eccentric loads. The research commenced with the generation of three-dimensional (3D) simulations using PLAXIS 3D.

The base model comprised a group of four (4) end-bearing stone columns, each with a diameter, *d*, of 1.0 m and a length, *L*, of 10.0 m (Figure 1). Following the initial modelling, an extensive parametric study was conducted on the reinforced footings. This involved systematically varying the load inclination angles, *β,* from 0° to 45° and eccentric distances, *e,* from 0.25 m to 1.00 m, which was evaluated across area replacement ratios, *Ar,* ranging from 0.1 to 0.5.

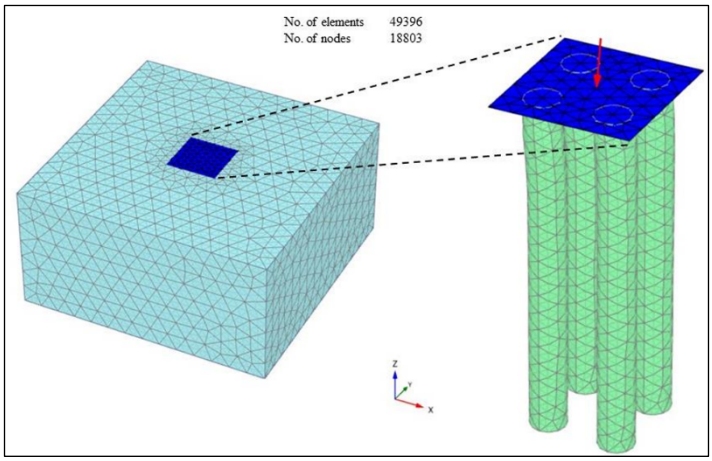


Figure 1: Numerical Model in PLAXIS 3D

In the second phase, empirical formulas were derived to predict the bearing capacity of stone columns under both inclined and eccentric loading conditions. These predictive equations were formulated using the dataset generated during the parametric analysis. The bearing capacity of stone columns under drained soil conditions can be determined using Eq. (1), Eq. (2), Eq. (3) and Eq. (4), which represent the modified eccentricity factor, e_γ and inclination factor, i_γ, respectively, for eccentric and inclined loading.

$$q_u = \frac{1}{2} B' \gamma \, N_\gamma \, i_\gamma \, s_\gamma \tag{1}$$

$$B' = B - 1.97 e_x \tag{2}$$

$$N_\gamma = 9.479 \, (1 + 2.427\alpha) \tag{3}$$

$$i_\gamma = \frac{1.11}{1 + e^{(0.165(\beta - 16))}} \tag{4}$$

In the final stage, these predictive models were integrated into a Microsoft Excel-based framework to develop the SCDesignPro software, providing engineers with an intuitive platform to accurately assess foundation performance under complex variables, including load inclination and eccentricity.

4.0 RESULT

SCDesignPro translates the empirical equations into a ready-to-use digital platform. The tool serves as a highly practical resource for engineers, researchers, and students by simplifying complex computational analyses, significantly reducing design time, and enhancing the overall reliability of soft-soil foundation designs. By effectively accommodating real-world loading complexities, SCDesignPro

emerges as an essential and efficient tool for both professional industry practice and academic application.

SCDesignPro is a user-friendly tool designed to determine the bearing capacity of stone columns under complex inclined and eccentric loading conditions. Users can navigate the SCDesignPro interface to enter key design variables, such as soil properties, footing and column sizes, and specific load configurations, as shown in Figure 2. SCDesignPro provides rapid, high-accuracy results tailored specifically for these complex field conditions.

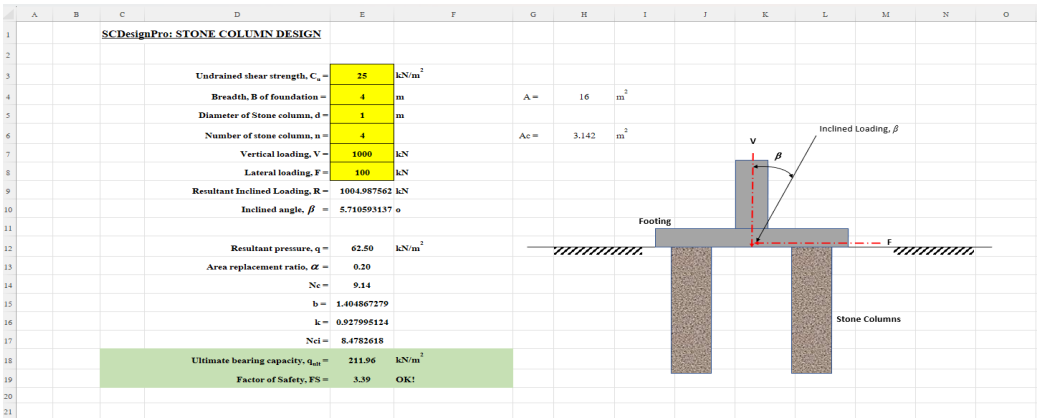


Figure 2: User interface of the SCDesignPro tool

The primary novelty of SCDesignPro is its ability to assess stone column bearing capacity under combined inclined and eccentric loading, complex conditions that are frequently overlooked by conventional design frameworks. The tool produces highly accurate design equations that offer comprehensive insights into realistic structural performance. As a result, SCDesignPro provides a pioneering, data-driven solution that not only resolves a critical industry challenge but also pushes the boundaries of modern geotechnical engineering.

SCDesignPro delivers substantial benefits to engineers by automating complex calculations, providing the flexibility to rapidly modify design parameters, and significantly minimising human errors. These operational efficiencies give the tool a strong commercial potential. It serves as a strategic asset for engineering firms seeking to optimise their design workflows and enhance overall project outcomes.

5.0 CONCLUSION

The development of SCDesignPro represents a significant advancement in geotechnical engineering, particularly in the design and analysis of stone columns subjected to complex loading conditions. The tool delivers substantial benefits to practitioners by automating calculations, providing the flexibility to rapidly modify design parameters, and significantly minimising design-related errors. Beyond enhancing operational efficiency, these capabilities ensure more resilient and reliable foundation solutions, even within challenging soil profiles. By bridging a critical gap in the market for specialised geotechnical software, SCDesignPro demonstrates strong commercialisation potential.

ACKNOWLEDGEMENT

The project head gratefully acknowledges Universiti Teknologi MARA Cawangan Pulau Pinang for the financial support provided toward the publication of this research.

REFERENCES

Ng, K. S., Idrus, J., & Chew, Y. M. 2022. Bearing capacity of stone column-reinforced soil under eccentric load. International Journal of Geosynthetics and Ground Engineering, 8, Article 53.

Ng, K. S., Idrus, J., & Chew, Y. M. 2021. Bearing capacity of stone column–reinforced foundation subjected to inclined loadings. International Journal of Geosynthetics and Ground Engineering, 7(3), Article 62.

Saha, A., & Deb, K. 2023. Bearing capacity and settlement response of stone column-supported foundations on soft soils. International Journal of Geomechanics, 23(4), 04023021.

CAMPUSIQ: AN AI-POWERED SMART FACILITY INTELLIGENCE DASHBOARD FOR SUSTAINABLE SMART CAMPUS ENVIRONMENTS

Rahimah Kassim[1,*], Adnan Bakri[2], Suhaila Shahul Hameed[3], Fauziah Abduyl Rahman[4], Ashraf Rohanim Asari[5]

[1,2,3,4,5] Universiti Kuala Lumpur, Malaysian Institute of Industrial Technology, Persiaran Sinaran Ilmu, Bandar Seri Alam, 81750 Johor Bahru, Johor

[*]Corresponding author: rahimahk@unikl.edu.my

ABSTRACT

Efficient facility management is an important component of smart campus development and sustainable operational practices in higher education institutions. However, many universities still rely on static timetable systems and fragmented digital records, which limit real-time visibility of classroom utilisation and facility availability. This situation often leads to inefficient space allocation, underutilised facilities, wasted time, and unnecessary energy consumption. To address these challenges, this study proposes the development of a Smart Facility Efficiency Dashboard using Microsoft Power BI. The proposed dashboard integrates timetable, occupancy, and facility-related data to provide real-time classroom availability, utilisation analytics, and energy-related insights on a single platform. The study adopts a quantitative approach that employs exploratory data analysis and dashboard visualisation techniques. Secondary datasets obtained from public facility datasets are used to analyse classroom utilisation patterns and identify operational inefficiencies. The dashboard is expected to support data-driven decision-making, improve space utilisation efficiency, reduce unnecessary energy consumption, and contribute to smart campus and sustainability initiatives. The findings of this study may assist educational institutions in enhancing operational management through intelligent and sustainable facility analytics systems.

Keywords: smart campus, facility intelligence, artificial intelligence (ai), business intelligence, sustainable facility management

1.0 INTRODUCTION

The rapid advancement of digital technologies has accelerated the adoption of Smart Campus initiatives, where data-driven solutions are increasingly used to enhance operational efficiency, sustainability, and the overall campus experience (Bakar et al., 2025). Effective facility management is a critical component of a Smart Campus, requiring continuous monitoring of classroom utilisation, energy consumption, and operational performance to ensure optimal resource allocation and informed decision-making (Tariq, 2026). However, many higher education institutions still rely on fragmented information systems, manual reporting, and isolated monitoring processes, limiting the ability of facility managers to obtain a comprehensive and real-time view of campus operations. This fragmentation often obscures significant energy-saving opportunities, as discrepancies between predicted and actual building usage remain largely undetected (Azizi et al., 2020).

These limitations often lead to underutilised facilities, unnecessary energy consumption, delayed decision-making, and increased operational costs (Cespedes-Cubides & Jradi, 2024). Furthermore, the lack of integrated analytics makes it challenging for institutions to support sustainability initiatives and achieve data-driven facility management. As universities continue to pursue digital transformation, there is an increasing need for an intelligent platform capable of consolidating multiple facility management functions into a single, interactive decision-support system (Abdelalim et al., 2025).

To address these challenges, this project introduces CampusIQ, an AI-powered Smart Facility Intelligence Dashboard developed using Microsoft Power BI. The dashboard integrates key facility management indicators, including classroom utilisation, energy consumption, and operational performance, into a unified platform that provides real-time visualisation and interactive analytics. (Giuda et al., 2023). By transforming fragmented operational data into meaningful insights, CampusIQ enables faster, evidence-based decision-making, improves resource utilisation, and supports sustainable campus management.

Beyond its application in higher education institutions, CampusIQ offers significant potential for deployment in schools, hospitals, government agencies, commercial buildings, and other smart facilities. Its scalable and modular architecture provides a practical foundation for future integration with Internet of Things (IoT) technologies, Artificial Intelligence (AI), and predictive analytics, supporting the evolution of intelligent and sustainable facility management ecosystems (Abdelalim et al., 2024, 2025).

2.0 OBJECTIVE

4. To develop an AI-powered Smart Facility Dashboard that integrates classroom utilisation, energy consumption, and operational performance into a single interactive platform for smart campus management.
5. To provide real-time data visualisation and intelligent analytics that support evidence-based decision-making, optimise resource utilisation, and improve operational efficiency.
6. To promote sustainable facility management by enabling continuous monitoring of key performance indicators and providing a scalable platform for future integration with Internet of Things (IoT) technologies and Artificial Intelligence (AI).

3.0 METHODOLOGY

CampusIQ was created using a systematic approach that included data integration, dashboard design, visual analytics development, and prototype implementation. The methodology centred on converting facility-related data into an intelligent dashboard that could support real-time monitoring and data-driven decision-making. Microsoft Power BI was selected as the development platform due to its interactive visualisation capabilities, scalability, and compatibility with a variety of data sources. The development process emphasised usability, functionality, and sustainability, ensuring that the dashboard effectively supported smart campus operations.

3.1 Data Integration and Preparation

The first stage involved identifying and integrating key facility management data from multiple sources. The dataset included classroom utilisation records, energy consumption data, and operational performance indicators. The collected data were cleaned, validated, and transformed using Microsoft Power Query to ensure consistency, completeness, and accuracy. This preprocessing stage established a reliable data model for subsequent analysis and dashboard development.

3.2 Dashboard Development

CampusIQ was developed using Microsoft Power BI to provide a centralised platform for facility intelligence. Interactive dashboards were designed to present key performance indicators (KPIs), charts, and visual analytics that enable users to monitor classroom occupancy, energy usage, and operational efficiency in real time. Features such as filtering, drill-down analysis, and dynamic reporting allow users to explore facility performance from different perspectives and support evidence-based decision-making.



Figure 1. Overall Architecture of CampusIQ

3.3 Intelligent Analytics and Decision Support

The dashboard transforms raw operational data into meaningful insights through interactive analytics and visual reporting. The system continuously monitors key indicators such as facility utilisation rates, energy consumption trends, and operational performance metrics to support resource optimisation

and strategic planning. The integrated dashboard enables facility managers to identify underutilised spaces, monitor energy performance, and make timely operational decisions that enhance both efficiency and sustainability.



Figure 2. CampusIQ Dashboard Interface

3.4 Prototype Implementation

A functional prototype of CampusIQ was successfully developed and demonstrated using Microsoft Power BI. The prototype validates the feasibility of integrating multiple facility management functions into a single intelligent platform. Its modular architecture supports future enhancement through the integration of Internet of Things (IoT) sensors, Artificial Intelligence (AI), and predictive analytics, enabling more advanced smart campus applications such as predictive maintenance, automated monitoring, and intelligent resource management.

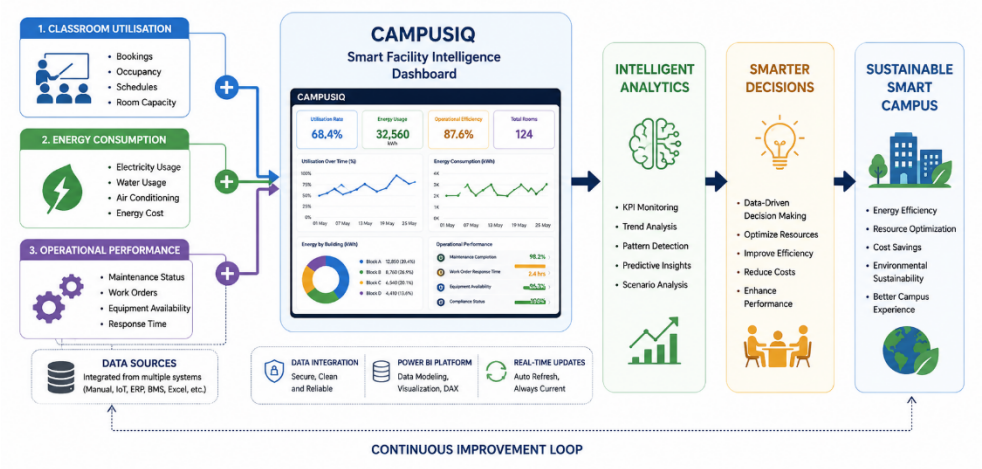


Figure 3. CampusIQ Development Framework

4.0 RESULTS

4.1 Novelty

CampusIQ introduces a novel approach to smart campus facility management by integrating classroom utilisation, energy monitoring, and operational intelligence into a single AI-powered dashboard. Unlike conventional facility management systems that operate independently and provide fragmented information, CampusIQ consolidates multiple data sources into one intelligent platform. The dashboard delivers real-time visual analytics and interactive decision support, enabling facility managers to monitor campus performance holistically. This integrated approach enhances operational visibility, supports

evidence-based decision-making, and establishes a comprehensive framework for sustainable smart campus management.

4.2 Advantages

CampusIQ provides several operational and strategic advantages for facility management. The interactive dashboard enables faster and more informed decision-making through real-time monitoring of key performance indicators. It improves resource allocation by identifying underutilised facilities and optimising space usage while reducing unnecessary energy consumption. Furthermore, the system enhances operational efficiency through continuous performance monitoring and visual analytics. CampusIQ promotes institutional environmental initiatives by incorporating sustainability indicators into daily facility management, resulting in greener and more resilient campuses.

4.3 Market Potential

CampusIQ possesses strong commercial and implementation potential due to its scalable and adaptable architecture. Although initially developed for smart campus environments, the dashboard can be readily customised for the deployment in schools, hospitals, government agencies, commercial office buildings, industrial facilities, and smart city initiatives. Built on Microsoft Power BI, the platform provides a cost-effective and practical solution that integrates easily with existing facility management systems. As organisations continue to embrace digital transformation and sustainable operations, CampusIQ represents a promising intelligent facility management solution with significant market opportunities across both the public and private sectors.

4.4 Development Status

CampusIQ has been successfully developed as a fully functional prototype using Microsoft Power BI. The prototype integrates classroom utilisation, energy consumption, and operational performance into a single intelligent dashboard, featuring interactive visualisation and real-time analytics. The successful implementation demonstrates the feasibility and practicality of the proposed solution for data-driven facility management in smart campus settings. The modular design also provides a strong foundation for future enhancements through the integration of Internet of Things (IoT) technologies, Artificial Intelligence (AI), and predictive analytics.

4.5 Academic Recognition

CampusIQ has successfully showcased its innovation value, practical relevance, and potential contribution to smart campus development at the UTM Innovation Exhibition. The exhibition provided an opportunity to validate the concept among academics, researchers, and industry practitioners while also emphasising its ability to support intelligent, data-driven, and sustainable facility management. This recognition reflects the innovation's readiness for broader adoption and future commercialisation.

5.0 CONCLUSION

CampusIQ represents a significant advancement in smart facility management by providing an integrated, AI-powered dashboard that consolidates classroom utilisation, energy consumption, and operational performance into a unified decision-support platform. Innovation enables organisations to transform operational data into actionable insights, resulting in improved efficiency, optimised resource allocation, enhanced sustainability, and faster evidence-based decision-making.

The successful development of a working prototype demonstrates the feasibility and readiness of the proposed solution for real-world implementation. With its scalable architecture, strong commercial potential, and capability for future integration with IoT technologies, Artificial Intelligence, and predictive analytics, CampusIQ offers a sustainable pathway towards intelligent campus ecosystems and next-generation smart facility management. This innovation contributes not only to operational excellence but also to the broader goals of digital transformation, environmental sustainability, and smarter communities.

CampusIQ successfully demonstrates how intelligent dashboard technologies can transform fragmented facility data into actionable insights for sustainable smart campus management. Innovation improves operational efficiency, supports evidence-based decision making, and optimises resource utilisation through interactive analytics. With its scalable architecture and strong commercial potential, CampusIQ provides a practical foundation for future AI-enabled smart campus ecosystems and intelligent facility management solutions.

ACKNOWLEDGEMENT

The authors would like to express sincere gratitude to Universiti Kuala Lumpur Malaysian Institute of Industrial Technology (UniKL MITEC) for providing the facilities, resources, and continuous support throughout the development of the CampusIQ innovation.

REFERENCES

Abdelalim, A. M., Essawy, A., Salem, M., Al-Adwani, M., & Шериф, A. (2024). Optimising Facilities Management Through Artificial Intelligence and Digital Twin Technology in Mega Facilities. In *Preprints.org*. https://doi.org/10.20944/preprints202412.2532.v1

Abdelalim, A. M., Essawy, A., Шериф, A., Salem, M., Al-Adwani, M., & Abdullah, M. S. (2025). Optimizing Facilities Management Through Artificial Intelligence and Digital Twin Technology in Mega-Facilities. *Sustainability*, *17*(5), 1826–1826. https://doi.org/10.3390/su17051826

Azizi, S., Rabiee, R., Nair, G., & Olofsson, T. (2020). Application of occupancy and booking information to optimize space and energy use in higher education institutions. *E3S Web of Conferences*, *172*, 25010–25010. https://doi.org/10.1051/e3sconf/202017225010

Bakar, M. R. A., Azli, B., & Ramli, A. S. (2025). *Advancing Higher Education Management Through Smart Campus Implementation*. 1–6. https://doi.org/10.1109/icitce65255.2025.11210786

Cespedes-Cubides, A. S., & Jradi, M. (2024). A review of building digital twins to improve energy efficiency in the building operational stage. *Energy Informatics*, *7*(1). https://doi.org/10.1186/s42162-024-00313-7

Giuda, G. M. D., Accardo, D., Gasbarri, P., Meschini, S., Tagliabue, L. C., & Scomparin, L. (2023). BIM-GIS and BI Integration for Facility and Occupancy Management of University Assets: The UNITO Pilot Case. In *Virtual Community of Pathological Anatomy (University of Castilla La Mancha)* (pp. 419–430). University of Castilla-La Mancha. https://doi.org/10.36253/979-12-215-0289-3.41

Salmon, K., Morejohn, J., Sanguinetti, A., & Pritoni, M. (2017). The Iterative Design of a University Energy Dashboard. *eScholarship (California Digital Library)*. http://www.escholarship.org/uc/item/67f2w46b

Tariq, M. U. (2026). *Building the IoT-Enabled Smart Campus* (pp. 103–130). https://doi.org/10.4018/979-8-3373-6831-3.ch004

Microsoft. (2025). *Microsoft Power BI documentation*. https://learn.microsoft.com/power-bi/ O'Leary, D. E. (2020). Artificial intelligence and big data in business intelligence. *Intelligent Systems in Accounting, Finance and Management, 27*(2), 71–84. https://doi.org/10.1002/isaf.1473

Al Dakheel, J., Del Pero, C., Aste, N., & Leonforte, F. (2020). Smart buildings features and key performance indicators: A review. *Sustainable Cities and Society, 61*, 102328. https://doi.org/10.1016/j.scs.2020.102328

ISO. (2021). *ISO 41001:2021 Facility management systems—Requirements with guidance for use*. International Organization for Standardization. https://www.iso.org/standard/68021.html

ERGODASH: ERGONOMIC DASHBOARD LAYOUT DESIGN FOR IMPROVED DRIVER PERFORMANCE AND SAFETY

Sabariah Mohd Yusoff[1, *], Nur Fatin Sharudin[1]

[1]Oil and Gas Section, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, Persiaran Sinaran Ilmu, Bandar Seri Alam, 81750, Johor, Malaysia

[*] Corresponding author: sabariahmy@unikl.edu.my

ABSTRACT

The rapid migration from analogue instrument clusters to information-rich digital interfaces has created a need for dashboard designs that support fast recognition without increasing visual distraction. ERGODASH is an evidence-based ergonomic dashboard layout concept developed to improve driver visual performance and safety by combining a high-visibility digital display with a clear hierarchy of primary and secondary information. The innovation addresses common interface problems, including visual clutter, weak prioritisation, inconsistent icon placement, and poor readability under different display conditions. ERGODASH was developed through a 3 x 3 full-factorial evaluation of three dashboard configurations (analogue, digital, and hybrid) and three brightness levels (low, medium, and high). Licensed drivers completed controlled component-search and information-reading tasks involving speed, fuel, trip, time, mileage, brightness, and average fuel-consumption indicators. Searching time, reading time, task-completion time, accuracy, and user preference were evaluated. Display brightness significantly influenced all time-based performance measures ($p < .001$), whereas dashboard type and the dashboard-by-brightness interaction were not statistically significant. Nevertheless, the high-brightness digital condition produced the best practical performance, with mean searching, reading, and total completion times of 4.722s, 2.6265s, and 7.350s, respectively. Compared with the low-brightness digital condition, total task-completion time improved by 25.9%. These findings were translated into the ERGODASH prototype through priority zoning, large legible indicators, spatial separation of information, simplified warning icons, and a visibility-focused display profile. The innovation offers a practical, modular, and potentially low-cost reference for automotive interface designers, simulator developers, and vehicle-HMI educators. ERGODASH demonstrates how experimental ergonomics can be converted into a usable dashboard design specification that supports faster information access and safer driver interaction.

Keywords: automotive ergonomics, digital dashboard, driver performance, human-machine interface, visual safety

1.0 INTRODUCTION

Vehicle dashboards have evolved from isolated analogue gauges into multifunctional human-machine interfaces that integrate speed, warnings, navigation, efficiency, and vehicle-status information. Although digital systems offer flexibility, poorly structured content can lead to increased visual search, cognitive workload, and off-road focus. Reviews of automotive interfaces therefore emphasise legibility, intuitive organisation, and low-distraction interaction as essential design requirements (Mandujano-Granillo et al., 2024; Strayer et al., 2019). On-road evidence similarly shows that visual-manual interaction and demanding secondary tasks can impair driver attention and performance (Zhong et al., 2024).

Dashboard form, indicator precision, visual hierarchy, and time pressure influence how quickly drivers locate and interpret information (Liu & Shen, 2025; Yang et al., 2022). The problem is therefore not the use of digital technology itself but the absence of an ergonomically validated layout that converts driver-performance evidence into practical design rules. This need is consistent with earlier findings that vehicle feedback quality and secondary-task demand influence human detection and response efficiency (Yusoff & Abd Razak, 2023; Yusoff & Giacomin, 2019). ERGODASH is an evidence-based dashboard design concept that addresses this gap by prioritising safety-critical information, separating secondary content, and applying a visibility-focused digital display profile. Its development combines objective task-performance data with usability-orientated design principles, an approach recommended for dashboard evaluation (Almasi et al., 2023).

2.0 OBJECTIVES

7. To develop a digital dashboard layout that prioritises safety-critical information through a clear visual hierarchy and spatial zoning
8. To evaluate the effects of dashboard configuration and brightness on searching time, reading time, task-completion time, and accuracy
9. To translate the best-performing experimental condition into a practical and modular ERGODASH interface concept for automotive HMI development and training

3.0 METHODOLOGY

3.1 ERGODASH DEVELOPMENT AND EVALUATION

ERGODASH was developed in three stages: ergonomic requirement identification, controlled factorial evaluation, and interface translation. The evaluation employed a 3 x 3 full-factorial design comprising three dashboard types (analogue, digital, and hybrid) and three display-brightness levels (low, medium, and high). Eligible participants possessed a valid Malaysian driving licence, at least three years of driving experience, normal or corrected-to-normal vision, and no reported neurological or cognitive impairment. They completed structured visual-search and reading tasks using common dashboard components: speedometer, tachometer, fuel level, time, trip data, mileage, brightness, and average fuel consumption. Searching time was measured from task onset until the target was located, reading time captured interpretation after location, and total task-completion time covered the full response sequence. Accuracy and subjective preference were also recorded. Analysis of variance at alpha = .05 tested the main and interaction effects, while descriptive comparisons identified the fastest practical configuration. This controlled approach reflects established driver-interface and design-of-experiments methods for quantifying search behaviour and secondary-task performance (Yang et al., 2022; Yusoff & Abd Razak, 2023).

3.2 INNOVATION DESIGN FEATURES

The resulting ERGODASH design employs a dominant primary zone for immediate driving information and separate secondary zones for efficiency, trip, and status data. Large numerical values, limited icon groups, whitespace, and consistent alignment all help to reduce competition between elements. The high-visibility profile is derived from the best experimental conditions; in vehicle implementation, the luminance should be calibrated to ambient conditions to maintain readability while avoiding glare. The modular architecture allows the same hierarchy to be adapted to internal-combustion, hybrid, and electric vehicles.

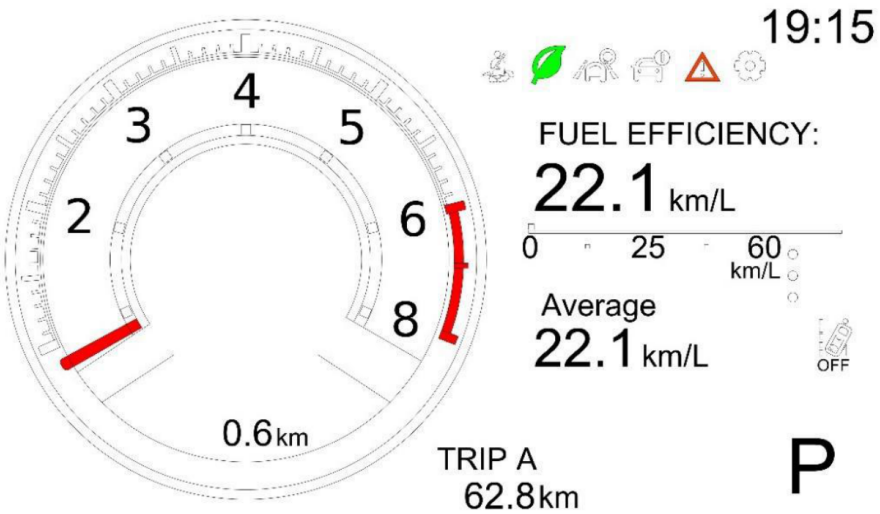


Figure 1: ERGODASH high-visibility digital dashboard concept with prioritised information zones.

Table 1: Core ERGODASH design features and intended ergonomic functions.

Design feature	ERGODASH implementation	Intended ergonomic function

Priority zoning	Speed, warnings, and gear position are placed in the primary visual zone.	Supports rapid access to safety-critical information.
Separated information groups	Fuel efficiency, trip data, time, and settings displayed in distinct secondary zones.	Reduces visual clutter and unnecessary search paths.
Legible visual coding	Large numerals, simple icons, whitespace, and consistent alignment.	Improves recognition and lowers interpretation demand.
Visibility-focused digital profile	High-visibility presentation with proposed ambient-light calibration.	Maintains readability across changing display conditions.

4.0 RESULT

4.1 PERFORMANCE VALIDATION

Display brightness was the dominant experimental factor and significantly affected searching time, reading time, and total task-completion time ($p < .001$). Dashboard type and the dashboard-by-brightness interaction were not statistically significant. However, the digital dashboard at high brightness recorded the best descriptive performance: 4.722 s searching time, 2.6265 s reading time, and 7.350 s total completion time. The digital layout was therefore selected for ERGODASH, as it combined the lowest practical time measures with the greatest flexibility for prioritising information. This selection is presented as an evidence-based design decision rather than a claim that digital format alone was statistically superior.

Table 2: Performance improvement from low- to high-brightness digital dashboard.

Performance measure	**Digital-low (s)**	**Digital-high (s)**	**Improvement**
Searching time	6.500	4.722	27.4%
Reading time	3.4016	2.6265	22.8%
Task-completion time	9.918	7.350	25.9%

4.2 NOVELTY, ADVANTAGE AND IMPACT

ERGODASH is novel in the way it converts factorial ergonomics data into a dashboard design specification rather than treating the interface as a purely aesthetic concept. Its combined contribution is: (i) experimentally informed selection of a visibility-focused digital configuration; (ii) a reusable hierarchy separating primary and secondary driving information; and (iii) a measurable performance baseline for future HMI prototypes. The design can be implemented as a software layout before expensive vehicle integration, which may reduce early prototyping iterations. Potential applications include automotive instrument clusters, driving simulators, retrofit displays, interface-evaluation laboratories, and teaching modules. By enabling faster access to essential information, ERGODASH has the potential to reduce avoidable glance demand and support safer driver decision-making, while remaining adaptable to different vehicle powertrains and screen sizes.

5.0 CONCLUSION

ERGODASH transforms the findings of a controlled dashboard experiment into an innovation-oriented interface concept for improved driver performance and safety. Brightness significantly influenced all time-based measures, and the high-brightness digital condition achieved the fastest practical performance. The resulting design prioritises essential information, separates secondary content, simplifies visual coding, and provides a modular foundation for future vehicle-HMI development. The innovation provides an evidence-based bridge between automotive ergonomics research and dashboard design that can be implemented. Further work should test adaptive brightness, eye-glance behaviour, workload, and real-driving performance with a larger and more diverse driver population.

ACKNOWLEDGEMENT

The authors acknowledge the support of Universiti Kuala Lumpur, Malaysian Institute of Industrial Technology, and all participants who contributed to the dashboard evaluation.

REFERENCES/RUJUKAN

Almasi, S., Bahaadinbeigy, K., Ahmadi, H., Sohrabei, S., & Rabiei, R. (2023). Usability evaluation of dashboards: A systematic literature review of tools. *BioMed Research International, 2023*, Article 9990933. https://doi.org/10.1155/2023/9990933

Liu, Y., & Shen, Z. (2025). The effects of dashboard design form on driving information reading performance under different time pressures. *Frontiers in Psychology, 16*, 1635951. https://doi.org/10.3389/fpsyg.2025.1635951

Lyu, N., Xie, L., Wu, C., Fu, Q., & Deng, C. (2017). Driver's cognitive workload and driving performance under traffic sign information exposure in complex environments: A case study of the highways in China. *International Journal of Environmental Research and Public Health, 14*(2), 203. https://doi.org/10.3390/ijerph14020203

Mandujano-Granillo, J. A., Reyes-Gonzalez, J., Cervantes-Perez, J. A., & Favela, J. (2024). Human-machine interfaces: A review for autonomous electric vehicles. *IEEE Access, 12*, 121635-121658. https://doi.org/10.1109/ACCESS.2024.3450439

Strayer, D. L., Cooper, J. M., Turrill, J., Coleman, J. R., Medeiros-Ward, N., & Biondi, F. (2019). Assessing the visual and cognitive demands of in-vehicle information systems. *Cognitive Research: Principles and Implications, 4*, Article 18. https://doi.org/10.1186/s41235-019-0166-3

Yang, H., Wang, Y., & Jia, R. (2022). Dashboard layout effects on drivers' searching performance and heart rate: Experimental investigation and prediction. *Frontiers in Public Health, 10*, 813859. https://doi.org/10.3389/fpubh.2022.813859

Yusoff, S. M., & Abd Razak, M. A. S. (2023). Driving efficiency: Unveiling the impact of secondary tasks through design of experiment (DOE). *Human Factors and Ergonomics Journal, 8*(2), 129-135. https://hfej.hfem.org/elementor-6886/

Yusoff, S. M., & Giacomin, J. (2019). The effect of vibrational energy distribution on the level of driver detection. *AIP Conference Proceedings, 2059*(1), 020032. https://doi.org/10.1063/1.5085975

Zhong, Q., Zhi, J., Xu, Y., Gao, P., & Feng, S. (2024). Assessing driver distraction from in-vehicle information system: An on-road study exploring the effects of input modalities and secondary task types. *Scientific Reports, 14*, 20289. https://doi.org/10.1038/s41598-024-71226-4

Jabal, A., P. Ahmad, P. Ayub & A.S. Emir. 2034. Money transfer effects on receiver mental health. Journal of Psychological Engineering and Science, 9 (22): 575-583. DOI:10.1016/jpes.2034.77.170.

iHADIR: AN INTELLIGENT EARLY WARNING SYSTEM FOR AUTOMATED STUDENT ATTENDANCE MANAGEMENT

Norhidayah binti Samat[1], Norsuhana binti Idris[1,*], Mimi Dalina binti Ibrahim[1], Intan Safina binti Othman[1]

[1]Kolej Poly-Tech MARA Cawangan Batu Pahat

[*] Corresponding author: norhidayah@kptm.edu.my

ABSTRACT

Student absenteeism remains one of the major challenges faced by higher education institutions because it directly affects academic performance, student engagement, learning outcomes, and graduation rates. At Kolej Poly-Tech MARA (KPTM), the existing attendance management process requires lecturers to manually monitor attendance records, calculate absence percentages, identify students exceeding attendance limits, prepare warning letters, and notify students individually. This manual workflow is repetitive, labour-intensive, and susceptible to human error, often delaying intervention. Consequently, students frequently receive warning notices only after their attendance has reached a critical stage, reducing opportunities for early corrective action. To overcome these limitations, the iHadir System was developed as an intelligent enhancement to the existing Student Information Management System (SPMP). Unlike conventional attendance monitoring systems that merely record attendance, iHadir introduces an automated real-time Early Warning System (EWS) that continuously analyses attendance records, identifies students who exceed predefined attendance thresholds, and instantly generates personalised warning notifications through email and SMS. The system eliminates manual calculations, paperwork, and repetitive administrative tasks while ensuring timely communication with students. The innovation significantly improves operational efficiency by reducing lecturers' administrative workload, increasing data accuracy, accelerating warning notification processes, and enabling proactive intervention. More importantly, students receive immediate alerts that encourage self-regulation and timely corrective action before disciplinary consequences occur. As a scalable and sustainable digital solution, iHadir supports KPTM's Smart Campus initiative by integrating automation, real-time analytics, and intelligent communication within the existing institutional infrastructure without requiring additional standalone systems. The innovation contributes to improved student retention, enhanced academic responsibility, and more efficient institutional governance, making it highly adaptable for implementation across higher education institutions.

Keywords: student attendance, early warning system, spmp, smart campus, digital transformation

1.0 INTRODUCTION

Student attendance is widely recognised as one of the strongest predictors of academic achievement, student engagement, and graduation success. Numerous studies have demonstrated that poor attendance is strongly associated with lower academic performance, increased dropout rates, and reduced student retention. Consequently, higher education institutions continuously monitor student attendance to identify students at risk and implement timely interventions.

At Kolej Poly-Tech MARA (KPTM), attendance monitoring is managed through the Student Information Management System (SPMP). Despite SPMP's electronic storage of attendance records, the subsequent processes are still largely manual. Lecturers and administrative officers must review attendance reports, identify students who exceed institutional attendance limits, prepare official warning letters, and distribute notifications individually.

This conventional workflow presents several challenges:

excessive administrative workload;
delayed identification of at-risk students;
repetitive manual calculations;
inconsistent warning delivery;
increased risk of human error.

More importantly, delayed warning notifications reduce opportunities for early intervention, allowing attendance problems to escalate before students receive official reminders. The rapid advancement of digital technologies and institutional digital transformation initiatives has created opportunities to automate repetitive administrative processes through intelligent information systems. Therefore, there is a growing need for an integrated attendance management solution capable of automatically identifying attendance violations and delivering immediate notifications to students.

The iHadir System was developed to address these operational challenges by introducing an intelligent Early Warning System that transforms attendance management from a reactive administrative process into a proactive student support mechanism.

2.0 OBJECTIVE

The objectives of the iHadir System are:

10. To automate student attendance monitoring using real-time attendance data from SPMP.
11. To provide an intelligent early warning mechanism that automatically identifies students exceeding attendance thresholds.
12. To generate and deliver personalised warning notifications via email and SMS without manual intervention.
13. To reduce lecturers' and administrative staff's workload while improving operational efficiency.
14. To support student retention through timely intervention and enhanced student awareness.

3.0 METHODOLOGY

3.1 SYSTEM DEVELOPMENT

The iHadir System was developed using an enhancement approach by integrating new functionalities into the existing Student Information Management System (SPMP). Rather than replacing the existing system, iHadir extends its capabilities through intelligent automation and real-time notification services.

The development process consists of four major stages:

Stage 1: Attendance Data Collection

Attendance records are automatically retrieved from SPMP after lecturers have completed their attendance submission.

Stage 2: Attendance Analysis

The system continuously analyses attendance percentages based on institutional attendance regulations. Once a student's absence reaches predefined warning thresholds, the system immediately flags the record.

Stage 3: Automated Warning Generation

Instead of requiring lecturers to manually prepare warning letters, iHadir automatically generates personalised warning notifications that include:

1. student information;
2. attendance percentage;
3. course details;
4. warning level;
5. recommended corrective actions.

Stage 4: Notification Delivery

The generated notification is automatically sent via:

- Email
- SMS

The entire process occurs in real time without requiring additional administrative intervention.

3.2 SYSTEM FEATURES

The major features of iHadir include:

1. Real-time attendance monitoring
2. Automated attendance analysis
3. Intelligent Early Warning System
4. Automatic email notification
5. SMS notification
6. Dashboard reporting
7. SPMP integration
8. Secure user authentication
9. Digital record management

4.0 RESULT

The implementation of iHadir demonstrates substantial improvements over conventional attendance management practices.

Unlike existing attendance systems that merely record attendance, iHadir transforms attendance data into actionable intelligence through automated intervention.

The innovation produces several measurable benefits.

For lecturers:

- eliminates manual attendance calculations;
- reduces administrative workload;
- allows greater focus on teaching.

For Student Affairs (SPA):

- accelerates warning issuance;
- improves consistency of attendance enforcement;
- reduces paperwork.

For Information Technology (IT):

- integrates seamlessly with existing SPMP infrastructure;
- maintains centralised data management;
- improves system reliability.

For students:

6. receive immediate attendance alerts;
7. become more aware of attendance responsibilities;
8. can take corrective action before disciplinary consequences occur.

Novelty

The novelty of iHadir lies in its integration of:

- automated attendance analytics;
- intelligent Early Warning System;
- real-time email and SMS notification;
- seamless SPMP integration.

Unlike conventional attendance systems that function solely as data repositories, iHadir actively supports institutional decision-making through intelligent automation.

Its proactive intervention capability significantly distinguishes it from traditional attendance monitoring approaches.

5.0 CONCLUSION

The iHadir System represents an innovative digital solution that modernises attendance management through intelligent automation and proactive intervention. By integrating automated attendance analysis, real-time early warning notifications, and seamless SPMP integration, the system significantly reduces administrative workload while improving operational efficiency and student engagement.

Beyond process automation, iHadir strengthens institutional governance by enabling timely interventions that support student retention and academic success. The innovation aligns with KPTM's Smart Campus initiative and demonstrates strong potential for implementation across higher education institutions seeking sustainable digital transformation. With its scalability, practicality, and measurable institutional impact, iHadir provides a future-ready model for intelligent attendance management and student support services.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Kolej Poly-Tech MARA (KPTM) for its continuous support in the development of the iHadir System. Special thanks are extended to the Student Affairs Department, Information Technology Unit, and academic staff whose valuable feedback contributed to the successful development of this innovation.

REFERENCES

1. Preprint

Alsuwaiket, M., Dawson, C., & Batmaz, F. (2020). Measuring the credibility of student attendance data in higher education for data mining. arXiv.

Kassarnig, V., Bjerre-Nielsen, A., Mones, E., Lehmann, S., & Lassen, D. D. (2017). Class attendance, peer similarity, and academic performance in a large field study. arXiv.

2. Journal paper

Canbolat, Y. (2024). Early warning for whom? Effect of early warning system on student absence. Educational Evaluation and Policy Analysis.

Imundo, M. N., et al. (2025). Student knowledge of and responses to an early alert system designed to enhance academic persistence. Applied Sciences, 15(11), 6316.

Kearney, C. A. (2023). School attendance problems and absenteeism as early warning signals: Review and implications for health-based protocols and school-based practices. Frontiers in Education, 8.

Sälzer, C. (2024). Addressing school absenteeism through monitoring. Education Sciences, 14(12), 1365.

3. Government/Institutional Report

Institute of Education Sciences. (2024). Using data and early warning systems to improve student attendance and engagement.

DAULAT: JEJAK WIRA NEGARA – A MULTI-LEVEL EDU-CARD AND MISSION BOARD GAME FOR MALAYSIAN HISTORY LEARNING

Siti Mariam binti Azman[1,*], Zulhilmi bin Khatam[1], Hafsyah binti Sohaimi[1], Ahmad Haikal Fikri bin Hazadi[1], Muhamad Zikri bin Kambali[1]

[1]Kolej Poly-Tech Mara Batu Pahat

[*]Corresponding author: siti_mariam@kptm.edu.my

ABSTRACT

History education in Malaysia remains largely dependent on conventional teaching methods that emphasise the memorisation of facts, dates, and historical figures. This approach often limits students' engagement, critical thinking, and appreciation of the nation's heritage. To address these challenges, DAULAT: Jejak Wira Negara was developed as a multi-level educational card and mission board game that transforms Malaysian history learning into an interactive, collaborative, and strategy-based experience. The innovation integrates historical figures, significant events, locations, artefacts, national chronology, and civic values into an immersive gameplay system that aligns with the Malaysian Primary School Standard Curriculum (KSSR), the Secondary School Standard Curriculum (KSSM), and higher education learning outcomes. The game consists of Leader Cards, Wira Cards, Rakyat Cards, Event Cards, Location Cards, Artefact Cards, Mission Cards, Colonial Pressure Cards, a Timeline Board, a Mini Map Board, a Teacher Guide, a Rulebook, and QR code-supported digital learning resources. The game features five gameplay modes: KSSR Junior Mode, KSSM Standard Mode, Classroom Cooperative Mode, Advanced Trading Card Game (TCG) Mode, and Boardgame Map Mode, which allow educators to adapt the learning experience according to students' age, cognitive ability, and curriculum requirements. The Core Malaysia Starter Pack integrates Peninsular Malaysia, Sabah, and Sarawak from the beginning, ensuring an inclusive historical narrative that spans early civilisations, colonial intervention, local resistance, independence in 1957, the formation of Malaysia in 1963, and nation-building. Unlike conventional educational games that primarily reinforce factual recall, DAULAT promotes historical inquiry, chronological reasoning, collaboration, and strategic decision-making through mission-based gameplay. The innovation offers a practical and engaging teaching resource for schools, higher education institutions, museums, exhibitions, and community heritage programmes while fostering historical literacy, national identity, and patriotism among learners.

Keywords: history education, game-based learning, gamification, Malaysian history, educational board game

1.0 INTRODUCTION

History education plays a vital role in fostering national identity, civic responsibility, and historical awareness among Malaysians. However, many students perceive history as a difficult and less engaging subject because classroom instruction frequently relies on lectures, textbooks, and memorisation of historical facts. These teacher-centred approaches often fail to encourage historical thinking skills, such as analysing historical evidence, identifying cause-and-effect relationships, evaluating multiple perspectives, and connecting historical events with present-day issues. Consequently, students may demonstrate low motivation, limited participation, and superficial understanding of Malaysian history.

Game-Based Learning (GBL) has been recognised as an effective pedagogical approach that promotes active participation, collaboration, critical thinking, and long-term knowledge retention. Nevertheless, existing educational history games in Malaysia generally cover only selected historical topics and are not fully aligned with the national curriculum.

To overcome these limitations, DAULAT: Jejak Wira Negara was developed as a comprehensive educational innovation that combines strategic card gameplay, mission-based learning, historical timeline reconstruction, geographical exploration, and digital learning support within a single learning ecosystem. The innovation covers the development of Malaysia from early civilisation to nation-building while aligning with the KSSR and KSSM History curriculum and supporting higher education learning activities.

2.0 OBJECTIVE

The objectives of this innovation are:

15. To develop a comprehensive educational board and card game that supports Malaysian history learning through interactive gameplay.
16. To enhance students' historical thinking skills, critical reasoning, collaboration, and problem-solving abilities using game-based learning strategies.
17. To promote patriotism and appreciation of Malaysian heritage by providing meaningful and curriculum-aligned historical learning experiences.

3.0 METHODOLOGY

The development of **DAULAT: Jejak Wira Negara** adopted a Design-Based Research (DBR) approach to ensure that the educational content, game mechanics, and learning objectives were systematically integrated into a practical teaching innovation. The development process consisted of five stages: (1) identifying problems in conventional history learning through curriculum analysis and classroom observations; (2) mapping historical content to the Malaysian Primary School Standard Curriculum (KSSR) and Secondary School Standard Curriculum (KSSM); (3) designing educational game mechanics, learning outcomes, and visual components; (4) developing and refining the game prototype; and (5) validating the product through expert review and pilot gameplay sessions.

The innovation combines educational board game mechanics with strategic card gameplay to encourage active learning, collaborative problem-solving, historical inquiry, and chronological reasoning. Unlike traditional history learning methods, DAULAT allows learners to interact with historical events through missions and decision-making activities while maintaining curriculum alignment.

3.1 Product Features and Functionality

The DAULAT learning package consists of several integrated educational components designed to provide an engaging and comprehensive learning experience. These include:

Table 1. Main Components of DAULAT: Jejak Wira Negara

Component	Educational Function
Leader Cards	Represent historical leaders with unique strategic abilities.
Wira Cards	Introduce Malaysian national heroes and their historical contributions
Rakyat Cards	Demonstrate the role of citizens in nation-building
Event Cards	Present major historical events that influence gameplay
Location Cards	Connect historical figures with significant locations across Malaysia
Artefact Cards	Introduce important cultural and historical artefacts
Mission Cards	Encourage problem-solving through curriculum-based historical missions
Colonial Pressure Cards	Simulate historical challenges during colonial rule
Timeline Board	Reinforces chronological understanding of Malaysian history
Mini Map Board	Develops geographical awareness of historical locations
QR Learning Resources	Provide additional digital learning materials and multimedia content
Teacher Guide & Rulebook	Support classroom implementation and independent gameplay

The game offers five different gameplay modes to accommodate learners with different educational levels and learning objectives:

9. **KSSR Junior Mode**
10. **KSSM Standard Mode**
11. **Classroom Cooperative Mode**
12. **Advanced Trading Card Game (TCG) Mode**
13. **Boardgame Map Mode**

These modes enable educators to adapt the game according to students' age, cognitive ability, classroom duration, and curriculum requirements.

Figure 1. Development Framework of DAULAT: Jejak Wira Negara

(Insert a flow diagram showing: Needs Analysis → Curriculum Mapping → Game Design → Prototype Development → Validation → Implementation.)

4.0 RESULT

The development of DAULAT successfully resulted in producing a comprehensive educational board game that integrates curriculum-based historical content with modern game-based learning strategies. The innovation transforms traditional history lessons into interactive learning experiences that encourage students to actively explore historical events instead of memorising isolated facts.

The product demonstrates several educational advantages. First, it enhances student engagement through collaborative missions, strategic gameplay, and interactive storytelling. Second, it strengthens historical thinking skills by requiring learners to analyse historical events, identify relationships between people and places, construct chronological sequences, and evaluate the consequences of historical decisions. Third, the inclusion of Peninsular Malaysia, Sabah, and Sarawak within the Core Malaysia Starter Pack provides a balanced and inclusive representation of Malaysian history.

The novelty of DAULAT lies in its integration of educational card games, mission-based board games, historical timeline construction, geographical exploration, and QR-supported digital learning within a single learning ecosystem. Unlike conventional educational board games, the innovation supports multiple educational levels through five gameplay modes and aligns directly with the KSSR and KSSM History curriculum. This flexibility enables its implementation in classrooms, museums, educational exhibitions, heritage programmes, and higher education institutions.

5.0 CONCLUSION

DAULAT: Jejak Wira Negara offers an innovative and practical approach to Malaysian history education by integrating curriculum-aligned historical content with engaging game-based learning strategies. The innovation addresses the limitations of conventional history instruction by promoting active participation, historical inquiry, critical thinking, collaboration, and patriotism through immersive gameplay.

Its multi-level design enables implementation across primary schools, secondary schools, higher education institutions, museums, and community heritage programmes. By combining educational value with strategic gameplay, DAULAT has strong potential to improve students' historical literacy while fostering a deeper appreciation of Malaysia's diverse historical heritage. Future work will focus on classroom implementation, empirical evaluation of learning effectiveness, and digital expansion to further enhance accessibility and educational impact.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Kolej Poly-Tech MARA Batu Pahat for its continuous support in the development of this educational innovation. The authors also thank all educators, reviewers, and participants who provided valuable feedback during the prototype development and evaluation stages.

REFERENCES/RUJUKAN

Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research, 86*(1), 79–122. https://doi.org/10.3102/0034654315582065

Gee, J. P. (2007). *What video games have to teach us about learning and literacy* (2nd ed.). Palgrave Macmillan.

Kementerian Pendidikan Malaysia. (2017). *Dokumen Standard Kurikulum dan Pentaksiran Sejarah Tahun 4–6*. Bahagian Pembangunan Kurikulum.

Kementerian Pendidikan Malaysia. (2018). *Dokumen Standard Kurikulum dan Pentaksiran Sejarah Tingkatan 1–5*. Bahagian Pembangunan Kurikulum.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist, 50*(4), 258–283. https://doi.org/10.1080/00461520.2015.1122533

Qian, M., & Clark, K. R. (2016). Game-based learning and 21st-century skills: A review of recent research. *Computers in Human Behavior, 63*, 50–58. https://doi.org/10.1016/j.chb.2016.05.023

Whitton, N. (2014). *Digital games and learning: Research and theory*. Routledge.

MINDMIRROR: An AI-Powered Emotional Wellness Companion for Proactive Mental Healthcare

Nor Syasyaamira Binti Ramli[1], Nur Fatin Nadzirah Binti Zaman[2, *], Nor Baizura Binti Mohamed

[1]Kolej Poly – Tech Mara Batu Pahat, Jalan Gading Emas 4, Sri Gading, 83000 Batu Pahat, Johor

[*] Corresponding author: syasyaamira@kptm.edu.my

ABSTRACT

Mental health challenges, including stress, anxiety, and depression, continue to affect individual wellbeing, productivity, and quality of life worldwide. Although digital mental health technologies have expanded access to emotional support, many existing solutions depend on active user participation, such as self-reporting, mood logging, or repeated engagement with dedicated applications. Such requirements may contribute to inconsistent long-term engagement, particularly when individuals are experiencing emotional distress (Baumel et al., 2019; World Health Organization [WHO], 2022). This highlights the need for a more seamless and proactive approach to everyday emotional wellness. MindMirror is proposed as an AI-powered emotional wellness companion designed to integrate proactive mental healthcare into users' daily routines through a smart mirror platform. The innovation employs multimodal artificial intelligence to analyse facial expressions, speech characteristics, contextual behavioural cues, and optional physiological indicators to recognise users' emotional states. These insights are processed by an Adaptive Emotional Intelligence Engine to provide personalised interventions, including guided breathing exercises, mindfulness prompts, motivational affirmations, calming visualisations, and tailored wellness recommendations. Unlike conventional digital mental health applications, MindMirror embeds emotional support within an everyday object, enabling non-intrusive emotional engagement without requiring continuous manual input. The proposed privacy-preserving architecture prioritises local processing of sensitive emotional data, while its modular design supports future integration with wearable devices, telehealth services, and smart home technologies. MindMirror therefore offers a user-centred approach that shifts emotional wellness from reactive intervention to proactive support. Its scalability and adaptability demonstrate potential for implementation across residential, educational, healthcare, and workplace environments, contributing to more accessible, personalised, and sustainable emotional wellness solutions.

Keywords: artificial intelligence; emotional wellness; smart mirror; mental healthcare; affective computing

1.0 INTRODUCTION

Mental health has become an increasingly significant public health concern worldwide, with stress, anxiety, and depression affecting individuals' wellbeing, productivity, and quality of life. According to the World Health Organization (WHO, 2022), approximately one in eight people globally lives with a mental disorder, highlighting the need for accessible and effective mental healthcare solutions.

Despite these advancements, many existing digital mental health solutions depend heavily on active user participation. Users are often required to complete self-assessments, manually log their emotions, or consistently access dedicated applications. Sustained engagement with mental health apps remains a significant challenge, limiting their effectiveness as long-term support tools (Baumel et al., 2019).

In addition, affective computing technologies have increasingly enabled computational systems to detect and interpret human emotional information through signals such as facial expressions, speech, and physiological responses (Calvo & D'Mello, 2010; Picard, 1997). However, there is still an opportunity to integrate these capabilities into an everyday platform that combines emotion recognition with personalised and proactive wellness support.

To address these limitations, this paper proposes MindMirror, an intelligent emotional wellness companion implemented through a smart mirror platform. MindMirror integrates multimodal artificial intelligence to recognise users' emotional states by analysing facial expressions, speech characteristics, contextual behavioural cues, and optional physiological indicators. Based on these emotional insights, the system provides adaptive wellness interventions, including guided breathing exercises, mindfulness prompts, motivational affirmations, calming visualisations, and personalised recommendations that support emotional regulation and wellbeing.

Unlike conventional digital mental health applications, MindMirror embeds emotional wellness support into an everyday household object that users naturally interact with, enabling continuous and non-intrusive engagement without requiring additional effort. By combining multimodal emotion recognition, adaptive artificial intelligence, and privacy-preserving system design, MindMirror shifts emotional healthcare from reactive intervention to proactive emotional wellness. This innovation offers a scalable solution with potential applications across homes, educational institutions, healthcare facilities, workplaces, and future smart healthcare ecosystems.

2.0 OBJECTIVES

The proposed MindMirror innovation aims to enhance emotional wellness through intelligent and proactive mental healthcare support integrated into users' daily routines. The specific objectives are:

18. **To develop an intelligent emotional wellness companion** that utilises multimodal artificial intelligence to recognise users' emotional states through facial expressions, speech characteristics, contextual behavioural cues, and optional physiological indicators.
19. **To provide personalised and adaptive emotional wellness interventions** by delivering real-time recommendations such as guided breathing exercises, mindfulness activities, motivational affirmations, calming visualisations, and self-care suggestions based on users' emotional conditions.
20. **To promote proactive emotional wellbeing** by embedding continuous and non-intrusive emotional support into an everyday smart mirror platform, encouraging early emotional awareness and healthy coping behaviours without requiring active self-reporting.
21. **To establish a scalable and privacy-preserving emotional wellness solution** that supports future integration with wearable devices, telehealth services, and smart healthcare ecosystems for broader adoption across residential, educational, healthcare, and workplace environments.

3.0 MINDMIRROR INTELLIGENT EMOTIONAL WELLNESS FRAMEWORK

MindMirror operates through the MindMirror Intelligent Emotional Wellness Framework (MIEW Framework), an integrated artificial intelligence framework designed to provide proactive and personalised emotional wellness support during users' everyday interactions. The framework combines multimodal emotion recognition, adaptive decision-making, personalised interventions, and privacy-preserving data management to create a seamless emotional wellness experience. Figure 1 illustrates the operational workflow of the proposed innovation.

Phase 1: Multimodal Emotional Data Acquisition

The system captures emotional information from multiple data sources, including facial expressions, speech characteristics, contextual behavioural patterns, and optional physiological signals obtained from compatible wearable devices. Affective computing research shows that emotional information can be derived from multiple behavioural and physiological modalities, providing a foundation for multimodal emotional assessment (Calvo & D'Mello, 2010; Picard, 1997).

Phase 2: AI-Based Emotion Recognition

Facial information can be analysed using deep-learning-based facial expression recognition, while complementary speech and contextual information can provide additional emotional cues. Deep neural networks have become widely applied in automatic facial expression recognition, particularly for learning representations from facial images and sequences (Li & Deng, 2022).

Phase 3: Adaptive Emotional Intelligence Engine

Once an emotional state has been identified, the Adaptive Emotional Intelligence Engine interprets the user's emotional context and determines the most appropriate wellness response. Rather than providing generic recommendations, the engine considers emotional patterns and contextual information to generate personalised interventions that are relevant to the user's current emotional needs.

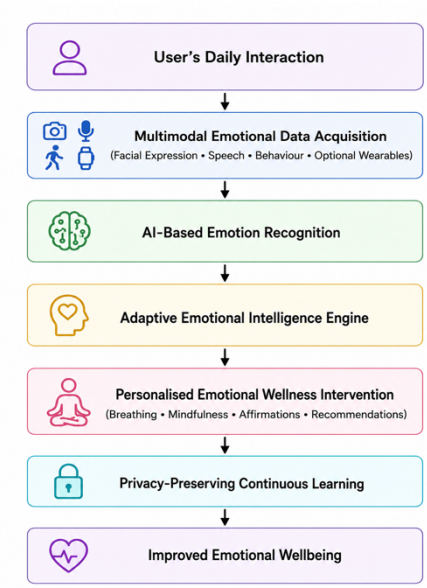
Phase 4: Personalised Emotional Wellness Intervention

Based on the recommendations generated by the intelligence engine, MindMirror delivers appropriate emotional wellness support directly through the mirror interface. These interventions may include guided breathing exercises, mindfulness activities, motivational affirmations, calming visualisations, emotional self-reflection prompts, and personalised wellness recommendations. The objective is to encourage emotional awareness, promote positive coping strategies, and support users' overall wellbeing through timely and non-intrusive interactions.

Phase 5: Privacy-Preserving Continuous Learning

To promote user trust and long-term adoption, MindMirror incorporates a privacy-preserving architecture in which sensitive emotional information is processed locally whenever feasible. The modular framework also supports future integration with wearable technologies, smart home systems, and telehealth platforms, enabling continuous improvement and scalability while maintaining user privacy and data security.

Figure 1. MindMirror Intelligent Emotional Wellness Framework (MIEW Framework)



4.0 INNOVATION IMPACT

MindMirror introduces a proactive approach to emotional wellness by applying affective computing to an everyday environment. Affective computing provides the theoretical and technological foundation for systems that can recognise and respond to human emotional information (Picard, 1997). Unlike many existing digital mental health solutions that require users to actively record their emotions or access dedicated applications, MindMirror is designed to recognise emotional cues during natural interactions and provide timely, personalised wellness support. This seamless integration is intended to encourage consistent engagement and promote early emotional awareness without disrupting daily activities.

The innovation is distinguished by its integration of multimodal emotion recognition, adaptive decision-making, personalised intervention, and privacy-preserving system architecture within a single intelligent platform. By combining facial expression analysis, speech emotion recognition, contextual behavioural assessment, and optional physiological monitoring, MindMirror is designed to develop a more comprehensive understanding of users' emotional wellbeing. The Adaptive Emotional Intelligence Engine further enhances personalisation by recommending interventions that are appropriate to each user's emotional condition rather than delivering generic wellness content.

In addition to its technical innovation, MindMirror demonstrates strong potential for practical implementation across multiple sectors. In residential settings, it has the potential to support individuals in maintaining emotional wellbeing through continuous self-care. Educational institutions may utilise the platform to promote student mental wellness and encourage early emotional awareness. Healthcare facilities could potentially adopt MindMirror as a complementary emotional wellness tool, while organisations may integrate it into workplace wellbeing initiatives to foster healthier and more supportive working environments. Its modular architecture also enables future integration with wearable devices, telehealth services, and smart home ecosystems, supporting long-term scalability and technological adaptability.

MindMirror particularly supports SDG 3: Good Health and Well-being by promoting emotional wellness and preventive mental healthcare, consistent with global efforts to strengthen mental health promotion, prevention, and care (WHO, 2022). The innovation also aligns with SDG 9 (Industry, Innovation and Infrastructure) by demonstrating the practical application of artificial intelligence in healthcare innovation, and SDG 11 (Sustainable Cities and Communities) by encouraging accessible and technology-enabled wellbeing solutions that contribute to healthier and more resilient communities. The key innovation features and anticipated impact of MindMirror are summarised in Table 1.

Table 1. Key Innovation Features and Expected Impact

INNOVATION FEATURE	EXPECTED IMPACT
Multimodal emotion recognition	Aims to provide a more comprehensive understanding of users' emotional states by integrating multiple emotional indicators
Adaptive Emotional Intelligence Engine	Designed to deliver personalised emotional wellness interventions based on users' emotional conditions
Non-intrusive daily interaction	Designed to encourage continuous emotional engagement without requiring active self-reporting
Privacy-preserving architecture	Enhances user trust through local processing and responsible data management
Scalable modular platform	Supports future integration with wearable devices, telehealth services, and smart home technologies across multiple application setting

5.0 CONCLUSION

MindMirror presents an innovative approach to emotional wellness by integrating multimodal artificial intelligence into a smart mirror platform that supports proactive and personalised mental healthcare. By combining emotion recognition, adaptive decision-making, and tailored wellness interventions, the proposed innovation enables continuous, non-intrusive emotional support during users' everyday routines. Unlike conventional digital mental health solutions that rely on active user engagement, MindMirror embeds emotional wellness into a familiar daily interaction, encouraging greater accessibility and long-term adoption.

Beyond its technological innovation, MindMirror demonstrates strong potential for real-world implementation across residential, educational, healthcare, and workplace settings. Its modular and privacy-preserving architecture further supports future integration with wearable devices, telehealth services, and smart healthcare ecosystems. As the demand for accessible mental healthcare continues to grow, MindMirror offers a scalable, and user-centred solution that contributes to healthier communities while advancing the application of artificial intelligence for emotional wellbeing.

REFERENCES

Baumel, A., Muench, F., Edan, S., & Kane, J. M. (2019). Objective user engagement with mental health apps: Systematic search and panel-based usage analysis. *Journal of Medical Internet Research, 21*(9), e14567. https://doi.org/10.2196/14567

Calvo, R. A., & D'Mello, S. (2010). Affect detection: An interdisciplinary review of models, methods, and their applications. *IEEE Transactions on Affective Computing, 1*(1), 18–37. https://doi.org/10.1109/T-AFFC.2010.1

Li, S., & Deng, W. (2022). Deep facial expression recognition: A survey. *IEEE Transactions on Affective Computing, 13*(3), 1195–1215. https://doi.org/10.1109/TAFFC.2020.2981446

Picard, R. W. (1997). *Affective computing*. MIT Press. https://doi.org/10.7551/mitpress/1140.001.0001

World Health Organization. (2022). *World mental health report: Transforming mental health for all*. World Health Organization. World Mental Health Report

YOURTAX PLUS

S. H Bakri[1] , Kalsum U. H[2] , Musa, S.B[3] , Ain, N.S[4] , Afzan, M.S[5]

[1,2,3,5] Department of Computer Science and Mathematics, Kolej Poly-Tech MARA Batu Pahat
[4]Department of General Study, Kolej Poly-Tech MARA Batu Pahat

(ct_halimah@kptm.edu.my)
(umi_kalsum@kptm.edu.my)
(suhaili_musa@kptm.edu.my)
(ain@kptm.edu.my)
(nur.afzan@kptm.edu.my)

ABSTRACT

Small and Medium-sized Enterprises (SMEs) play a vital role in Malaysia's economic growth and contribute significantly to employment and national economic development. However, many SME owners continue to face challenges in managing their business tax records due to manual bookkeeping, disorganised receipts, incomplete documentation, and limited knowledge of deductible business expenses. These issues often result in inaccurate tax reporting, difficulties in preparing supporting documents, and an increased risk of non-compliance with the requirements of Lembaga Hasil Dalam Negeri Malaysia (LHDN). The growing adoption of digital technologies provides opportunities to improve tax management through mobile-based solutions that are accessible, efficient, and user-friendly. This study presents the design and development of YourTax Plus Tracking, a prototype Android mobile application developed to assist SME taxpayers in recording their business income and expenses, organising supporting tax documents, monitoring deductible expenses, and estimating their income tax liabilities. The prototype was developed using the Agile Software Development Methodology, which emphasises iterative development, continuous improvement, and user-centred design throughout the software development process. The application was implemented as a native Android application using the Kotlin programming language, and Firebase Authentication, Cloud Firestore, and Firebase Cloud Storage were integrated to provide secure user authentication, cloud-based data management, real-time database synchronisation, and digital document storage. The prototype includes several core modules, namely user authentication, business profile management, income and expense recording, receipt upload, tax estimation, and tax summary reporting. Functional, integration, and usability testing were conducted to verify the prototype's functionality, reliability, and ease of use. The evaluation indicates that the prototype successfully supports the essential activities for tax management required by SME taxpayers, while also providing a centralised platform for managing tax-related information through a mobile device. Overall, the proposed prototype demonstrates the potential of cloud-based mobile technologies to improve tax record management, support more accurate tax estimation, and encourage better tax compliance among Malaysian SMEs. Furthermore, the prototype provides a practical foundation for future enhancement into a comprehensive mobile tax management system with additional features and wider implementation.

Keywords: android mobile application, SME taxpayers, kotlin, firebase, cloud firestore, tax management, income tax, agile software development, prototype.

1.0 INTRODUCTION

Managing business income tax can be challenging for small and medium-sized enterprises (SMEs), particularly in tracking deductible business expenses, maintaining supporting documents, and complying with tax reporting requirements. According to Nurhazwani et al. (2024), the evolution of YourTax Plus services in Malaysia has improved the efficiency of tax administration and encouraged taxpayers to adopt digital solutions for managing their tax-related information.

To address this issue, the YourTax Plus Tracking application prototype is designed to help users monitor their taxable income and predict their income tax obligations more accurately. The application prototype serves as a centralised platform that allows users to record tax-related transactions, track tax relief claims, and manage supporting documents in a systematic manner. Research has shown that digital tax management systems can significantly improve tax compliance and reduce the administrative burden faced by taxpayers, particularly SMEs (Lee & Nair, 2024).

This application prototype allows users to store proof of purchases and receipts required by Lembaga Hasil Dalam Negeri Malaysia (LHDN), ensuring that all documentation is readily available during tax filing. The implementation of digital record management has been recognised as an effective approach to improving document accessibility and reducing the risk of missing important tax-related records (Ramírez-Rosas et al., 2024). Furthermore, the increasing adoption of e-invoicing among SMEs calls for integrated systems capable of managing tax documents efficiently (San et al., 2024).

The application prototype also sends timely reminders for users to upload and record their tax-related expenses and reliefs. Additionally, YourTax Plus Tracking generates summary reports that compare taxable income against the total tax reliefs obtained, providing users with a clear financial overview. Recent studies indicate that intelligent tax systems incorporating predictive analytics and artificial intelligence can assist taxpayers in estimating tax liabilities more accurately and making informed financial decisions (Hossain et al., 2025).

The primary users of this prototype are SME owners who require a convenient and organised approach to managing their business tax records and estimating their tax liabilities. By leveraging digital technologies and user-friendly features, the application prototype aims to improve tax management practices and support compliance with LHDN requirements.

2.0 OBJECTIVE

1. To develop an Android mobile application prototype for SMEs to record business income, deductible expenses, and supporting tax documents
2. To assist SME taxpayers in monitoring deductible business expenses throughout the financial year.
3. To estimate tax liabilities for business income using recorded financial transactions.

3.0 METHODOLOGY

The development of the YourTax Plus Tracking mobile application prototype follows the Agile Software Development Methodology, which supports iterative development, continuous feedback, and incremental improvement. This approach allows the prototype to be refined based on the requirements of Small and Medium-sized enterprise (SME) taxpayers. The prototype is developed as a native Android application using the Kotlin programming language, with Firebase Authentication, Cloud Firestore, and Firebase Cloud Storage serving as the cloud-based backend services, as shown in Figure 1.

3.1 REQUIREMENT ANALYSIS

This phase focuses on identifying the functional and non-functional requirements of the prototype through literature review, analysis of Lembaga Hasil Dalam Negeri Malaysia (LHDN) tax regulations, and user requirement analysis involving SME owners. The prototype is designed to demonstrate the core functionalities required for SME tax management, as in Figure 2.

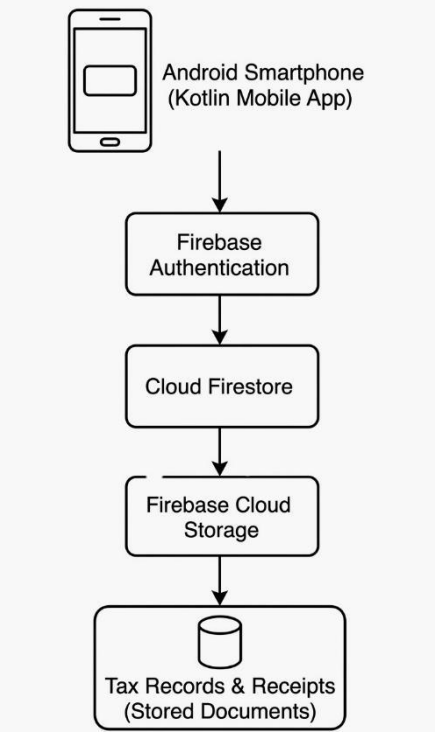


Figure 1: System architecture and data management flow for tax management application.



Figure 2: The core functionalities required for SME tax management.

The non-functional requirements include usability, security, cloud accessibility, and system performance.

3.2 SYSTEM DESIGN

The prototype architecture is designed using object-oriented principles and modelled with UML diagrams, including Use Case, Activity, Sequence, and Class Diagrams. The prototype consists of the following components:

22. Android mobile application developed using Kotlin
23. Firebase Authentication for secure user authentication
24. Cloud Firestore for storing tax-related information
25. Firebase Cloud Storage for storing receipt images and supporting documents

This cloud-based architecture enables the prototype to demonstrate secure data storage and real-time synchronisation.

3.3 PROTOTYPE DEVELOPMENT

The prototype is developed using Android Studio with Kotlin as the programming language. Development is carried out in iterative Agile sprints, where each sprint focuses on implementing and refining selected features. The prototype includes the following modules:

14. User Authentication Module
15. Business Profile Module
16. Income and Expense Recording Module
17. Receipt Upload Module
18. Tax Estimation Module
19. Tax Summary Dashboard

Firebase services are integrated to demonstrate cloud-based authentication, real-time database synchronisation, and secure document storage in the prototype.

3.4 PROTOTYPE TESTING

Testing is conducted to verify that the prototype functions as intended and meets user requirements. The testing activities include:

- Unit testing to verify individual modules.
- Integration testing to ensure proper interaction between the Android application and Firebase services.
- Functional testing to validate the prototype's core features.
- Usability testing involving selected SME users to evaluate ease of use, navigation, and overall user experience.

Feedback obtained during testing is used to improve the prototype.

4.0 RESULT

The developed prototype demonstrates the feasibility of using a mobile application prototype to support SMEs in managing tax-related information. Firstly, it provides a centralised digital platform for managing tax-related documents, reducing reliance on physical record-keeping and minimising the risk of lost or incomplete receipts. Digital tax record systems improve efficiency in financial documentation and reduce the administrative burden for users (Ramírez-Rosas et al., 2024). Secondly, the implementation can create a positive impact on tax relief tracking by allowing users to continuously update and categorise eligible expenses according to LHDN guidelines. This helps users avoid missed deductions and ensures better tax compliance. In addition, the integration of automated reminders and tax summaries improves user discipline in maintaining records throughout the year. Studies also show that user-friendly and well-designed digital tax systems significantly improve adoption rates among SMEs by enhancing usability and accessibility (Anggraeni, 2025).

The prototype YourTax Plus has the potential to improve on both users and the broader tax ecosystem in Malaysia. For individuals and SMEs, the system improves financial awareness by providing real-time insights into taxable income, deductions, and estimated tax liabilities. This enables better financial planning and reduces the stress associated with annual tax filing. From a national perspective, improved

record accuracy and compliance may contribute to a more efficient tax administration and reduced errors in tax submissions to LHDN. Furthermore, emerging technologies such as artificial intelligence and predictive analytics are increasingly being applied in tax systems to enhance forecasting accuracy and decision-making processes (Hossain et al., 2025). By incorporating similar intelligent features, the application prototype supports the broader digital transformation of taxation systems and fosters a more compliant and organised tax culture among SMEs.

5.0 CONCLUSION

In conclusion, the YourTax Plus Tracking application prototype addresses critical challenges faced by Malaysian taxpayers, particularly SMEs, in managing income tax documentation, tracking tax reliefs, and estimating tax obligations. The reliance on manual processes often leads to inefficiencies, missing records, and inaccurate tax reporting. By introducing a centralised, intelligent, and user-friendly digital platform, this project aims to simplify tax management and improve compliance with LHDN requirements. The adoption of digital tax systems has been widely recognised as a key factor in improving efficiency and transparency in tax administration (Nurhazwani et al., 2024). Moreover, the integration of forecasting and automation features aligns with current trends in digital taxation and artificial intelligence-driven financial systems (Hossain et al., 2025). Overall, the proposed system contributes to a more efficient, accurate, and technology-driven approach to personal and SME tax management in Malaysia.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support and cooperation provided by Kolej Poly-Tech MARA Batu Pahat throughout this research. The institution's assistance and contributions were invaluable to the successful completion of this study.

REFERENCES

Anggraeni, W. A. (2025). Digital readiness and tax system usability: A structural framework for MSME compliance in emerging economies. *Sinergi International Journal of Accounting and Taxation, 3*(3). DOI: https://doi.org/10.61194/ijat.v3i3.883

Hossain, M. Z., Hasan, L., Kumu, R. A., Bepari, M., & Sultana, S. (2025). The role of artificial intelligence in taxation and compliance: Challenges and future prospects. *European Journal of Science, Management and Technology, 1*(6), 73–85. DOI: https://doi.org/10.59324/ejsmt.2025.1(6).08

Lee, J. Y. V., & Nair, S. (2024). Tax compliance among SMEs: A study in Selangor Malaysia. *Asia Pacific Journal of Business, Humanities and Education, 9*(2).

Nurhazwani, S., Mohamad, A., Mohd Nasir, N. E., & Abdul Malak, S. S. D. (2024). YourTax Plus services and their evolution: The case of Malaysia. *Advances in Social Sciences Research Journal, 11*(9.2), 79–90.

Ramírez-Rosas, J. G., Neri-Suárez, M., & Torres-González, M. A. (2024). Automation of fiscal auditing in SMEs through a sequential algorithm for extracting tax receipts: A focus on the digital economy. *International Journal of Combinatorial Optimization Problems and Informatics, 15*(5).

San, S., Wan, N. Z. N., Razak, S., Saidi, N., & Abdul Hamid, M. (2024). E-invoicing implementation: Adoption challenges among SMEs and implications for stakeholders. *International Journal of Entrepreneurship and Management Practices*. DOI: https://doi.org/10.35631/IJEMP.830007

PALMVISTA: AN AI-POWERED WEBGIS PLATFORM FOR HISTORICAL OIL PALM YIELD RISK MONITORING AND DECISION SUPPORT

Syila Izawana Ismail[1*], Norsuzila Ya'acob[2] , Murizah Kassim[3], Mohamed Mazmira Mohd Masri[4],

[1]Faculty of Electrical Engineering, Universiti Teknologi MARA, Cawangan Terengganu
[2,3]Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor
[4]Entomology and Pest Management, Malaysian Palm Oil Board, Malaysia

[*] Corresponding author: syila5416@uitm.edu.my

ABSTRACT

Poor monitoring of oil palm yield at the field level can lead to delayed management decisions, reduced productivity, and inefficient plantation operations. Current practices mainly rely on manual field observations and historical production records, making it difficult to accurately identify and visualise yield risk across plantation areas. In order to assist plantation managers in visualising and analysing yield risk across plantation areas, this project presents an AI-powered spatial risk mapping platform, an interactive WebGIS application. Unlike conventional monitoring systems, the platform combines artificial intelligence with an innovative temporal feature engineering framework to improve historical yield risk prediction using freely available multi-temporal satellite-derived vegetation indices, a soil moisture indicator, and land surface temperature variables. The platform automatically processes satellite-derived data through feature-specific lag optimisation, seasonal encoding, and feature reduction before generating yield risk classifications for each field using machine learning models. The generated historical yield risk classifications are presented as dynamic spatial risk maps, allowing users to monitor plantation blocks across different monitoring periods through an interactive WebGIS interface. The temporal feature engineering framework significantly improved classification performance compared with conventional non-temporal approaches, with the best-performing model achieving a classification accuracy exceeding 99%. The platform provides plantation managers with a practical, scalable, and cost-effective solution for yield monitoring, operational planning, and data-driven decision-making. By transforming freely available satellite-derived data into actionable spatial intelligence, the innovation supports precision agriculture and sustainable oil palm plantation management.

Keywords: WebGIS, oil palm yield risk, decision support system, artificial intelligence

1.0 INTRODUCTION

Oil palm plantations require continuous monitoring to maintain productivity and support effective plantation management. However, current monitoring practices still rely heavily on manual field inspections and historical production records, making it difficult to identify high-risk plantation blocks and respond promptly to changing field conditions (Chong et al., 2017; Hoe & Shukor, 2019). As plantation areas continue to expand, there is an increasing need for a practical digital solution that enables faster monitoring and more informed decision-making (Ismail et al., 2025; Puangsuwan et al., 2025; Rina Sari & Irawan, 2025; Sum & Shukor, 2019). PalmVista was developed to address this challenge by providing an AI-enabled WebGIS platform for monitoring historical yield risks in oil palm and supporting decision-making. The platform integrates historical yield risk information with interactive spatial visualisation, enabling plantation managers to monitor plantation performance through dynamic risk maps, analytical dashboards, and intelligent decision-support tools. Instead of analysing large volumes of historical data manually, users can quickly identify high-risk blocks, evaluate historical risk trends, and prioritise field inspections, all through a single integrated WebGIS interface.

PalmVista is powered by an intelligent prediction engine that combines freely available satellite-derived data with a Temporal Feature Engineering Framework to generate reliable historical yield risk information. The generated results are automatically transformed into interactive visualisations and management insights, eliminating the need for specialised knowledge in artificial intelligence or geographic information systems. Through its user-friendly design and practical functionality, PalmVista offers a more efficient

plantation monitoring, operational planning, and data-driven decision-making, contributing to the digital transformation of oil palm plantation management.

2.0 OBJECTIVES

The objectives of PalmVista are:

26. to develop an AI-enabled WebGIS platform for field-level oil palm yield risk monitoring,
27. to provide interactive spatial visualisation and analytical dashboards for monitoring plantation performance and identifying high-risk areas, and
28. to support timely and informed decision-making through intelligent decision-support tools for sustainable oil palm plantation management.

3.0 METHODOLOGY

3.1 PALMVISTA SYSTEM OVERVIEW

PalmVista is an AI-enabled WebGIS platform developed to support field-level oil palm yield risk monitoring and decision-making. The platform integrates historical yield risk information with interactive spatial visualisation and analytical dashboards, enabling plantation managers to monitor plantation performance, identify high-risk blocks, and plan field inspections more efficiently. As illustrated in Figure 1, PalmVista operates through four main stages. Users first select the analysis criteria, which include the plantation block, year, month, and risk level. The platform then displays the selected data on an interactive dashboard that includes key performance indicators (KPIs), spatial risk maps, historical trends, and risk distributions. PalmVista also offers question-based decision support to generate management insights prior to producing inspection recommendations that aid in prioritising field operations and facilitating timely decision-making.



Figure 1. PalmVista Decision Support Workflow

3.2 KEY FEATURES OF PALMVISTA

PalmVista integrates several interactive modules that support plantation monitoring and decision-making. Each module is intended to convert historical yield risk information into useful spatial insights, allowing users to monitor plantation performance, identify high-risk areas, and make informed management decisions using a single WebGIS platform. Figure 2 depicts the main features and their respective functions.

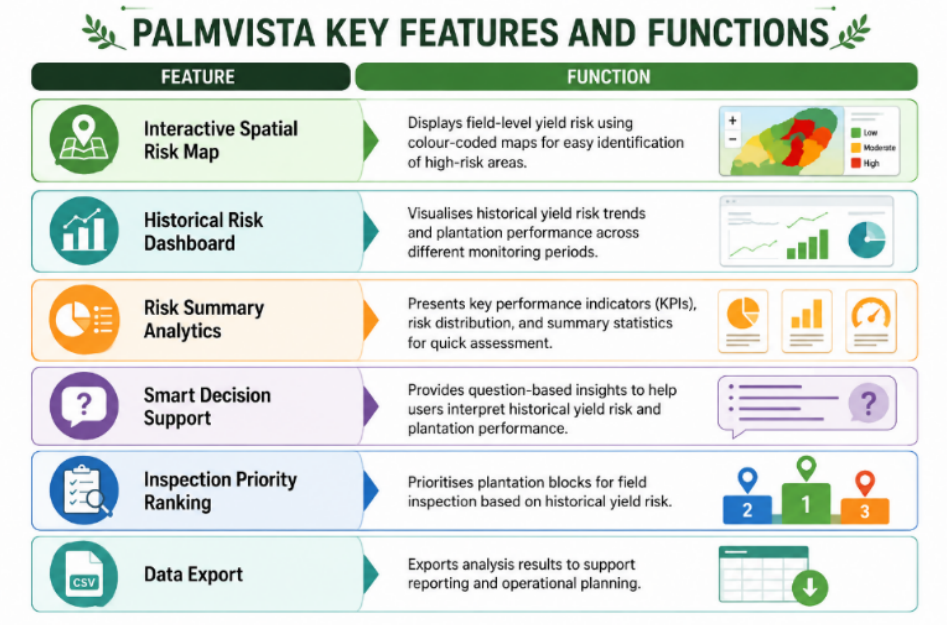


Figure 2. Key Features and Functions of PalmVista

3.3 SYSTEM FUNCTIONALITY

PalmVista is designed with a simple and user-friendly workflow to support plantation monitoring and decision-making. Users begin by selecting the plantation block, year, month, and risk level. The platform then retrieves the corresponding historical yield risk information and presents it through interactive maps, dashboards, and analytical charts. Based on the selected data, PalmVista provides management insights and inspection recommendations, allowing users to identify priority areas and make timely operational decisions. The results can also be exported for reporting and plantation management purposes.

3.4 PRACTICAL APPLICATIONS

PalmVista provides a practical decision-support platform for managing oil palm plantations by transforming historical yield risk information into actionable spatial insights. The platform enables plantation managers to monitor plantation performance, identify high-risk blocks, prioritise field inspections, and support operational planning through a single WebGIS interface. As a web-based application, PalmVista can be accessed through a standard web browser without requiring specialised GIS software, making it straightforward to deploy and use in daily plantation operations. By integrating spatial visualisation with analytical dashboards and intelligent recommendations, PalmVista promotes more efficient, timely, and data-driven plantation management while reducing reliance on manual monitoring.

4.0 RESULTS

PalmVista was demonstrated using historical data on oil palm yields from four plantation blocks (B36–B39) covering the period from 2017 to 2023. The platform successfully visualised historical yield risk using interactive maps, analytical dashboards, and intelligent decision-support modules. The underlying AI classification model achieved an accuracy exceeding 99%, demonstrating the capability of PalmVista to provide reliable historical yield risk information for plantation monitoring and operational planning. The main interface of PalmVista is shown in Figure 3, illustrating how historical yield risk information is transformed into interactive spatial visualisation and analytical dashboards for practical plantation monitoring.

4.1 PALMVISTA DASHBOARD INTERFACE

As shown in Figure 3, PalmVista provides an integrated WebGIS dashboard for historical yield risk monitoring and decision support. The dashboard combines interactive filters, key performance indicators (KPIs), spatial risk maps, and analytical visualisations within a single interface. Users can monitor plantation performance by selecting different plantation blocks, years, months, and risk levels, allowing efficient assessment of historical yield risk. Figure 3 demonstrates how PalmVista integrates multiple monitoring functions into a single dashboard, enabling plantation managers to visualise historical yield risk and plantation performance more efficiently.

As shown in Figure 4, the Smart Decision Support module transforms historical yield risk information into question-based recommendations that support inspection planning and operational decision-making. The module assists users in identifying the highest-risk plantation blocks, evaluating historical block performance, understanding risk patterns, and prioritising field inspections according to the selected monitoring period.

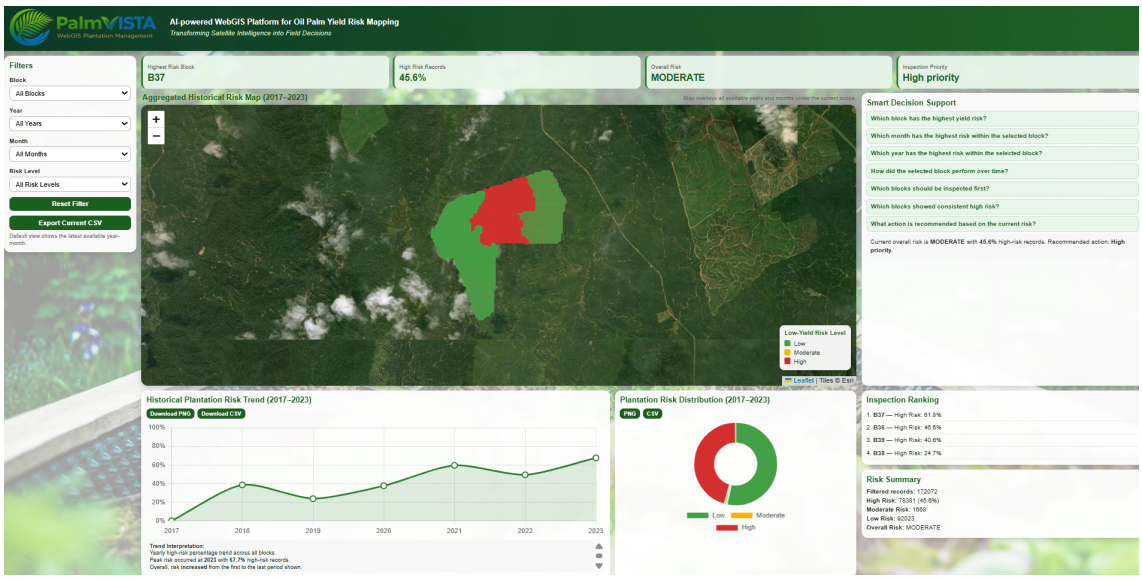


Figure 3. PalmVista Dashboard Interface for Historical Yield Risk Monitoring and Decision Support

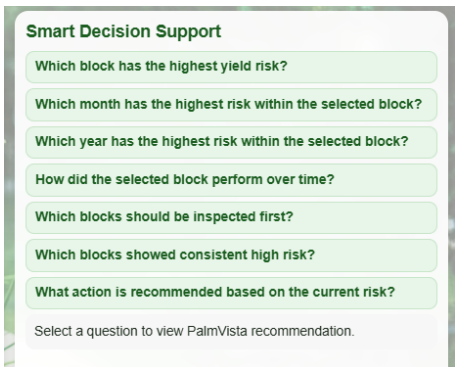


Figure 4. Smart Decision Support Module

4.2 *INNOVATION HIGHLIGHTS*

PalmVista introduces several innovative features that distinguish it from conventional plantation monitoring systems. Rather than simply displaying historical plantation information, PalmVista integrates artificial intelligence, satellite-derived data, WebGIS visualisation, and intelligent decision-support into a single platform for practical plantation management. Figure 5 illustrates the key innovations of PalmVista. Collectively, these innovations position PalmVista as an integrated AI-powered WebGIS platform that transforms historical plantation data into actionable spatial intelligence for smarter and more sustainable management of oil palm plantations. Beyond these technical innovations, PalmVista offers a practical digital solution for managing oil palm plantations by supporting historical yield risk monitoring and operational planning. Plantation companies, government agencies, and researchers can adopt the platform to improve monitoring efficiency, optimise field inspections, and support data-driven decision-making. Its web-based architecture and scalable design also provide opportunities for future implementation across larger plantation areas and integration with other smart agriculture technologies.



Figure 5. Key Innovations of PalmVista

5.0 CONCLUSION

PalmVista demonstrates how artificial intelligence and WebGIS can be translated into a practical decision-support platform for smarter and more sustainable plantation management. The platform enables plantation managers to monitor historical yield risk, visualise plantation performance, and prioritise field inspections via an interactive and user-friendly interface. By transforming complex analytical outputs into actionable spatial insights, PalmVista promotes more efficient, data-driven, and sustainable plantation management.

ACKNOWLEDGEMENT

The authors would like to thank Universiti Teknologi MARA (UiTM) for its continuous support and FELDA Cherul 2, Terengganu, for providing the plantation data used in the development and demonstration of PalmVista.

REFERENCES

Chong, K. L., Kanniah, K. D., Pohl, C., & Tan, K. P. (2017). A review of remote sensing applications for oil palm studies. *Geo-Spatial Information Science*, *20*(2), 184–200. https://doi.org/10.1080/10095020.2017.1337317

Hoe, J. H., & Shukor, S. A. A. (2019). Monitoring Oil Palm Tree Health-A Review. *IOP Conference Series: Materials Science and Engineering*, *705*(1). https://doi.org/10.1088/1757-899X/705/1/012033

Ismail, S. I., Ya'acob, N. S., Kassim, M., & Nik Dzulkefli, N. N. S. (2025). Seasonal Monitoring and Analysis of Soil Moisture and Vegetation Health in Oil Palm Plantations Using Remote Sensing. *International Journal of Geoinformatics*, *21*(4), 82–96. https://doi.org/10.52939/ijg.v21i4.4069

Puangsuwan, K., Puttinaovarat, S., Sriklin, N., Phutthamongkhon, W., & Kajornkasirat, S. (2025). An Integrated IoT- and Machine Learning-Based Smart Management and Decision Support System for Sustainable Oil Palm Production. *Sustainability (Switzerland)*, *17*(24). https://doi.org/10.3390/su172411204

Rina Sari, D. A., & Irawan, M. D. (2025). Implementation of Key Performance Indicators in the Palm Oil Harvest Monitoring Information System. *Green Intelligent Systems and Applications*, *5*(2), 150–163. https://doi.org/10.53623/gisa.v5i2.782

Sum, A. F. W., & Shukor, S. A. A. (2019). Oil Palm Plantation Monitoring from Satellite Image. *IOP Conference Series: Materials Science and Engineering*, *705*(1). https://doi.org/10.1088/1757-899X/705/1/012043

DEVELOPMENT OF REAL-TIME NETWORK INTRUSION DETECTION SYSTEM ON WIRELESS ENVIRONMENT

Alif Ajmi Mansuri, Anis Afiqah Sharip, Raihana Md Saidi, Fatin Nadhirah Zabani,
*Hajar Izzati Mohd Ghazalli

Faculty of Computer and Mathematical Sciences, UiTM Cawangan Melaka Kampus Jasin

*Corresponding author: hajarizzati@uitm.edu.my

ABSTRACT

Wireless communication is rapidly expanding, bringing with it a growing security issue. For example, adversarial cyber threats are increasingly challenging for traditional, rule-based Network Intrusion Detection Systems (NIDS) to keep up with. Most current systems still rely on signature-based detection or sit at the network gateway, which leaves them exposed to internal threats and largely blind in heavily encrypted wireless environments. To tackle this problem, this work develops an image-based deep learning NIDS that detects intrusions by converting raw network packets into spatial RGB images. Rather than inspecting packet content directly, the system allows computer vision models to pick up on malicious behaviour through the spatial and temporal patterns embedded in network traffic. The system is built around a dual-pipeline architecture, in which one pipeline trains the model using the CIC-IDS2017 dataset, while the other handles real-time detection by capturing live traffic. Spatial features are extracted using an EfficientNet-B0 Convolutional Neural Network (CNN), while Gated Recurrent Units (GRU) manage temporal sequencing, which gives the system a strong balance between accuracy and computational efficiency. The results show that using header-only information for image extraction produces a testing accuracy of 99.11%. Overall, this approach demonstrates how deep learning models trained on image representations of network packets can effectively detect both known and previously unseen attacks.

Keywords: NIDS, deep learning, wireless networks, image-based analysis, intrusion detection

1.0 INTRODUCTION

As the world advances digitally, large organisations and critical infrastructures are increasingly exposed to cyberattacks, where any interruption or malicious intrusion can lead to significant financial and operational losses (Brando et al., 2022; *When It's Time to Build a SOC, Nearly 90% of Organizations Prefer Outsourced or Hybrid Models*, n.d.). However, traditional NIDS rely heavily on pre-set signature-based rules and manual feature engineering. These traditional inspection methods often cause a loss of crucial information and lead to high false alarm rates (Saeed et al., 2024).

Furthermore, because standard NIDS primarily operate at the network gateway, they are capable of detecting only external threats and are highly ineffective against insider attacks originating from within the network (Kumar & Kumar, 2023). Consequently, existing systems struggle to adapt to newly emerging Wi-Fi-based attacks and heavily encrypted environments (Kharatmal et al., 2025).

The motivation of this development is to overcome conventional feature engineering by transforming raw network traffic data into visual representations (images). By developing a real-time, image-based NIDS, the system learns complex attack behaviours from the statistical and spatial structure of packets rather than from the encrypted content itself. Ultimately, this innovation addresses the ongoing challenge of striking a balance between the computing economy and detection precision, especially for real-time edge deployment (R et al., 2025).

2.0 OBJECTIVE

The objectives of this innovation are:

29. To design a real-time network-based intrusion detection system that detects malicious activity with low false positives in a wireless environment.
30. To develop a network-based intrusion detection system by classifying image representations from network traffic using EfficientNet-B0.
31. To test the accuracy of the developed system.

3.0 METHODOLOGY

This section details the system architecture, data processing, and integration steps used to develop the real-time image-based NIDS, based directly on the project's developmental pipeline

3.1 DUAL-PIPELINE ARCHITECTURE

The system is built upon a highly integrated dual-pipeline architecture. Figure 1 shows the architecture.

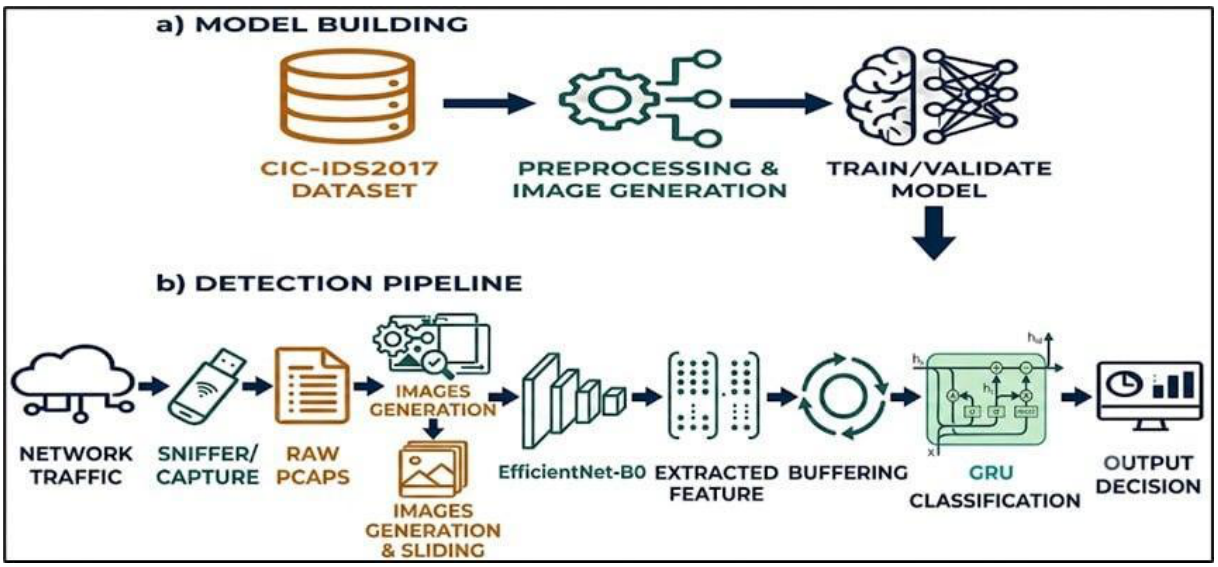


Figure 1: Dual-pipeline architecture

- **Model Development Pipeline:** Utilises the CIC-IDS2017 public dataset. To enable real-time packet-level detection, the system operates directly on raw Packet Captures (PCAPs) rather than traditional statistical flow CSVs. A label-matching algorithm separates the chaotic stream of raw PCAPs into localised files, each containing exactly 24 sequential packets based on the CSV metadata.
- **Real-Time Detection Pipeline:** Designed to evade the complicated port-mirroring steps of traditional NIDS, this pipeline utilises a USB network adapter that supports Wi-Fi monitor mode. This enables the machine to directly sniff and inspect visible, incoming network packets within the local environment.

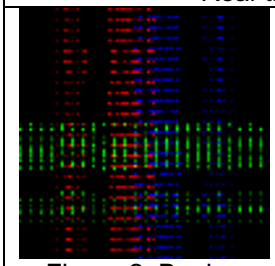
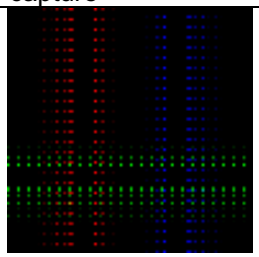
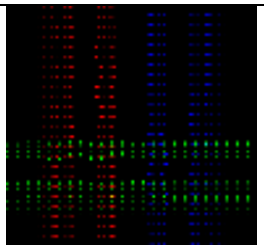
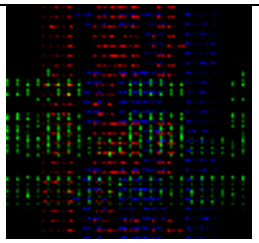
3.2 IMAGE GENERATION

The core of the methodology is the packet-to-image conversion engine, which transforms network traffic into a 224x224 RGB image. The real-time transformation algorithm executes the following steps:

20. **Masking and Sanitisation:** Sensitive routing fields, specifically the Source IP and Destination IP, are explicitly masked to zero to prevent the model from overfitting to specific devices.
21. **Thresholding and Padding:** Each packet byte array is strictly controlled; packets larger than 384 bytes are truncated, while smaller packets are zero-padded until the length equals exactly 384 bytes.
22. **Image Upscaling**: The sequence of 24 packets (totalling 9,216 bytes) is flattened and reshaped into a 96x96 2D greyscale image. It is then stacked into a 3-channel RGB format and upscaled to a 224x224x3 dimension using interpolation to perfectly fit the EfficientNet-B0 input requirements.

The output for the image representation of network data from real-time capture and CIC-IDS2017 is shown in Table 1. The generated images use a sequential extraction mode that contains only a header and follows a linear pattern. Each category clearly shows the difference in pattern, providing a clear distinction between malicious and benign behaviours.

Table 1 output for the image representation

Real-time capture		CIC-IDS2017	
			
Figure 2: Benign	Figure 3: Malicious	Figure 4: Benign	Figure 5: Malicious

3.3 CLASSIFICATION ALGORITHM (CNN + GRU)

A hybrid Convolutional Neural Network (CNN) and Gated Recurrent Unit (RNN) architecture was chosen to balance computational efficiency with high diagnostic accuracy.

- **EfficientNet-B0 Backbone**: Initialised with ImageNet pretrained weights, the classification layer is removed and replaced with a global average pooling layer. This allows the network to act as a spatial feature extractor, outputting a fixed-length 1280-dimensional feature vector for each 24-packet image.
- **GRU Temporal Sequencing**: The 1280-dimensional feature vectors are accumulated and passed into a GRU configured with a hidden size of 256 across multiple recurrent layers. This enables the model to learn temporal dependencies across sequential traffic windows.
- **Overlapping Sliding Window**: In live deployment, extracted feature vectors are stored in a sequence buffer. The buffer uses a 50% overlapping sliding window, ensuring that every new prediction retains half of the previous sequence, which preserves the temporal context required to detect stealthy, multi-stage attacks.

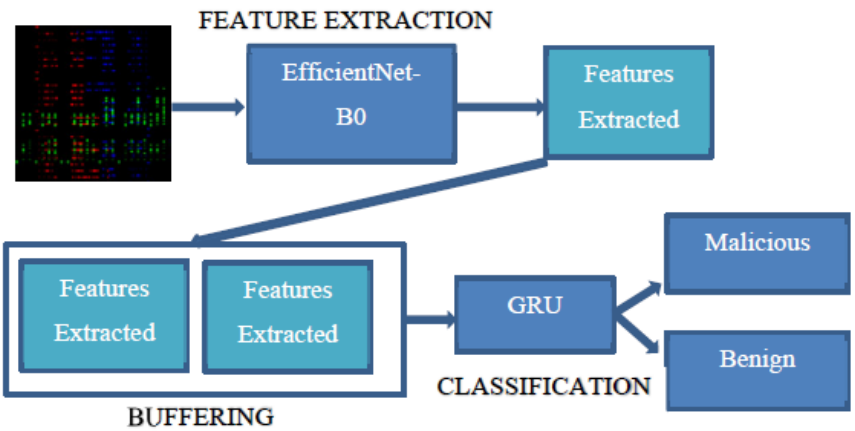


Figure 6: Classifier Training

3.4 GRAPHICAL USER INTERFACE (GUI)

A web-based GUI is developed to allow SOC analysts to easily interpret real-time network conditions. The backend is built using a Python Flask framework that relies on a thread-locked global memory state to safely buffer concurrent packet captures and GRU feature sequences. The dynamic JavaScript frontend renders the JSON data across three main modules:

- Main Monitor (Figure 7): Provides direct live-feed monitoring and layout manipulation.
- Analysis Page (Figure 8): Displays historical attack patterns and timeline graphs for deep forensic investigation.
- IP Tracker (Figure 9): Associates detected malicious windows with specific IP addresses stored in temporal buffers.

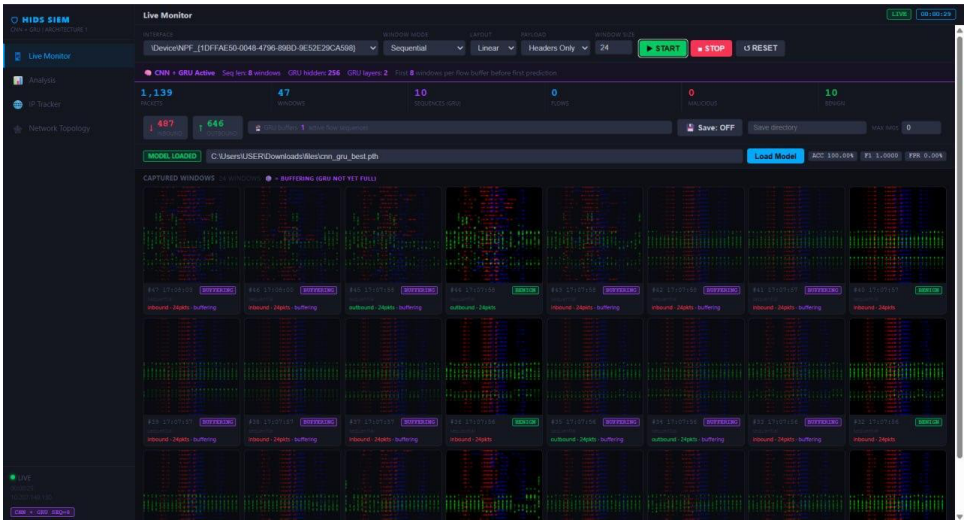


Figure 7: Main Monitor

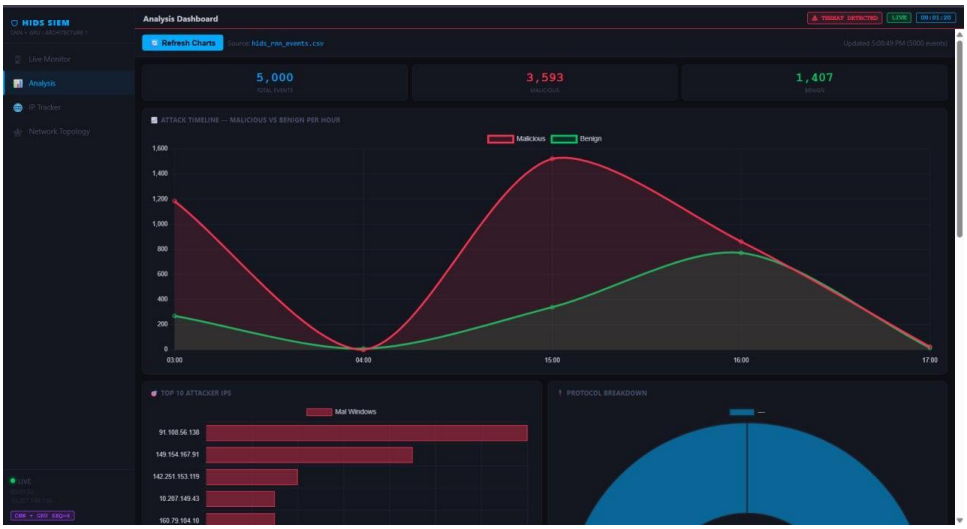


Figure 8: Analysis Page

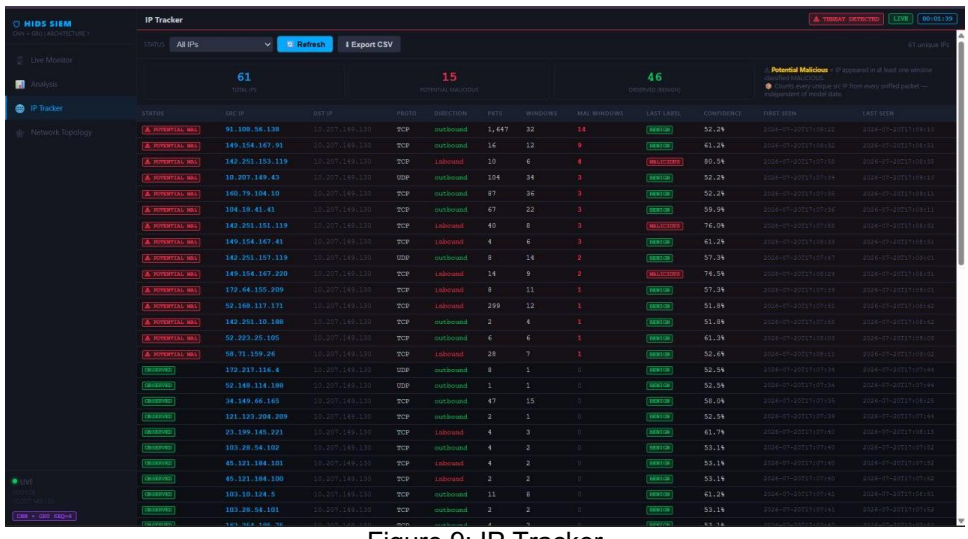


Figure 9: IP Tracker

4.0 RESULT

Under controlled conditions, all three filling patterns (linear, spiral, and zigzag) achieved an identical 100% test accuracy. Because the convolutional backbone proved to be robust to the spatial arrangement of the pixels, the linear filling method was permanently adopted for the final system due to its ease of implementation and low computational overhead.

During standardised testing on the CIC-IDS2017 dataset, both the standalone CNN (EfficientNet-B0) and the CNN+GRU hybrid achieved 100% accuracy and F1-scores. However, during real-world live wireless deployment testing, a critical generalisation variance was discovered. When the model trained purely on the secondary dataset (CIC-IDS2017) was tested on live real-time traffic, its F1-score dropped dramatically to 3.85%. To address this problem, the architecture was retrained using primary data captured directly from the real-time testbed environment. The retrained real-time model successfully achieved 99.11% accuracy and a 99.01% F1-score when deployed on live network traffic, ultimately proving the functionality and edge-capability of the developed HIDS software. Table 2 shows the result.

Table 2 Result

Model trained on	Tested on	Accuracy	Precision	Recall	F1	FPR
CIC-IDS2017	Real-time	55.36%	50.00%	2.00%	3.85%	1.61%
Real-time	Real-time	99.11%	98.04%	100.00%	99.01%	1.61%

5.0 CONCLUSION

The real-time, hybrid host-based NIDS successfully addresses the blind spots of traditional signature-based detection systems operating in encrypted, wireless environments. By converting packet data into spatial RGB images and utilising a hybridised EfficientNet-B0 and GRU pipeline, the system learns hidden temporal and spatial attack patterns. The development of a lightweight, overlapping buffer mechanism and a dynamic SOC dashboard proves the system's economic and practical viability. It provides small and medium enterprises (SMEs) and security analysts with an advanced AI-powered defence layer, significantly reducing false alarm fatigue and minimising the manual processing overhead required for threat monitoring.

REFERENCES

Brando, D., Kotidis, A., Kovner, A., Lee, M. J., & Schreft, S. L. (2022). Implications of Cyber Risk for Financial Stability. *FEDS Notes*, *2022.0*(3077.0). https://doi.org/10.17016/2380-7172.3077

Kharatmal, N. S., Prof.M.N.Bhosale, & Prof.S.D.Pingale. (2025). A Review - Wi-Fi Deauthentication And Rogue Access Point Detection Using Wireless IDS Techniques. *International Journal of Scientific Development and Research*, *10*(12), a475–a479. https://ijsdr.org//viewpaperforall.php?paper=IJSDR2512050

Kumar, Y., & Kumar, V. (2023). A Systematic Review on Intrusion Detection System in Wireless Networks: Variants, Attacks, and Applications. *Wireless Personal Communications*, *133*(1), 395–452. https://doi.org/10.1007/S11277-023-10773-X/METRICS

R, S. S., T, N., K, S., & G, D. M. (2025). Enhanced network security through an intelligent deep learning-based intrusion detection system with optimized performance. *Knowledge-Based Systems*, *329*, 114322. https://doi.org/10.1016/J.KNOSYS.2025.114322

Saeed, R., Khaliq Qureshi, H., Ioannou, C., & Lestas, M. (2024). A Proactive Model for Intrusion Detection Using Image Representation of Network Flows. *IEEE Access*, *12*, 160653–160666. https://doi.org/10.1109/ACCESS.2024.3489772

When it's time to build a SOC, nearly 90% of organizations prefer outsourced or hybrid models. (n.d.). Retrieved June 30, 2026, from https://www.kaspersky.com/about/press-releases/when-its-time-to-build-a-soc-nearly-90-of-organizations-prefer-outsourced-or-hybrid-models

SISTEM PELAPORAN BDR PENSYARAH UITM JOHOR (SPBDR)

Mohd Lezam Bin Lehat[1,*], Noridah Binti Sain[1], Alizah Binti Ali[1], Nurul Haida Binti Johan[1], Mas Ervina Binti Samsuddin[1]

[1]UiTM Cawangan Johor Kampus Segamat, KM 12, Jalan Muar off Jalan Universiti, 85000 Segamat Johor

[*] Corresponding author: mohdlezam@uitm.edu.my

ABSTRACT

The transition to flexible working arrangements in higher education has necessitated the development of robust digital solutions to ensure institutional productivity and accountability. However, traditional and fragmented reporting workflows often lack the capability to systematically track remote academic tasks, resulting in data integrity and administrative issues. To address this issue, this project focuses on developing and implementing the 'Sistem Pelaporan BDR Pensyarah UiTM Johor' (SPBDR), a dedicated remote-work reporting and monitoring system for academics at Universiti Teknologi MARA (UiTM) Johor. Developed as an online solution utilising Google Sheets and Google Apps Script, SPBDR features an intuitive user interface for lecturers to submit operational details such as teaching preparation, research, faculty or university projects and cloud-based verification links via Google Drive. Administratively, the system incorporates a structured, role-based access control framework to facilitate tiered monitoring, where the Head of the Center of Studies supervises faculty-specific data while the Deputy Rector of Academic Affairs is provisioned with global administrative access. The implementation of SPBDR demonstrates that real-time dashboard analytics, which display Key Performance Indicators (KPIs) such as registration percentages and activity breakdowns, effectively streamline administrative oversight, enhance data integrity, and optimise academic governance. Ultimately, SPBDR serves as an efficient tool that effectively addresses the operational gap between remote academic autonomy and institutional compliance, providing a cost-effective framework for modern educational management.

Keywords: academic governance, dashboard monitoring, google apps script, google sheets, remote work reporting, work from home

1.0 INTRODUCTION

The implementation of Work From Home (WFH) policies for academic staff requires an effective ecosystem to measure operational sustainability and performance. In an institutional setup like Universiti Teknologi MARA (UiTM) Johor, monitoring daily activities during remote work presents distinct challenges. Traditional manual reporting approaches such as submitting weekly text logs or filling independent online forms, frequently result in fragmented data streams. This fragmentation introduces major data integrity issues, making it difficult for the management to cross-verify compliance in real time.

Furthermore, administrative leaders such as the Head of the Center of Studies and the Deputy Rector of Academic Affairs require structured, high-level visibility to manage faculty performance efficiently. Without a centralised framework, evaluating critical metrics such as daily class statuses, teaching preparation engagement, research progression, and university project alignment becomes an administratively exhausting task. Motivated by these challenges, the 'Sistem Pelaporan BDR Pensyarah UiTM Johor (SPBDR)' was developed to transform remote work accountability through a streamlined, automated, and cloud-integrated monitoring interface.

2.0 OBJECTIVE

The primary objectives driving the development of SPBDR are:

32. To design an intuitive, centralised online reporting form that enables lecturers to systematically log multi-categorical BDR activities along with cloud-based verification evidence.

33. To implement a role-based access monitoring dashboard that provides faculty-restricted visibility for Heads of Learning Centres and global oversight capabilities for the Deputy Rector of Academic Affairs.

34. To automate the calculation and visualisation of critical real-time performance indicators (KPIs) and to replace manual verification with dynamic analytics.

3.0 METHODOLOGY

The SPBDR system is strategically engineered as a serverless, cloud-based web application leveraging the Google Workspace Ecosystem. Previous studies have shown that cloud-based frameworks and infrastructures in higher education institutions can significantly reduce deployment and operational costs by minimizing capital investment requirements, optimizing resource utilization, and lowering infrastructure maintenance expenses (Choi et al., 2019; Qasem et al., 2021). The architecture utilises Google Sheets as the core relational database and Google Apps Script as the engine for backend logic, authentication routing, and automated frontend rendering. According to Ivasenko (2025), low-code solutions provide higher education institutions with a cost-effective approach to implementing digital marketing and automation initiatives, while also reducing dependence on specialised IT personnel.

3.1 SYSTEM ARCHITECTURE AND USER INTERACTION

As shown in Figure 1, the lecturer-facing frontend restricts reporting to formal academic classifications (Research, Teaching and Learning Preparation, Faculty/University Projects, and Miscellaneous). The interface enforces data validity by making cloud-hosted verification links (Google Drive URLs) mandatory before form submission. Enforcing mandatory hyperlink verification in digital activity logging reduces reporting discrepancies and ensures auditable transparency. The integration of cloud storage platforms such as Google Drive in educational environments enables asynchronous access to institutional documents, supports efficient data retrieval, and reduces system integration complexity by leveraging existing cloud infrastructure for seamless storage and sharing of information (Amalia et al. 2024).

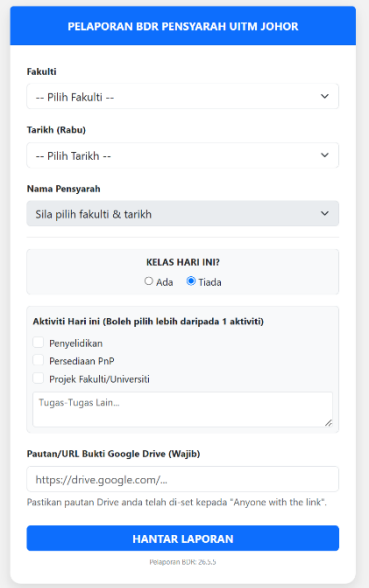


Figure 1: Lecturer's view

3.2 ADMINISTRATIVE DASHBOARD DESIGN

For administrative management, as shown in Figure 2, the system provides a centralised monitoring command centre. Role-Based Access Control (RBAC) is implemented via script logic to filter operational views based on administrative hierarchies:

23. Head of the Center of Studies: Granted access to view data pertaining only to their respective faculties.

24. Deputy Rector of Academic Affairs: Granted institution-wide access to query, view, and analyse aggregated metrics across all faculties.

The system translates raw data rows into dynamic data analytics blocks summarising key administrative metrics as structured below:

Table 1: System Metric Mapping for BDR Oversight

Metric Category	Data Type Visualised	Operational Target
Faculty Engagement	Registration Percentage (%)	Total accountability & compliance rates
Academic Continuity	Daily Class Status	Active teaching verification
Core Pillars Focus	Percentage Distribution of Activities	Monitoring focus on research, PdP, and projects

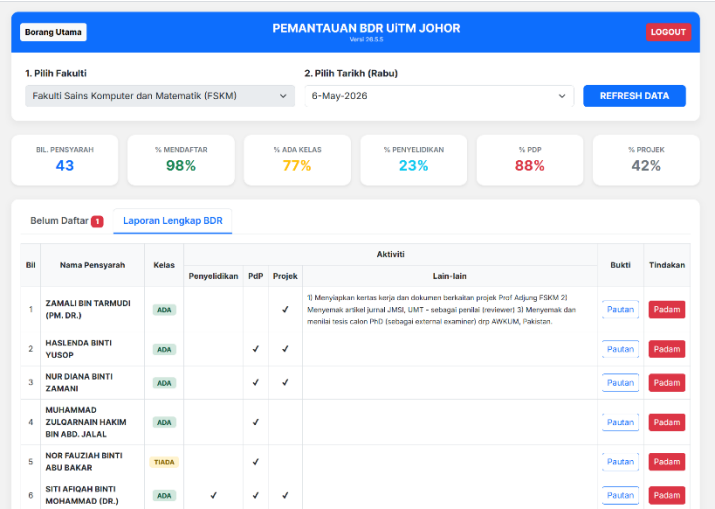


Figure 2: Administrator's view

Real-time educational dashboards centralise institutional data, enabling efficient monitoring of performance indicators and supporting timely, evidence-based decision-making for proactive academic governance (Masiello et al., 2024).

4.0 RESULT

The deployment of SPBDR yields significant improvements in both organisational productivity and administrative efficiency. The primary outcome is the elimination of administrative lag through automated analytics; real-time registration percentages and operational breakdowns are instantly rendered on the dashboard as shown in Figure 2.

The system introduces high novelty by turning static cloud spreadsheets into an active, low-code enterprise application without recurring software licensing overheads. Its unique approach to tiered administrative visibility ensures strict adherence to data privacy standards while concurrently equipping top management with immediate, actionable data for strategic governance. Data integrity is guaranteed through the automated pairing of lecturer task logs with active verification hyperlinks, drastically minimising reporting discrepancies.

5.0 CONCLUSION

The Sistem Pelaporan BDR Pensyarah UiTM Johor (SPBDR) effectively bridges the operational gap between remote academic autonomy and institutional administrative oversight. By utilising accessible yet powerful low-code tools like Google Apps Script and Google Sheets, the project demonstrates how higher education institutions can modernise workforce governance cost-effectively. Economically, this system reduces human labour hours spent on consolidating manual reports and avoids the expensive procurement of proprietary software. For the wider scientific and academic community, this architecture serves as a functional blueprint for implementing lean, high-impact digital workflows in modern educational management.

REFERENCES/RUJUKAN

Amalia, P. S., Haerani, E., Romli, R. A., & Roshinta, T. A. (2024). Optimising data management in web applications through Google Drive API integration and synchronisation. *JICO: International Journal of Informatics and Computing*. https://iaico.org/index.php/JICO/article/view/4

Choi, C.-H., Lee, C., Lee, J. J., & Lee, K. (2019). Understanding the deployment cost of cloud computing services for higher education institutions. In *Proceedings of the 2019 International Conference on Information and Communication Technology Convergence(ICTC)* (pp. 438–443). IEEE. https://doi.org /10.1109/ICTC46691.2019.8939863

Ivasenko, O. A. (2025). Socio-economic efficiency of using low-code platforms in digital marketing in higher education institutions. *Economics and Region, 98*(3). https://doi.org/10.31470/2415-3729-2023-18-48-65

Masiello, I., Mohseni, Z., Palma, F., Nordmark, S., Augustsson, H., & Rundquist, R. (2024). *A current overview of the use of learning analytics dashboards*. *Education Sciences, 14*(1), 82. https://doi.org/10.3390/educsci14010082

Qasem, Y. A. M., Abdullah, R., Jusoh, Y. Y., Atan, R., & Asadi, S. (2021). Analyzing continuance of cloud computing in higher education institutions: Should we stay, or should we go? *Sustainability, 13*(9), Article 4664. https://doi.org/10.3390/su13094664

ADAPTIVE SMART PLATFORM: SUSTAINING JOHOR'S IDENTITY THROUGH INNOVATION

Shaffika Suhaimi[1], Ungku Hajah Noorakmal Binti Ungku Sulaiman[2], Khairunnisha Ismail[1], Tan You Fu[1], Lah Wan Yee[1], Bambang Suhartono bin Mohd Said[1]

[1]Southern University College, Johor, Malaysia
[2]Perbadanan Perpustakaan Awam Johor, Johor, Malaysia

*Corresponding author: shaffika@sc.edu.my

ABSTRACT

This system introduces a pioneering smart innovation designed to sustain and preserve the unique story of Johor, aligning with global calls for sustainability, resilience, and cultural continuity. Unlike conventional platforms that overlook Johor's cultural, historical, and environmental narrative, this solution integrates artificial intelligence, interactive storybooks, adaptive quizzes, family communication tools, and a centralized dashboard to safeguard local heritage while promoting long-term resilience. By embedding intelligent technologies with adaptive design and resource-efficient practices, the system enhances operational efficiency, reduces ecological impact, and ensures Johor's identity and legacy are maintained for future generations. The platform's modular and scalable architecture empowers diverse stakeholders including communities, educators, and industry partners to engage with Johor's story in meaningful ways. Interactive storybooks and quizzes foster literacy and critical thinking, while the family chat module strengthens intergenerational dialogue and cultural transmission. The dashboard provides real-time insights into learning progress, resource utilization, and engagement, enabling informed decision-making and sustainable practices. Early findings demonstrate improved adaptability to disruptions, optimized resource use, and the creation of social and economic value rooted in cultural sustainability. This innovation exemplifies how smart technologies can extend beyond technical efficiency to preserve heritage, foster environmental responsibility, and shape intelligent solutions for a sustainable and resilient future. By combining data-driven insights with cultural storytelling and family-centred engagement, the system positions Johor as a model for integrating sustainability with digital innovation, ensuring that its legacy continues to inspire and educate generations to come.

Keywords: smart innovation, cultural sustainability, artificial intelligence, interactive learning

1.0 INTRODUCTION

In the contemporary digital era, reading habits among children have seen a significant decline, primarily driven by the proliferation of digital entertainment and short-form content. As young learners increasingly gravitate toward visual and interactive media on smartphones, traditional literacy practices are often sidelined (Katawazai, R., 2022). This shift presents a challenge for parents and educators, as reading remains a fundamental pillar for vocabulary development, knowledge retention, and imagination (Katawazai, R., 2022). Research suggests that digital reading on smartphones can be effective if it follows comprehension strategies, yet many existing tools lack the engagement necessary to sustain interest in long-term reading habits (Sari, N., et al., 2022). A critical gap identified in this landscape is the severe shortage of localized educational materials that promote the specific culture and history of Johor. While many applications offer general or foreign content, they fail to connect Malaysian learners with their own state's unique heritage, such as the legends of Batu Pahat or the historical significance of the Royal Town of Muar (Amran, 2023). Furthermore, parents often find themselves without the necessary digital tools to monitor their child's progress, assign relevant reading materials, or participate in the storytelling process (Amran, 2023). This adds a layer of complexity to the parental role in an age where monitoring student engagement is vital. The Little Johor Explorer project was conceived to bridge this gap by developing a personalized, bilingual (Malay and English) mobile application that fosters a love for reading through Johor-themed storytelling.

By integrating interactive elements such as Text-to-Speech (TTS) narration, gamified reward engines, and an AI-powered chatbot ("Mr. Knowledge"), the system transforms cultural preservation into an immersive learning experience. The primary goal is not only to improve literacy but to instil a sense of belonging and pride in Johor's identity by modernising traditional archives into accessible digital formats for early childhood and primary school learners. Ultimately, this initiative aligns with national efforts to strengthen digital literacy while ensuring that Johor's rich traditions are enthusiastically embraced by the next generation.

2.0 OBJECTIVE

2.0To develop a personalized reading application that encourages children to explore Johor's history and culture through storytelling.
3.0To implement interactive features such as text-to-speech narration, quizzes, and reward systems (stars and badges) to enhance engagement and learning.
4.0To provide a parent module that allows monitoring of children's reward tracking and reading progress tracking.

3.0 METHODOLOGY

This project utilizes the Rapid Application Development (RAD) methodology to ensure fast development and flexible refinement based on user feedback. The process consists of four key phases: Requirements Planning, User Design, Construction, and Cutover. This iterative approach allows for continuous improvement of interactive elements like animations and quizzes (Turner and Hicks, 2019). The final application is built using the Flutter framework for cross-platform performance and Firebase for backend data synchronization (as shown in Figure 1).

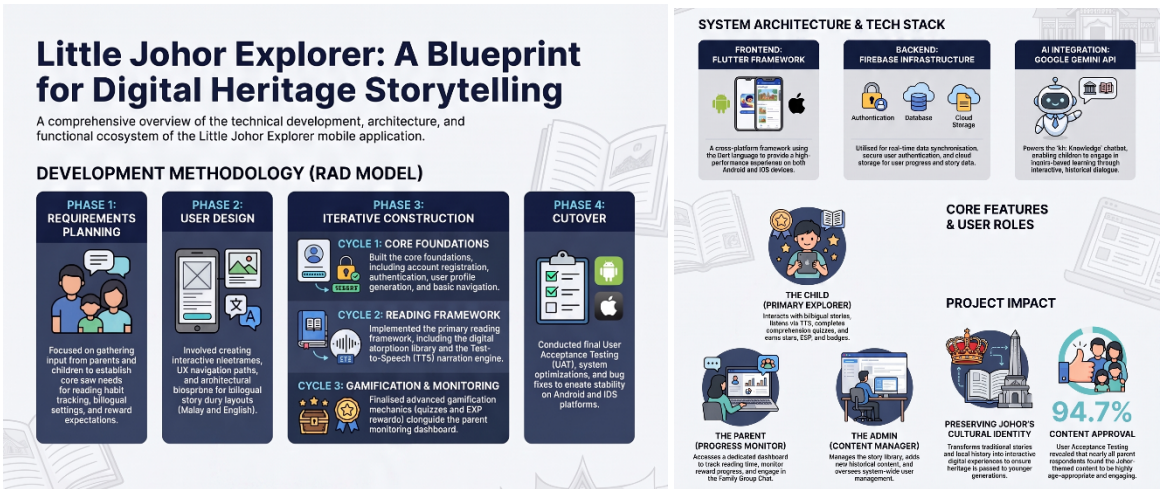


Figure 1 LJE Development Methodology

4.0 RESULT

The implementation phase successfully translated the theoretical designs into a functional version 1.0 of the Little Johor Explorer, built using the Flutter framework and Firebase for robust, cross-platform performance on both Android and iOS. A comprehensive suite of features was deployed, including a bilingual TTS engine specifically tuned with a slower speech rate and pitch to accommodate young learners and a gamified reward system that triggers visual confetti and badges upon the successful completion of quizzes. A standout technical achievement was the integration of the Google Gemini AI API, which facilitates interactive, age-appropriate dialogues between children and "Mr. Knowledge" chatbot, encouraging inquiry-based learning about local heritage. Figure 2 and Figure 3 represent the app's UI.

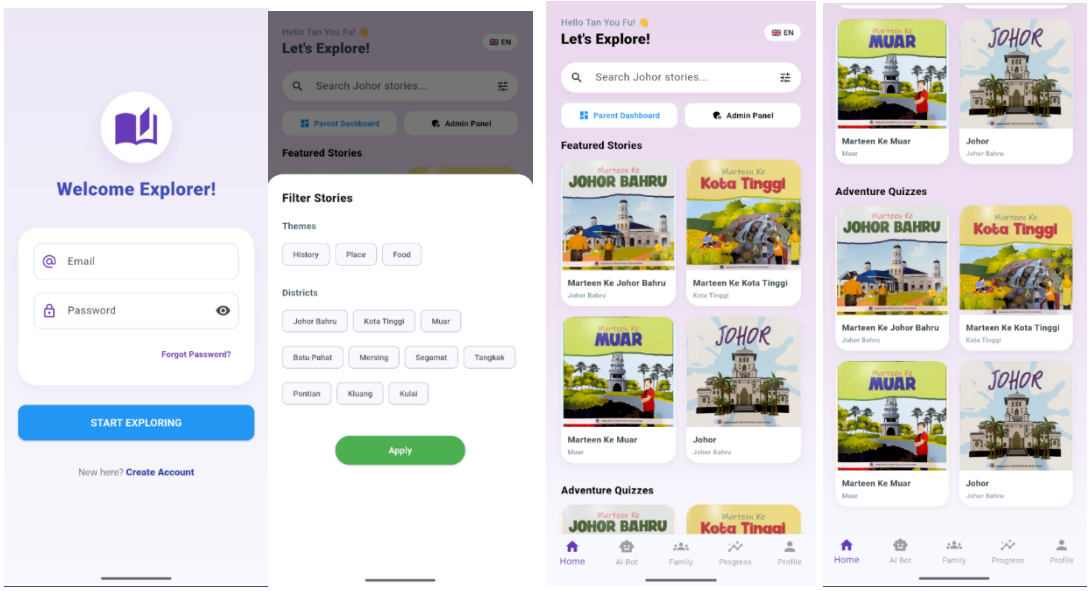


Figure 2: On boarding and Core Navigation

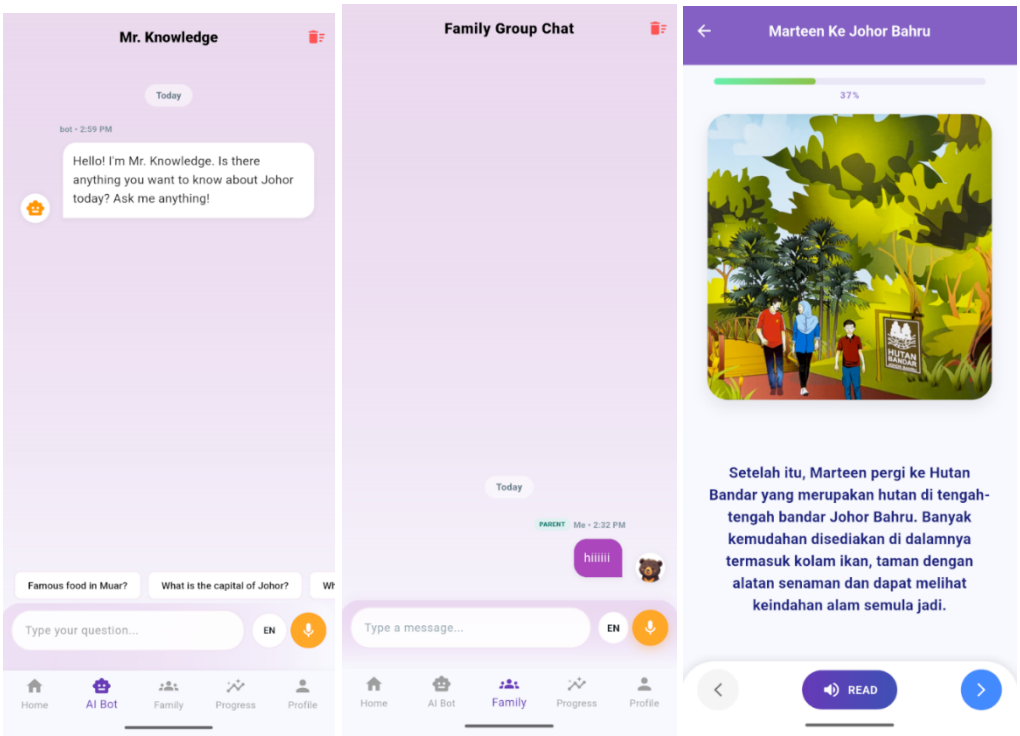


Figure 3: Innovation Features (AI Chatbot for Johor, and TTS)

To validate the system's effectiveness, a User Acceptance Test (UAT) was conducted among a target audience of parents and children in Johor. The results were overwhelmingly positive, with 94.7% of parent respondents confirming that the content was age-appropriate and culturally relevant. 89.5% of parents agreed that the application successfully boosted their children's interest in reading, while 84.2% reported a noticeable improvement in reading comprehension and consistent reading habits. Furthermore, the registration process was found easy to navigate by 80% of users, demonstrating the system's usability for families.

The feedback from children was equally encouraging, with 100% of the 24 young participants reporting that they found the application fun and engaging. The children specifically highlighted their enjoyment of the pictures, the audio narration, and the thrill of earning badges as rewards for their reading efforts. Functional testing across 15 different modules ranging from login and authentication to the AI chatbot and

family chat functions all returned a "Pass" status, confirming the platform's stability and reliability. These findings demonstrate that the project successfully met its core objectives, providing a data-driven confirmation that combining gamification with localized storytelling is an effective instructional approach for modern literacy.

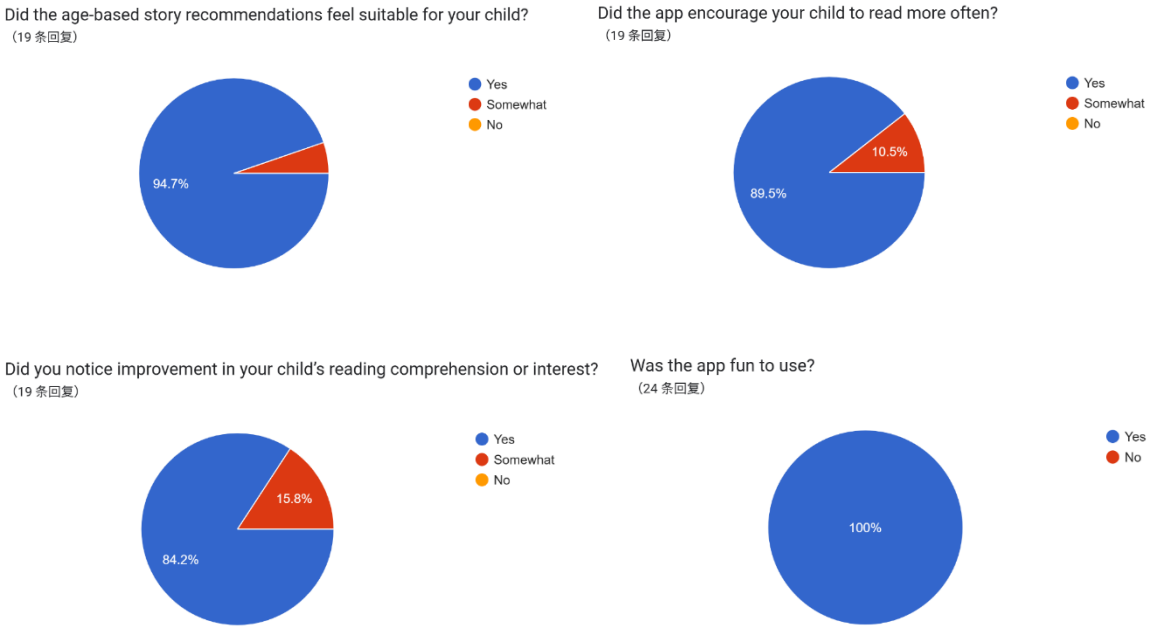


Figure 4: Apps feedback after the testing phase

5.0 CONCLUSION

The Little Johor Explorer project stands as a successful testament to the strategic and collaborative synergy between Southern University College (SUC) and the Perbadanan Perpustakaan Awam Johor (PPAJ). This partnership allowed each institution to play a vital role in producing the application: SUC provided the technical expertise required for the system architecture, Flutter development, and AI integration, while PPAJ contributed the essential historical archives and content verification to ensure cultural accuracy.

By transforming traditional library archives into an interactive digital format, the project achieves a sustainable collaborative model that addresses the decline in children's reading habits. This innovation promotes cultural sustainability by safeguarding Johor's unique heritage such as the stories of Muar, Batu Pahat, and Kota Tinggi for future generations within an efficient, digital ecosystem. Furthermore, the project's scalable architecture ensures its long-term viability, allowing for future content expansion and potential adaptation to other regions. Ultimately, the high User Acceptance Testing (UAT) results, where 89.5% of parents reported a boost in reading interest, confirm that this joint initiative successfully bridges the gap between digital entertainment and meaningful heritage education.



Figure 5: Official launch of the Adaptive Smart Platform: Little Johor Explorer during the Piknik Membaca Johor programme, jointly organized with Perbadanan Perpustakaan Awam Johor (PPAJ).

ACKNOWLEDGEMENT

The author expresses sincere gratitude to Perbadanan Perpustakaan Awam Johor (PPAJ) for their invaluable support as the project sponsor and primary provider of cultural content. Special appreciation is extended to Southern University College (SUC) for the technical expertise and research contribution essential to the successful development of the Little Johor Explorer application. This collaborative effort has been instrumental in merging institutional sponsorship with academic innovation to preserve Johor's rich cultural heritage.

REFERENCES

Amran, A. N. (2023). Enhancing Secondary Education: A Mobile Application for Student Performance Monitoring and Curriculum Management. The Asian Journal of Professional and Business Studies.

Katawazai, R. (2022). An Evaluation of the Cultural Elements within Malaysian Year 1 English Textbooks: KSSR SK English Year 1 and CEFR Super Minds 1. Sains Humanika.

Sari, N., AkbarJono, A., & Martina, F. (2022). The Effect of Gamification In Learning On Students' Reading Comprehension. Siducat.org.

Turner, K. H., & Hicks, T. (2019). Connected Reading: A Framework for Understanding How Adolescents Encounter, Evaluate, and Engage With Texts in the Digital Age. Reading Research Quarterly.

$\alpha - SESD$: EASY TECHNIQUE FOR SKETCHING TRIGONOMETRIC FUNCTION GRAPHS IN THE E-HIGH 5 TRIGO MODULE

Hamimah binti Ibrahim [1], Rohani binti Ishak[2], Widad binti Ahmad Ridzuan[3], Siti Nursyafiqah binti Mohd Saupee[4]

[1] Selangor Matriculation

[] E-mel : bm-2739@moe-dl.edu.my

ABSTRACT

Trigonometric function graphs are among the most challenging subtopics in the Mathematics curriculum of the Matriculation Programme, as students often experience difficulties in identifying basic graph shapes, determining maximum and minimum points, and sketching graphs accurately. Classroom observations, quizzes, and interviews revealed that these difficulties stem from students' weak understanding of the relationship between function equations and graph shapes, as well as the lack of a systematic visual approach to graph sketching. To address these issues, the e-High 5 Trigo Module was developed by integrating the α-SESD technique, the Five-Finger Model, and digital learning through QR codes. The module combines concise notes, interactive exercises, and instructional videos to help students master graph sketching in a systematic, accurate, and efficient manner. The study was conducted in May 2024 and involved 21 Science stream students from class S2K2T3 at Selangor Matriculation College using a pre-test, post-test, and questionnaire. The findings showed that the mean score increased significantly from 37.66 to 94.76, while the standard deviation decreased from 17.26 to 5.13, indicating improved achievement and more consistent mastery. The questionnaire recorded a high mean score of 4.89, reflecting excellent user acceptance, confidence, and satisfaction with the module. In addition, the module reduced the time required to sketch graphs by up to 80%. Overall, the e-High 5 Trigo Module proved effective in enhancing students' mastery of trigonometric function graphs through an innovative digital learning approach. It also has the potential to be adopted as a teaching and learning resource at the secondary, pre-university, and higher education levels and to be commercialised as a digital learning module that supports self-directed learning and technology-driven educational transformation.

Keywords: modul e-high 5 trigo, trigonometric function graphs, digital learning

1.0 INTRODUCTION

Trigonometric Function Graphs is a subtopic under Functions and Graphs in the SM015 Mathematics syllabus of the Matriculation Programme following the curriculum revision in the 2022/2023 academic session. This topic requires students to understand the relationship between trigonometric equations and their graphical representations, including identifying graph shapes, determining maximum and minimum points, and sketching graphs accurately.

However, classroom observations, quizzes, exercises, and interviews involving 21 students from class S2K2T3 revealed that many students had difficulty identifying the basic graph shapes, determining maximum and minimum points, and interpreting the effects of parameters in trigonometric functions. These findings are consistent with previous studies, which reported that students often struggle to relate equations to graphical representations and rely more on procedural methods than conceptual understanding (Zaini & Retnawati, 2019; Rohimah & Prabawanto, 2020; Lin et al., 2020). To overcome these challenges, the e-High 5 Trigo Graphs Module was developed as a structured visual and digital learning resource to support students in understanding and sketching trigonometric function graphs.

2.0 OBJECTIVE

This innovation was implemented to achieve the following objectives:

i. to improve students' skills in determining the maximum and minimum points of the graphs of sin(ax + b) and cos(ax + b) and the vertical asymptotes of the graph of tan(ax + b).
ii. to improve students' skills in sketching trigonometric function graphs accurately and quickly.

3.0 METHODOLOGY

3.1 RESEARCH DESIGN AND PARTICIPANTS

This study employed a pre-experimental research design using a one-group pre-test and post-test approach. The participants consisted of 21 Science stream students from class S2K2T3 at Selangor Matriculation College. The study was conducted in May 2024 to evaluate the effectiveness of the e-High 5 Trigo Graphs Module in improving students' mastery of trigonometric function graph sketching.

3.2 IMPLEMENTATION OF THE INNOVATION

The implementation of the e-High 5 Trigo Graphs Module involved a learning approach that integrated the α-SESD technique, the Five-Finger Model, and QR code-based digital learning. Students followed a systematic learning process beginning with understanding the basic concepts of trigonometric function graphs, identifying important graph characteristics, determining maximum and minimum points, and sketching graphs based on the guidelines provided in the module. The module consists of concise notes, interactive exercises, and instructional videos accessible through QR codes to facilitate visual and self-directed learning. This approach allows students to review the learning materials according to their individual pace while improving their graph-sketching skills through a **clear step-by-step process.** In line with the findings of Arhin et al. (2024), the integration of ICT in Mathematics learning creates a more dynamic learning environment, promotes active learning, and enhances students' conceptual understanding. Therefore, the use of QR code-based digital resources in this module enhances interactive digital learning and contributes to improving students' mastery of trigonometric function graphs.

3.3 DATA COLLECTION

Three instruments were used for data collection: pre-test, post-test, and questionnaire. The pre-test and post-test were administered to measure students' improvement in sketching trigonometric function graphs after the implementation of the module. The questionnaire was used to evaluate students' acceptance, confidence, and satisfaction toward innovation.

4.0 RESULT AND DISCUSSIONS

4.1 DATA ANALYSIS

The collected data were analysed using mean scores and standard deviation to determine students' achievement before and after the intervention. The questionnaire data were analysed using mean scores to evaluate students' perceptions and acceptance of this module.

4.1.1 Comparison of Pre-Test and Post-Test Scores

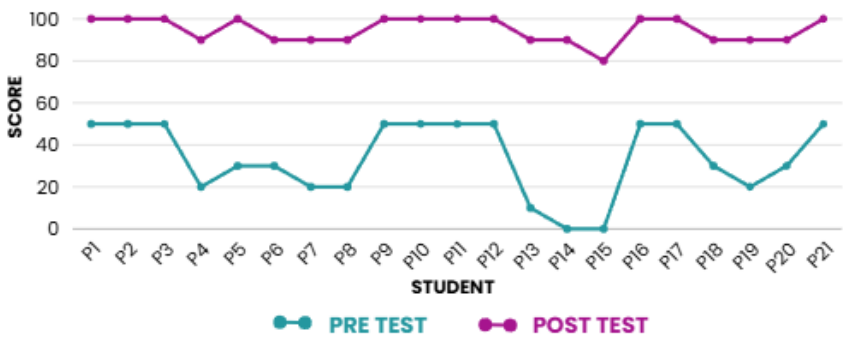


Figure 1: Comparison of Pre-Test and Post-Test Scores

Table 1: Total Scores, Mean Scores, and Standard Deviations for the Pre-Test and Post-Test

Test Type	Pre Test	Post Test
Total Score	790	1990

Mean Score	37.62	94.76
Standard Deviation	17.26	5.13

Based on Table 1, students demonstrated significant improvement after the implementation of this module. The higher mean score and lower standard deviation indicate improved performance and more consistent achievement, indicating that the objectives of the innovation were successfully achieved. Students demonstrated improved competency in identifying key characteristics of trigonometric graphs and applying appropriate techniques for graph sketching.

4.1.2 Student Feedback

Based on classroom interviews, students were invited to provide feedback on this module. Overall, the responses were highly positive, indicating that the module enhanced their understanding, confidence, and interest in learning trigonometric graphs. Some of the students' comments are as follows:

"I've started to enjoy sketching trigonometric graphs because this module provides systematic steps that make the concepts much easier to understand."

"The 5-Finger teaching aid really helped me understand how to sketch the graphs."

"The 5-Finger Module is great! It's attractive, easy to follow, and the explanations are very clear."

"I can't believe I'm able to sketch the graphs much faster than before."

4.1.3 Questionnaire

The questionnaire results revealed high levels of student satisfaction with this module, with mean scores ranging from 4.76 to 4.95 across all seven items. These findings indicate that the module effectively enhanced students' understanding, confidence, interest, and graph-sketching skills, thereby promoting more meaningful and engaging learning of trigonometric graphs.

4.1.4 Graph Race Activity

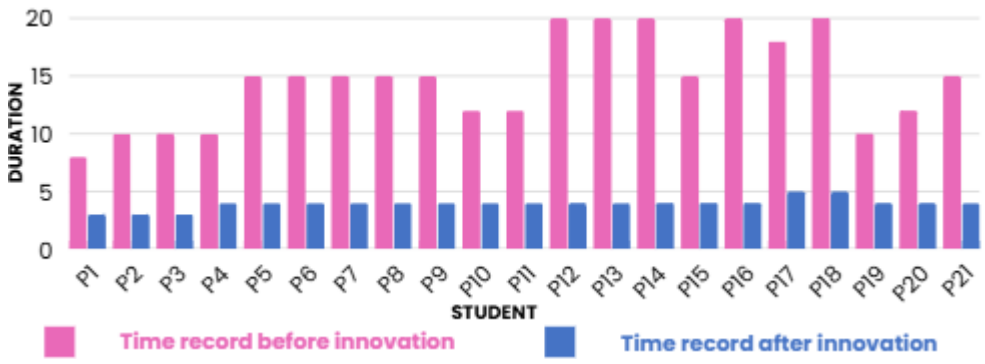


Figure 2: Time Taken for the Graph Race Activity

Based on Figure 2, the Graph Race results showed that this module reduced graph-sketching time by up to 80%, improving students' efficiency, confidence and engagement in learning trigonometric graphs.

4.2 RESULTS AND DISCUSSION

4.2.1 Improvement in Students' Achievement and Confidence

The improvement in students' achievement indicates that the module effectively strengthened their conceptual understanding and confidence in solving trigonometric graph problems. The structured learning approach helped students connect equations with graphical representations more effectively.

4.2.2 Enhancement of Teaching and Learning Efficiency

The integration of QR codes, notes and instructional videos supports self-directed learning, reduces dependence on repeated explanations and enables students to develop graph-sketching skills more independently.

4.3 INNOVATION NOVELTY AND ADVANTAGES

The novelty of this module lies in the integration of the **α-SESD technique**, **Five-Finger Model**, mnemonic strategies, QR code-based learning, and instructional videos into a single integrated framework for trigonometric graph sketching. Unlike conventional approaches that mainly rely on formula memorisation and static examples, this module provides a step-by-step visual strategy that guides students in understanding the relationship between trigonometric equations and graphical representations. This unique combination transforms trigonometric graph sketching into a simpler, more organised, and learner-friendly process.

4.4 IMPACT AND EFFECTIVENESS OF INNOVATION

4.4.1 Learning Impact

The module enhances students' confidence, independence, and conceptual understanding by providing a visual and guided learning approach. Students are able to relate trigonometric equations to graph characteristics more effectively.

4.4.2 Teaching and Learning Efficiency

The implementation of this module enhances teaching and learning efficiency through a structured approach. The integration of QR codes, concise notes, and instructional videos supports self-directed learning while reducing the need for repeated explanations and improving students' graph-sketching skills.

4.4.3 Cost Effectiveness and Productivity

The module is a cost-effective innovation developed using accessible digital resources without requiring additional equipment. It enhances productivity by supporting lecturers in delivering concepts more effectively while allowing students to learn at their own pace.

4.5 SIGNIFICANCE AND POTENTIAL APPLICATION

This module contributes to mathematics education by supporting innovative, student-centred and technology-enhanced learning. The module has strong potential for wider implementation across secondary schools, vocational colleges, pre-university programmes and higher education institutions that involve trigonometric graph sketching. Its adaptability, accessibility and cost-effectiveness enable the module to be expanded to other mathematical topics and adopted as a digital learning resource. Based on the Technology Readiness Level (TRL) framework, the e-High 5 Trigo Module is classified as TRL 7 because it has been fully developed and successfully validated in a real classroom teaching and learning environment.

5.0 DISSEMINATION, RECOGNITION AND INTELLECTUAL PROPERTY

5.1 DISSEMINATION AND KNOWLEDGE SHARING

The module has been disseminated among mathematics educators at Selangor Matriculation College, Negeri Sembilan Matriculation College and secondary schools through knowledge-sharing sessions and national as well as international presentations.

5.2 VALIDATION AND INTELLECTUAL PROPERTY

The module has received validation from the Master Trainer of Additional Mathematics, Kuala Langat District and has been registered with MyIPO under registration number CRLY2025W06350, demonstrating its credibility, originality and potential for wider adoption.

6.0 CONCLUSION

This module has proven to be an effective technology-enhanced teaching and learning resource for Subtopic 5.5: Sketching Trigonometric Function Graphs. The module is suitable not only for students in the two-semester and four-semester Matriculation Programmes, but also for secondary school students taking Additional Mathematics and learners in other educational institutions. Furthermore, it promotes independent and flexible learning by enabling students to access learning materials anytime through QR code technology, aligned with the principles of 21st Century Learning (PAK-21). In addition, the module contributes to scholarly activities and supports innovative teaching and learning practices within the Matriculation Division.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to the Matriculation Division, Ministry of Education Malaysia and the Mathematics Unit, Selangor Matriculation College (KMS) for their support, encouragement and cooperation throughout the development and implementation of the e-High 5 Trigo Module. Special appreciation is also extended to the Matriculation Programme students who participated in this innovation for their commitment, involvement and valuable feedback.

Finally, the authors would like to acknowledge all individuals and parties who have contributed directly or indirectly to the successful development, dissemination and implementation of the module as an innovative approach in mathematics teaching and learning for the Matriculation Programme.

REFERENCES

Alexandru Maries, Shih-Yin Lin, Chandralekha Singh (2020). Challenges in designing appropriate scaffolding to improve students' representational consistency: The case of a Gauss's law. https://doi.org/10.48550/arXiv.2006.16842

Arhin, J., Boateng, F., Akosah, E., & Gyimah, K. (2024). Perceptions and Readiness of High School Mathematics Teachers for Integration of ICT Tools in Teaching and Learning of Mathematics. Pedagogical Research. https://doi.org/10.29333/pr/14032

S M Rohimah and S Prabawanto (2020). J. Phys.: Conf. Ser. 1521 032002 Students' difficulties in solving trigonometric equations and identities Journal of Physics Conference Series 1521(3):032002. https://iopscience.iop.org/article/10.1088/1742-6596/1521/3/032002

Sharone Qc Jonim, Aidah Abdul Karim (2023). Meningkatkan Kemahiran Berfikir Aras Tinggi dalam Trigonometri Bagi Pelajar Tingkatan 5 dengan Menggunakan Lembaran Kerja. Malaysian Journal of Social Sciences and Humanities (MJSSH) (e-ISSN: 2504-8562) 2023, Volume 8, Issue 5, e002320. https://doi.org/10.47405/mjssh.v8i5.2320

Zaini, A.H.& Retnawati, H.(2019). What Difficulties that Students Working in Mathematical Reasoning Questions? *Journal of Physics: Conference Series*, 1397(1), 012079. https://iopscience.iop.org/article/10.1088/1742-6596/1397/1/012079

SMART WINDOW GUARDIAN : AN IOT-BASED CHILD SAFETY WINDOW PROTECTION SYSTEM

Nor Azlina binti Rais[1], Zalina binti Kemat[2,] , Nor Syasyaamira Binti Ramli[3],
Nur Fatin Nadzirah Binti Zaman,

[1]Kolej Poly-Tech MARA Batu Pahat, Jalan Gading Emas,
Taman Gading Emas, Sri Gading, 83300 Batu Pahat, Johor.

 Nor Azlina binti Rais : azlina_r@kptm.edu.my

ABSTRACT

Falls from residential windows remain a repeated child safety problem in Malaysia, mainly in high-rise houses such as apartments and condominiums. Most victims are children under the age of six, and many incidents happen when caregivers are briefly unfocussed. As urbanisation grows, more families are living in high-rise residences, creating an urgent need for everyday safety solutions to prevent accidental window falls. Conventional window designs mostly highlight ventilation and aesthetics while overseeing child safety. Most windows can be easy to open wide enough for kids to climb through, while existing safety devices are often expensive, difficult to install, or lack smart monitoring design. As a result, parents and childcare providers require an affordable, reliable, and user-friendly solution that enhances child safety without affecting normal window operation. This innovation aims to develop the Smart Window Guardian, an integrated child safety system that prevents accidental falls by combining mechanical protection, secure locking, and Internet of Things (IoT)-based monitoring. The system incorporates three layers of protection. The first layer is a mechanical window opening restrictor that limits the opening to 5–8 cm, preventing children from passing through. The second layer is a magnetic safety lock installed at a height of 140 cm from the floor, making it inaccessible to young children. The third layer consists of an audible alarm, an LED warning indicator, and an IoT-enabled mobile notification system that immediately alerts parents when the window is opened beyond the safe limit. The device is designed for easy installation without damaging existing window structures. The estimated production cost is RM80–RM120 per unit, while the prototype cost is approximately RM300. The Smart Window Guardian provides an affordable, practical, and scalable safety solution for apartments, condominiums, childcare centres, and nurseries. By integrating mechanical safety features with IoT technology, it enhances child protection, reduces the risk of accidental falls, and provides parents with real-time monitoring. This innovation has the potential to reduce child injuries and fatalities while promoting safer residential environments.

Keywords: child safety, smart home technology, internet of things (iot), window opening restrictor, accident prevention residential safety

1.0 INTRODUCTION

Falls from residential windows are a recurring child safety issue in Malaysia. Most victims are children under the age of six, and these incidents often occur within a short period when parents or caregivers are momentarily absent. This problem indicates that conventional window designs do not adequately consider the safety of young children. In response to this issue, an innovative safety product known as the Smart Window Guardian has been proposed.

2.0 OBJECTIVE

35. To develop the Smart Window Guardian as an innovative child safety window protection system.
36. To integrate mechanical, magnetic, and IoT technologies into a comprehensive window safety solution.
37. To decrease the risk of accidental falls among children living in high-rise residential buildings

3.0 METHODOLOGY

The product integrates three layers of protection. The first layer is a mechanical window opening restrictor that limits the window opening to between 5 and 8 centimetres, preventing children from passing through. The second layer is a magnetic safety lock installed at a height of 140 centimetres from the floor, making it difficult for young children to access. The third layer consists of an audible alarm and an LED warning light that are activated whenever the window is opened beyond the safe limit, together with real-time notifications sent to parents' smartphones through an Internet of Things (IoT) connection. The product is designed for easy installation without damaging the existing building structure. The estimated mass production cost ranges from RM80 to RM120 per unit, while the prototype development cost is approximately RM300. The primary target market includes parents living in apartments and condominiums, as well as childcare centres and nurseries. This innovation is expected to contribute to reducing the risk of injuries and fatalities resulting from children falling from residential windows.

3.1 SMART WINDOW SAFETY SYSTEMS

Yusuf et al. (2021) stated that falls from residential windows are a recurring child safety issue in Malaysia's high-rise housing, but the strongest direct Malaysian evidence is still concentrated in design and policy analyses rather than hospital-based epidemiology. Similar results were reported recently (Sitiayu et al., 2016). Flaherty (2020) reported that most paediatric window falls involve young children, usually occur at home, and often happen from low or mid-level floors, not only from very tall towers. (Sitiayu, 2016) (Flaherty et al., 2020) ".

Apostolopoulou (2023) stated that parents and childcare providers need a solution that is low-cost, reliable, and easy to use, but the evidence supports a layered approach: simple physical window safeguards for prevention, paired with low-cost digital monitoring and alerts for added supervision. Senthamilarasin (2019) stated that IoT monitoring is the best-supported way to add caregivers' awareness, remote supervision, and rapid alerts, but it works best as a supplement to physical safeguards rather than as a stand-alone solution.

Wagh (2025) reported that across the child-safety literature, useful systems combine sensors, connectivity, and simple interfaces for real-time status, alarms, and logging. Zhang (2024) mentioned that monitoring systems increasingly use multi-sensor or AI detection for hazards, with reported accuracies of 96.5%-99.7% in prototype studies

Gao (2024) reported that conventional windows in the supplied corpus are described mainly as manual open-close fixtures, whereas smart-window designs add sensing, automation, and safety control layers. Guntur (2023) reported that restrictors such as window restrictors and stops are explicitly recommended to reduce child fall risk

Melinda (2025) stated that smart child locks should be used for automated detection plus electronic actuation rather than passive closure alone. This is later mentioned by Shalini (2026).

Viscomti (2020) mentioned that the case for Smart Window Guardian is strongest if it stays cheap, simple, and retrofit-friendly. Several lower-ranked papers support this point directly, not just the top-ranked ones. This was later stated found to be agreed by Visconti (2020) and Shalini (2026)

Zhao (2024) reported that a wireless smart-lock system network is the best choice due to easy installation. Roy (2023) reported that the house security and smart lock systems must be at the low cost and at the affordable price. This is also stated by Guntur 2023 and Anitha 2027. Roy (2023) suggested the price to be low-cost positioning, but they do not directly validate the exact RM80–RM120 figure. Similar result were reported recently (Melinda 2025, Anitha 2017)

.**Table 1: Comparison between Conventional Windows and Smart Window Guardian**

Feature	Conventional Window	Smart Window Guardian
Opening Restrictor	No	Yes
Child Safety Lock	No	Magnetic Lock
Alarm System	No	Audible Alarm + LED

IoT Notification	No	Yes
Installation	Standard	Easy Retrofit
Cost	None	RM80–RM120



Figure 1: Short description of figure. Insert figures after they are cited in the text.

4.0 RESULT

A business idea of the Smart Window Guardian was successfully developed to demonstrate the proposed child safety concept. The prototype integrates three safety features: a mechanical window opening restrictor, a magnetic safety lock, and an Internet of Things (IoT)-based monitoring system. The design allows for easy installation on existing windows without requiring structural modifications, making it suitable for retrofit applications. The estimated production cost ranges from RM80 to RM120 per unit, while the prototype development cost is approximately RM300. The proposed system is intended for use in apartments, condominiums, childcare centres, and nurseries. The integration of mechanical protection and real-time monitoring is expected to enhance child safety by reducing the risk of accidental falls from residential windows and providing parents with timely alerts when unsafe window openings occur.

5.0 CONCLUSION

The Smart Window Guardian is an innovative child safety solution designed to reduce the risk of accidental window falls among young children. The integration of mechanical protection, magnetic locking, and IoT-based monitoring provides a comprehensive approach to residential window safety. Its low production cost, ease of installation, and retrofit capability make it suitable for widespread adoption in apartments, condominiums, childcare centres, and nurseries. With further development and validation, the Smart Window Guardian has strong potential for commercialisation and could contribute significantly to improving child safety in high-rise residential environments.

ACKNOWLEDGEMENT

I would like to extend my sincere appreciation to my team members for their unwavering support, valuable guidance, and constructive feedback throughout the development of the Smart Window Guardian. Their knowledge, dedication, and collaborative efforts played a significant role in the successful completion of this project.

I would also like to express my heartfelt gratitude to the General Studies Department, Kolej Poly-Tech MARA Batu Pahat, for providing the facilities, resources, and technical assistance that greatly supported the implementation of this innovation.

My deepest appreciation goes to my family and friends for their continuous encouragement, understanding, and moral support throughout this journey. Their patience and motivation have been a constant source of strength.

Finally, I would like to thank everyone who has contributed, either directly or indirectly, to the successful completion of this project. Their support and encouragement are sincerely appreciated.

REFERENCES/RUJUKAN

Apostolopoulou, Katerina, et al. "Secure windows for child safety: A retrospective study of window falls in children, aiming to raise prevention awareness." Child's Nervous System, 2023, pp. 1 - 11, https://doi.org/10.1007/s00381-023-05964-7

Flaherty, M., Raybould, T., Savarino, J., Yager, P., Mooney, D., Farr, B. J., Giuliano, J. S., Neeman, E., Campbell, B., Thaker, S., McKiernan, C., Lewis, D., Epp, T. K., Baertschiger, R., Jackson, C., Rideout, L., Shah, A., Falank, C., Ontengco, J. B., .Masiakos, P. (2020). Unintentional Window Falls in Children and Adolescents.. *Academic pediatrics*. https://doi.org/10.1016/j.acap.2020.07.008

Guntur, J., Raju, S., Niranjan, T., Kilaru, S., Dronavalli, R., & Kumar, N. C. S. (2023). IoT-Enhanced Smart Door Locking System with Security. SN Computer Science, 4, 1-5. https://doi.org/10.1007/s42979-022-01641-9

Roy, S., Kabir, M. H., & Ahmed, M. T. (2023). IoT Based Low-Cost Smart Home Automation and Security System Using Wireless Technology. Australian Journal of Engineering and Innovative Technology. https://doi.org/10.34104/ajeit.023.01010112

Yusuf, S. Z., Tahir, Z., & Samsudin, S. (2021). Analysis Of Elements Influencing Child Safety In High-Rise Buildings Using Analytical Method. Planning Malaysia. https://doi.org/10.21837/pm.v19i18.1037

Zhao, A., Wang, B., Shi, C., Li, D. Y., & E. (2024). An Energy-Saving and Environment-Friendly Networked Intelligent Door Lock System for Offices. Int. J. Distributed Sens. Networks, 2024, 1-13. https://doi.org/10.1155/2024/5699802

DUALXAI: A MULTI-TIER WEB ARCHITECTURE FOR SECURE DEEPFAKE DETECTION USING CONVOLUTIONAL NEURAL NETWORKS AND EXPLAINABLE AI

Farid Hakimi Bin Zulhardy[1], Azlinda Binti Abdul Aziz[2], Nurul Najwa Binti Abdul Rahid@Abdul Rashid[3], Mohd Hafifi Bin Mohd Supir[4], Raihana Binti Md Saidi[5,*]

[1,2,3,4,5] Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Cawangan Melaka Kampus Jasin, 77300 Merlimau, Melaka, Malaysia

[*]Corresponding author: raihana@uitm.edu.my

ABSTRACT

The rapid spread of highly realistic fake videos and images, commonly known as deepfakes, has become a major threat to digital trust and security. Unfortunately, current AI tools used to spot these fakes are often confusing black boxes that give a simple binary answer without explaining their reasoning. Furthermore, most commercial tools require users to upload sensitive files to the internet, creating significant data privacy risks. To address these issues, this project aimed to develop a secure and easily understandable forensic tool that translates complex AI predictions into clear, visual evidence for users. DualXAI is a privacy-focused web platform for detecting deepfakes. Because it processes files locally on the user's own computer system, it keeps sensitive media completely safe from cloud-based vulnerabilities. The system is powered by a lightweight web framework and a highly accurate AI model called EfficientNet-B0. To make the AI's decisions transparent, DualXAI uses Explainable AI (XAI) to generate colour-coded pictures, or heatmaps, that highlight the exact manipulated parts of a face. In testing, the platform proved highly reliable and user-friendly, successfully analyzing media with a 100% pass rate across all functional scenarios. The system presents users with a clear prediction label, a confidence score, clarity metrics and easy-to-read text explanations. This ensures that anyone can understand the results without needing technical expertise. Ultimately, DualXAI successfully proves that AI can be both highly accurate and completely transparent, offering a safe and reliable tool for verifying digital media while laying the groundwork for future improvements like live-stream analysis and audio deepfake detection.

Keywords: convolutional neural networks, data privacy, deepfake detection, digital forensics, explainable AI

1.0 INTRODUCTION

The rapid spread of highly realistic fake videos and images, commonly known as deepfakes, poses a significant threat to digital trust, online security, and everyday accountability (Singh & Shinde, 2026; Sunil et al., 2025; Waseem et al., 2023a). While modern artificial intelligence effectively identifies these visual manipulations (Awotunde et al., 2022; Thulasimani & Pooja, 2026; Triveni et al., 2026; Zafar et al., 2025), a critical limitation remains: these advanced tools often operate as opaque "black boxes." When a video is submitted for analysis, the system may generate a simple "Fake" or "Real" label without explaining the underlying rationale (Sadiq et al., 2026). This lack of transparency makes it difficult for professionals such as journalists, lawyers, and digital investigators to rely on these tools for high-stakes, real-world forensic cases where trust and definitive proof are essential (Vamsi et al., 2022). Furthermore, most commercial deepfake detection platforms require users to upload sensitive files to external cloud servers. For digital forensics experts handling highly confidential investigation files, transferring data to a third-party server introduces severe data privacy and security risks.

To address the dual challenges of opaque AI decision-making and cloud-based privacy risks, this study introduces a secure web platform designed to prioritize data privacy (Anand et al., 2024). Instead of transmitting sensitive data over the internet, the proposed system processes all media locally on the user's local hardware. This approach guarantees that sensitive facial data remains entirely private and protected from external vulnerabilities or data leaks.

To achieve seamless operation on standard computing hardware, the system relies on three primary technical pillars. First, it utilises a lightweight web framework called Flask, which allows the system to run efficiently and responsively without requiring high-powered computing resources. Second, deepfake detection is performed by a highly accurate AI model known as the EfficientNet-B0 Convolutional Neural Network (Chauhan et al., 2026; Mallet et al., 2023; Patel et al., 2023; Waseem et al., 2023b). This specific model is optimised to detect manipulations efficiently while maintaining high accuracy across various faces and inputs.

To resolve the "black box" limitation, the platform integrates Explainable AI (XAI) to translate complex computational outputs into clear visual proof (Aleem et al., 2026). Rather than providing a binary output, the system generates colour-coded heatmaps that highlight the specific facial regions that were altered. By incorporating confidence scores and accessible textual explanations, the platform ensures the results are interpretable, successfully bridging the gap between complex AI operations and human understanding.

2.0 OBJECTIVE

To solve the problems of confusing AI and privacy risks in deepfake detection, this research aims to build a secure and easy-to-understand tool. The main goal is to use Explainable AI (XAI) to turn complex AI decisions into clear visual proof for both images and videos.

3.0 METHODOLOGY

3.1 Multi-Tier Framework Architecture

The proposed deepfake detection system, DualXAI is engineered upon a highly cohesive, multi-tier framework designed to seamlessly integrate user interaction, backend processing and deep learning inference. As illustrated in Figure 1, this architectural paradigm is divided into three primary tiers:

38. ***Presentation Tier:*** Functioning as the user application interface, this tier is developed using standard web technologies (HTML, CSS and JavaScript). It provides an interactive, browser-based dashboard that facilitates secure media uploads and renders comprehensive, user-friendly visualisations of the forensic results.
39. ***Application Tier:*** Bridging the front-end interface and the analytical models is the Application Tier, constructed upon the lightweight Python Flask micro-web framework. This central business logic layer operates entirely locally, managing essential system routing, automated file validation and the overarching orchestration of the forensic and preprocessing pipelines.
40. ***Model Tier:*** The core analytical engine resides within the Model Tier, powered by the EfficientNet-B0 Convolutional Neural Network (CNN). Unlike conventional CNN architectures that scale spatial dimensions (such as depth and resolution) independently, EfficientNet-B0 employs an optimized compound coefficient to uniformly scale the network's depth, width and resolution. This structural innovation ensures superior computational efficiency and robust feature extraction across varied facial inputs, making it highly suitable for resource-conscious local deployment.

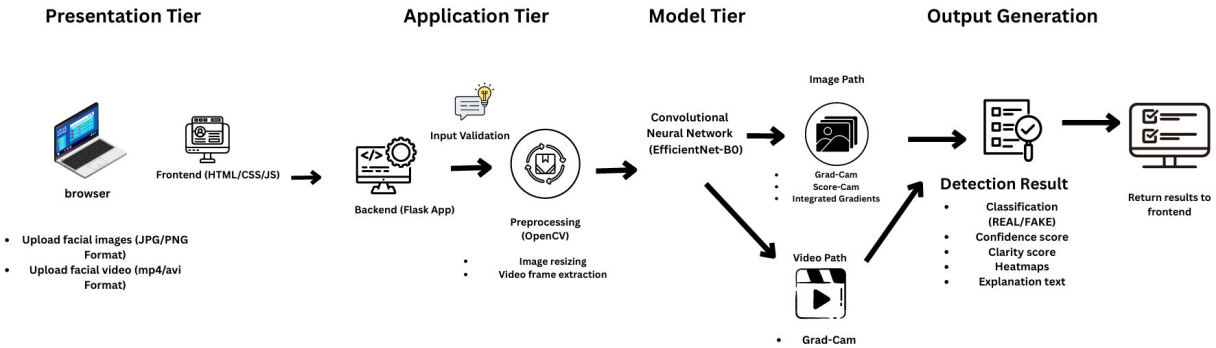


Figure 1: Multi-Tier System Architecture of the DualXAI Deepfake Detection Framework

3.2 Media Preprocessing Pipeline

To perfectly prepare data before the AI analyses it, the system uses OpenCV to process files in three simple steps:

5.0 **File Validation:** The platform checks the file type, securely accepting safe images (JPG, PNG) and videos (MP4, AVI). It automatically blocks unsupported or unsafe formats to protect the system's security.
6.0 **Normalization:** Approved static images are resized to a standard 224x224 pixels and adjusted so the EfficientNet-B0 model can easily read them.
7.0 **Frame Extraction:** For videos, the system extracts individual frames one by one. Each frame is then resized and adjusted just like the images, allowing the AI to thoroughly analyse the entire video timeline.

3.3 Explainable Artificial Intelligence (XAI) Suite

To overcome the black-box nature of deep learning and maximize forensic clarity, DualXAI integrates three specialized Explainable AI (XAI) methods that translate raw algorithmic predictions into clear visual evidence

i. **Grad-CAM:** This technique utilizes network gradients to generate a basic localization map, effectively highlighting the broader macro-regions of a manipulated face that most heavily influenced the model's prediction
ii. **Score-CAM:** Score-CAM evaluates activation maps by measuring increases in confidence scores when specific regions are highlighted. This creates a stable, noise-free visualization that avoids the inconsistencies and artifacts often seen in purely gradient-based approaches
iii. **Integrated Gradients (IG):** To deliver granular, pixel-level visual evidence, IG calculates gradients along a linear path from a baseline to the input image. This resolves the algorithmic "gradient saturation" issue, ensuring the forensic impact of subtle, manipulated pixels is accurately captured and displayed.

4.0 RESULTS

Testing demonstrated that DualXAI is highly reliable and user-friendly. The drag-and-drop interface seamlessly accepts valid media (JPG, PNG, MP4, AVI) while automatically blocking unsafe files. Behind the scenes, processing runs smoothly using OpenCV to prepare media frames, while the EfficientNet-B0 model accurately classifies faces as REAL or FAKE.

Figure 2 illustrates the dashboard's "Result Page," which clearly displays the REAL/FAKE verdict alongside a Confidence Score indicating the model's certainty. To ensure the AI's decision is fully transparent, the dashboard also provides visual heatmaps highlighting manipulated regions, a Clarity Score evaluating these visual explanations and a plain-text natural language summary.

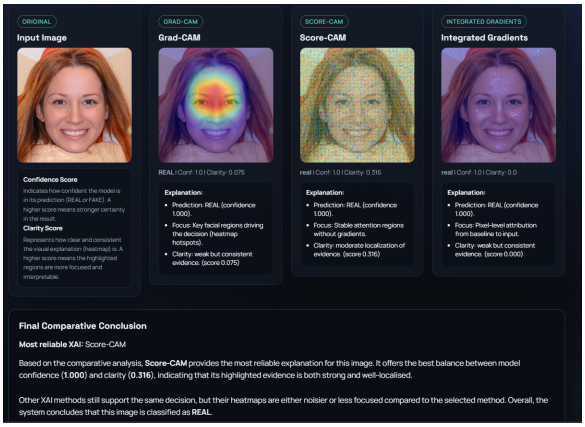


Figure 2: User Interface Dashboard Displaying the Synthesized Deepfake Detection Results and Explainable AI (XAI) Metrics

To validate this workflow, standardised functional testing was conducted with three independent users. As detailed in Table 1, the system achieved a flawless 100% pass rate across all core tasks, from initial file validation to the final rendering of XAI forensic metrics

Table 1: Functional Evaluation of the Deepfake Detection System

Test ID	Scenario	Expected Result	Tester 1	Tester 2	Tester 3
FT1	Upload valid JPG/PNG image	Upload accepted and process successfully	Pass	Pass	Pass
FT2	Upload invalid MP4/AVI video*	The system stops uploading and shows an error message.	Pass	Pass	Pass
FT3	View Detection Result	System shows REAL/FAKE prediction result	Pass	Pass	Pass
FT4	View Heatmap (Image)	User can view the heatmap of Grad-CAM, Score-CAM and Integrated Gradients for image	Pass	Pass	Pass
FT5	View Heatmap (Video)	User can view the heatmap of the Grad-CAM for video	Pass	Pass	Pass
FT6	View Confidence Score	After detection, user can view the Confidence Score	Pass	Pass	Pass
FT7	View Clarity Score	After detection, user can also view clarity score	Pass	Pass	Pass
FT8	View Explanation	User can view the explanation result.	Pass	Pass	Pass

The system's biggest success is that it visually proves its decisions instead of just giving a simple "REAL" or "FAKE" answer. It creates color-coded heatmaps that highlight the exact manipulated areas of a face, using three distinct techniques for images and one for video frames. The results page gives users four easy-to-understand metrics: a clear prediction label, a Confidence Score showing the AI's certainty, a Clarity Score evaluating the heatmap's focus on key features and a simple written explanation. This ensures anyone can confidently understand the findings without needing technical skills. Overall, the functionality testing confirmed that every component of the system works cohesively together as a single pipeline, from the initial file upload to the final visual result screen. Testers successfully passed all functional scenarios, proving that the framework is a reliable, secure and highly understandable tool for detecting deepfakes in practical applications

5.0 CONCLUSION

DualXAI successfully proves that AI can accurately detect deepfakes while clearly explaining its decisions. It offers a reliable and private way to spot fake media. However, the system has a few limits. Its accuracy can drop in poor lighting, low resolutions, or if the face is covered or turned away. Checking long videos frame by frame also takes too much time and computer power. To fix this, future updates will focus on analysing whole videos faster and processing live streams and adding voice detection to catch fake audio and phone scams, making it a complete defence tool.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Faculty of Computer and Mathematical Sciences at Universiti Teknologi MARA (UiTM) Cawangan Melaka Kampus Jasin for providing the necessary resources and support to conduct this research.

REFERENCES

Aleem, M., Umair, M., Zubair, M., Ibrahim, R., Naseem, M. T., Raza, M. M., Ali, M. N., & Kim, B.-S. (2026). Seeing through the fake: Explainable AI with multiple CNNs for deepfake detection. IEEE Access. https://doi.org/10.1109/ACCESS.2025.3649128

Anand, R., Santhosh, L., Asha, K. N., Potdar, V., Kumar, R., Raj, R., & Sharma, S. (2024). Video authenticity detection using web-enabled techniques. International Journal for Research in Applied Science & Engineering Technology, 12(5), 5617–5623. https://doi.org/10.22214/ijraset.2024.62881

Awotunde, J. B., Jimoh, R. G., Imoize, A. L., Abdulrazaq, A. T., Li, C.-T., & Lee, C.-C. (2022). An enhanced deep learning-based DeepFake video detection and classification system. Electronics, 12(1), 87. https://doi.org/10.3390/electronics12010087

Chauhan, R., Sethi, M., & Ahuja, S. (2026). Controlled benchmarking of CNN architectures for fake face classification under standardized synthetic conditions. International Journal of Innovative Technology and Interdisciplinary Sciences, 9(1), 597–624. https://doi.org/10.15157/IJITIS.2026.9.1.597-624

Mallet, J., Pryor, L., Dave, R., & Vanamala, M. (2023). Deepfake detection analyzing hybrid dataset utilizing CNN and SVM. In 2023 7th International Conference on Intelligent Systems, Metaheuristics & Swarm Intelligence (ISMSI 2023) (pp. 1–5). Association for Computing Machinery. https://doi.org/10.1145/3596947.3596954

Patel, Y., Tanwar, S., Bhattacharya, P., Gupta, R., Alsuwian, T., Davidson, I. E., & Mazibuko, T. F. (2023). An improved dense CNN architecture for deepfake image detection. IEEE Access. https://doi.org/10.1109/ACCESS.2023.3251417

Sadiq, S., Ullah, S., Abuzinadah, N., Alharthi, R., Alabdullah, B., Umer, M., Alsubai, S., & Kryvinska, N. (2026). DEFT-Net: Explainable deepfake text detection for combating information disorder in the age of generative AI. International Journal of Computational Intelligence Systems, 19(86). https://doi.org/10.1007/s44196-026-01192-4.

Singh, A. V., & Shinde, A. V. (2026). Deep Guard AV: Audio-visual deepfake detection framework using hybrid audio learning, CNN-LSTM video analysis, and automated transcript logging. International Journal of Innovative Research in Engineering, 7(2), 493–499. https://doi.org/10.59256/ijire.20260702060

Sunil, R., Mer, P., Diwan, A., Mahadeva, R., & Sharma, A. (2025). Exploring autonomous methods for deepfake detection: A detailed survey on techniques and evaluation. Heliyon, 11(2), e42273. https://doi.org/10.1016/j.heliyon.2025.e42273

Thulasimani, K., & Pooja, J. (2026). Performance analysis of deepfake video detection using deep learning model. ICTACT Journal on Soft Computing, 17(1). https://doi.org/10.21917/ijsc.2026.0579

Triveni, V., Mogili, U., Vani, J., Revathi, K., Prakash, G. J., Kumar, C. K., & Chakri, P. (2026). A hybrid deep learning approach for deepfake image detection using CNN and MTCNN-based facial feature extraction. International Journal for Research in Applied Science and Engineering Technology, 14(3), 1874–1878. https://doi.org/10.22214/ijraset

Vamsi, V. V. V. N. S., Shet, S. S., Reddy, S. S. M., Rose, S. S., Shetty, S. R., Sathvika, S., Supriya, M. S., & Shankar, S. P. (2022). Deepfake detection in digital media forensics. Global Transitions Proceedings, 3, 74–79.

Waseem, S., Abu Bakar, S. A. R. S., Ahmed, B. A., Omar, Z., Eisa, T. A. E., & Dalam, M. E. E. (2023a). DeepFake on face and expression swap: A review. IEEE Access. https://doi.org/10.1109/ACCESS.2023.3324403

Waseem, S., Abu-Bakar, S. A. R., Omar, Z., Ahmed, B. A., & Baloch, S. (2023b). Boosting deepfake detection features with attention units. In Proceedings of the 5th World Symposium on Software Engineering (WSSE) (pp. 1–6). ACM. https://doi.org/10.1145/3631991.3632037

Zafar, F., Khan, T. A., Akbar, S., Ubaid, M. T., Javaid, S., & Kadir, K. A. (2025). A hybrid deep learning framework for deepfake detection using temporal and spatial features. https://doi.org/10.1109/ACCESS.2025.3566008

BUFFER TOOL KIT AND WIZER.ME DIGITAL APPLICATION FOR BUFFER SOLUTION LEARNING

Ummi Kalthum binti Mansor[1], Amal Hayati binti Jamali[2,], Asniati binti Sabil[3],

[1,3]Negeri Sembilan Matriculation College, Malaysia
[2]Kedah Matriculation College, Malaysia

[1] bm-0228@moe-dl.edu.my

ABSTRACT

In line with the Malaysian Ministry of Education's digital education reform, this project addresses students' difficulties in the Chapter 7: Ionic Equilibria within Chemistry course at Negeri Sembilan Matriculation College. Students frequently struggled to conceptualise abstract buffer mechanisms and identify buffer types, which hindered their ability to solve complex calculations. The primary objective of this project is to ensure that 100% of the targeted students can successfully identify acidic and basic buffers and clearly explain pH changes upon the addition of small amounts of strong acids or bases. To achieve this, the innovation employs the 5E Learning Model, integrating a physical Buffer Tool Kit with 'Wizer.me' digital worksheets. The physical kit offers a hands-on, puzzle-based learning experience for matching chemical equations and keywords, whilst the Wizer.me application addresses physical limitations by providing immediate digital feedback and interactive assessment formats. Implemented over a period of six months with a target group of 25 students, this hybrid approach yielded highly significant educational improvements. Mean test scores surged from 11.9 in the initial Pre-test to 24.7 in the final Post-test, with all students achieving an excellent mastery level. Furthermore, student satisfaction increased to a highly positive mean score of 4.83 out of 5.00, showing a strong preference for using both learning tools together. The Buffer Tool Kit also secured official MyIPO copyright (LY2025M02918) and garnered formal validation from a university subject matter expert. In conclusion, combining physical manipulatives with modern interactive digital platforms effectively bridges the educational gap between macroscopic and submicroscopic chemistry concepts. This practical innovation significantly enhances both student engagement and conceptual understanding in learning buffer solutions.

Keywords: buffer solution, digital education, chemistry, 5E model, Wizer.me

1.0 INTRODUCTION

Digital education reform is essential to prepare a generation that is ready to face 21st-century challenges and compete globally. The Ministry of Education Malaysia highlights the empowerment of a quality digital education ecosystem and the integration of technology in teaching and learning in its Strategic Plan 2024-2030. To keep up with these changes, chemistry lecturers at Kolej Matrikulasi Negeri Sembilan (KMNS) collaborated to improve their digital skills, aiming to make lessons more interactive and effective.

This innovation stems from a problem identified during lessons on Buffer Solutions in Chapter 7: Ionic Equilibria for the Chemistry 1 SK015 course in Matriculation. Students frequently struggled to solve calculation questions because they failed to master basic concepts. They had difficulty identifying buffer solutions and explaining the mechanism of how buffers maintain pH values using relevant chemical equations. To truly understand these abstract concepts, students need to integrate macroscopic, submicroscopic and symbolic domains. Therefore, this innovation combines a physical Buffer Tool Kit with the Wizer.me digital application to improve students' foundational understanding before they move on to complex calculations.

2.0 OBJECTIVE

The primary objectives of this educational innovation are to ensure that:

41. 100% of students can successfully identify whether a mixture is an acidic buffer or a basic buffer.
42. 100% of students can clearly explain the changes in the pH of a buffer solution when a small amount of strong acid is added.
43. 100% of students can clearly explain the changes in the pH of a buffer solution when a small amount of strong base is added.

3.0 METHODOLOGY

Past studies by Nurfauzia et al. (2021) and Iswan Setiadi et al. (2017) have reported that the discovery method is suitable and effective for enhancing learning in the topic of buffer solutions. Consequently, a lesson plan for buffer solutions was developed based on the 5E Instructional Model (Bybee et al., 2006), which encompasses five structured phases of exploration: Engage, Explore, Explain, Elaborate, and Evaluate (Figure 1).

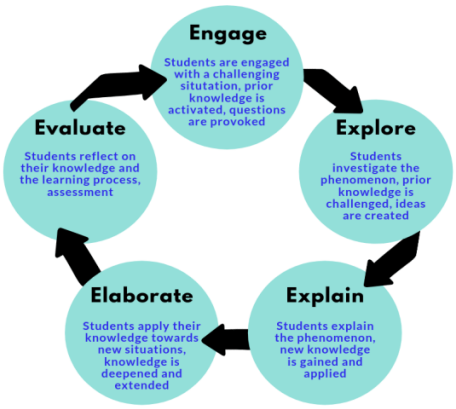


Figure 1: The 5E Learning Cycle

The innovation was tested over a period of 6 months on a target group of 25 students (8 males and 17 females) from the Practicum H2T1 Life Sciences Stream, 2024/2025 session. The lesson plan was designed based on the 5E Learning Model, which consists of five phases: Engage, Explore, Explain, Elaborate and Evaluate.

The methodology was carried out in two main cycles; Cycle 1 (Physical Innovation) and Cycle 2 (Digital Integration).

3.1 PHYSICAL INNOVATION

Two short videos were introduced to show the macroscopic view (a pH meter reading) and a submicroscopic animation of chemical reactions. Following this, the physical "Buffer Tool Kit" was used. This kit is an interactive cardboard tool featuring matching and fill-in-the-blank questions, where answers are provided as small coloured pieces containing arrows, chemical formulas and keywords (Figure 2).

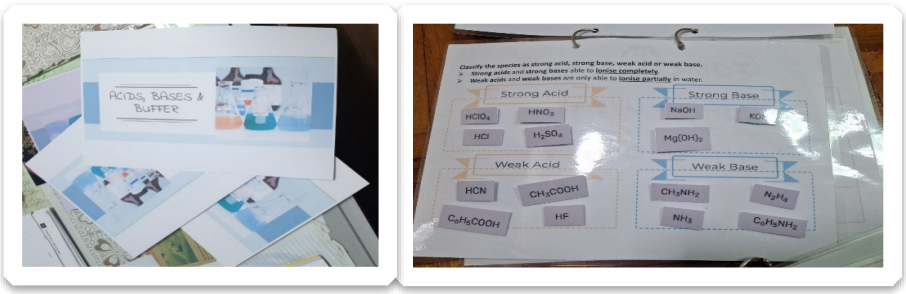


Figure 2: Buffer Tool Kit innovation

3.2 DIGITAL INTEGRATION

To address limitations in the physical kit such as the lack of immediate feedback and difficult assessment, the digital application Wizer.me was introduced. Wizer.me allowed lecturers to create interactive digital worksheets with open-ended, multiple-choice, matching and image-based questions. It provided immediate feedback to students and supplied lecturers with data on student scores and completion times. Three digital worksheets were created to support the Explore, Elaborate and Evaluate phases (Figure 3).

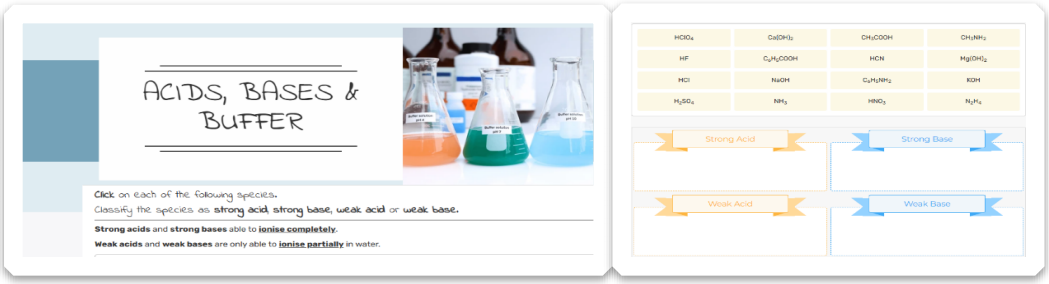


Figure 3: Wizer.me digital worksheet

4.0 RESULT

The implementation of the physical and digital innovations showed a significant improvement in student performance and engagement.

4.1 TEST SCORE IMPROVEMENTS

Before the innovation, students took a Pre-test and their understanding was re-evaluated using Post-tests after the interventions. The results of the analysis show a significant increase in students' achievement, with the mean mark increasing from 11.9 in the pre-test to 24.7 in the post-test (Table 1).

Table 1: Students' Mean Score in the Pre-test and Post-test

No.	Skills Assessed	Full Score	Mean Score	
			Pre-test	Post-test
1.	Identifying an acidic buffer solution or a basic buffer solution.	12	7.5	10.6
2.	Explaining the change in pH of a buffer solution when a small amount of a strong acid is added.	8	3.1	7.3
3.	Explaining the change in pH of a buffer solution when a small amount of a strong base is added.	8	1.4	6.8
	Overall	**28**	**11.9**	**24.7**

4.2 STUDENTS' FEEDBACK QUESTIONNAIRE

A questionnaire containing five items based on a 5-point Likert scale (1–5) and one open-ended question was used to gather student feedback. The findings from the questionnaire indicated that the students gave highly positive feedback regarding the effectiveness of the teaching and learning implementation (Table 2).

Table 2: Analysis of Feedback on the Effectiveness of Teaching and Learning

No.	Questionnaire Items	Mean Score
1.	The activities throughout this tutorial class were suitable for achieving the learning objectives.	4.88
2.	The activities implemented helped to improve my knowledge and understanding of buffer solutions & buffer actions.	4.80
3.	The activities implemented helped to improve my skills in writing equations related to buffer solutions & buffer actions.	4.76
4.	The activities carried out were interactive and enjoyable.	4.80
5.	The Buffer Tool Kit succeeded in engaging my interest in learning about buffer solutions & buffer actions.	4.88
6.	This learning method should be continued for other chemistry topics.	4.84
	Overall	**4.83**

When asked about their preferences, 56.0% of students favoured the digital Wizer.me worksheets for their convenience and speed while 44.0% preferred the physical Buffer Tool Kit because it was highly interactive and creative. This proves that both tools have unique strengths and should be used together (Table 3).

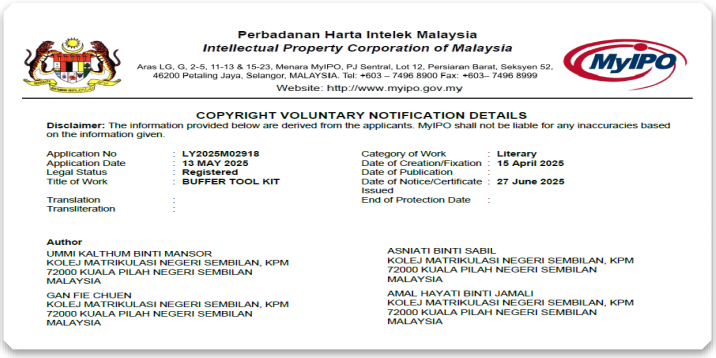
Table 3: Students' Feedback Regarding Highly Preferred Learning Materials

Wizer.me digital worksheets	Physical Buffer Tool Kit
25. More convenient, faster and save time **26.** All options can be seen easily **27.** Easy to access at anytime and anywhere **28.** Can still do group work and easier to do the work given **29.** I don't have to follow other people's pace when doing task independently **30.** Good for independent learning	**31.** More interactive **32.** More creative **33.** Fun and easy to understand **34.** Being allowed to discuss helped me understand buffers better.

5.0 CONCLUSION

The Buffer Tool Kit was successfully registered for copyright with the Intellectual Property Corporation of Malaysia (MyIPO) under the registration number LY2025M02918 (Figure 4). Furthermore, it received formal recognition from a senior lecturer at UiTM Cawangan Negeri Sembilan, who validated it as a highly suitable teaching aid for both secondary and tertiary education levels (Figure 5).

Figure 4: Copyright for the Buffer Toolkit with the Intellectual Property Corporation of Malaysia



Perbadanan Harta Intelek Malaysia
Intellectual Property Corporation of Malaysia

Aras LG, G, 2-5, 11-13 & 15-23, Menara MyIPO, PJ Sentral, Lot 12, Persiaran Barat, Seksyen 52, 46200 Petaling Jaya, Selangor, MALAYSIA. Tel: +603 – 7496 8900 Fax: +603– 7496 8999
Website: http://www.myipo.gov.my

COPYRIGHT VOLUNTARY NOTIFICATION DETAILS

Disclaimer: The information provided below are derived from the applicants. MyIPO shall not be liable for any inaccuracies based on the information given.

Application No	: **LY2025M02918**	Category of Work	: **Literary**
Application Date	: **13 MAY 2025**	Date of Creation/Fixation	: **15 April 2025**
Legal Status	: **Registered**	Date of Publication	:
Title of Work	: **BUFFER TOOL KIT**	Date of Notice/Certificate Issued	: **27 June 2025**
Translation	:	End of Protection Date	:
Transliteration	:		

Author

UMMI KALTHUM BINTI MANSOR
KOLEJ MATRIKULASI NEGERI SEMBILAN, KPM
72000 KUALA PILAH NEGERI SEMBILAN
MALAYSIA

GAN FIE CHUEN
KOLEJ MATRIKULASI NEGERI SEMBILAN, KPM
72000 KUALA PILAH NEGERI SEMBILAN
MALAYSIA

ASNIATI BINTI SABIL
KOLEJ MATRIKULASI NEGERI SEMBILAN, KPM
72000 KUALA PILAH NEGERI SEMBILAN
MALAYSIA

AMAL HAYATI BINTI JAMALI
KOLEJ MATRIKULASI NEGERI SEMBILAN, KPM
72000 KUALA PILAH NEGERI SEMBILAN
MALAYSIA

Figure 5: Letter of Recognition from the Senior Lecturer of the School of Chemistry & Environmental Studies (PPKAS), UiTM Negeri Sembilan Branch

The 5E Model-based approach, which emphasises the macroscopic, submicroscopic and symbolic domains through the integration of digital applications with the Buffer Tool Kit, is effective in improving students' mastery of the fundamental concepts of buffer solutions. This approach benefits students of various intelligences and learning styles. The Wizer.me digital worksheets enable self-paced learning and make the learning process more flexible, interactive and engaging. Meanwhile, collaborative learning through physical teaching and learning materials such as the Buffer Tool Kit, also successfully fosters teamwork and enhances interpersonal communication skills among students. Overall, the approach used

in this innovation is well-suited to the digital learning ecosystem and aligns with the 4C elements (communication, collaboration, critical thinking and creativity) of 21st-century learning. To ensure high-quality teaching and learning that remains relevant to current developments, the research team will extend this approach to other topics in the future.

ACKNOWLEDGEMENT

Great appreciation is extended to the research and innovation team from the Chemistry Unit of Kolej Matrikulasi Negeri Sembilan (KMNS): Gan Fie Chuen, Ummi Kalthum binti Mansor, Asniati binti Sabil and Amal Hayati binti Jamali. Special thanks are also given to the subject matter expert, ChM Dr Suhaidi bin Ariffin from UiTM Cawangan Negeri Sembilan, for evaluating and recognising the quality of this educational tool. Finally, we acknowledge all the lecturers and students who participated in sharing sessions and provided valuable feedback to make this project a success.

REFERENCES

Bybee, R. W., Taylor, J. A., Gardner, A., & Van, P. (2006). The BSCS 5E Instructional Model: Origins and Effectiveness. https://www.researchgate.net/publication/242363914_The_BSCS_5E_Instructional_Model_Origins_Effectiveness_and_Applications (Accessed on August 19, 2025)

Kementerian Pendidikan Malaysia (2024). *Pelan Strategik Kementerian Pendidikan Malaysia 2024 – 2030*.https://www.moe.gov.my/storage/files/shares/Bahagian%20dan%20Unit/Bahagian%20Perancangan%20Strategik%20Dan%20Hubungan%20Antarabangsa/Pelan%20Strategik%20KPM%202024-2030.pdf

Nurfauzia, N., Ijirana, I., & Suherman, S. (2021). Application of discovery learning model to improve the understanding concept of high school students on buffer topic. Jurnal Akademika Kimia, 10(1), 26–31. https://doi.org/10.22487/j24775185.2021.v10.i1.pp26-31

Setiadi, I., & Irhasyuarna, Y. (2017). Improvement of Model Student Learning Through The Content of Solutions Guided Discovery Buffer. IOSR Journal of Research & Method in Education (IOSRJRME), 07(01), 01–09. https://doi.org/10.9790/7388-0701050109

TRANSFORMING SELECTION IN INNOVATION CONFERENCES THROUGH FUZZY LOGIC INTERACTIVE AND GUI TOOLS

Wan Munirah Wan Mohamad[1,*], Nurhazirah Mohamad Yunos[1], Nur Syamilah Arifin[1], Nor Kamariah Kasmin @ Bajuri[1], Nur Idayu Alimon[1]

[1]Universiti Teknologi MARA (UITM) Cawangan Johor, Kampus Pasir Gudang, Jalan Purnama, Bandar Seri Alam, 81750 Masai, Johor.

[*]Corresponding author: wanmunirah@uitm.edu.my

ABSTRACT

This study introduces a fuzzy logic-based evaluation framework integrated with an interactive Graphical User Interface (GUI) to transform the winner selection process at innovation conferences. To address the subjectivity and rigid constraints of traditional assessment methods, the proposed model evaluates submissions across three core dimensions: Content, Presentation, and Innovation. Leveraging MATLAB's Fuzzy Logic Designer (FLD), the system defines fundamental membership functions and establishes a robust fuzzy rule base. A Mamdani fuzzy inference system is subsequently deployed to automate and generate precise award classifications. To ensure technical reliability, the system's outputs are rigorously validated through a comparative analysis between manual mathematical calculations and the digital system models. Additionally, an intuitive GUI is developed to streamline the evaluation process, allowing judges to input data efficiently, analyse multi-criteria metrics, and make data-driven decisions in real time. Ultimately, this research demonstrates how fuzzy logic systems can significantly enhance the fairness, accuracy, and flexibility of competitive evaluations, thereby improving decision-making rationality and elevating the operational integrity of innovation conference systems.

Keywords: fuzzy logic approach, Mamdani inference system, graphical user interface, innovation conferences, decision support system

1.0 INTRODUCTION

Innovation conferences play a pivotal role in driving technological advancement and societal progress by fostering groundbreaking ideas across various disciplines. By encouraging participants—particularly students—to think creatively and explore uncharted possibilities, these platforms cultivate a culture of continuous development. However, evaluating submissions in today's highly competitive environment presents a significant challenge, as judges must navigate an immense volume of competing concepts. To reliably identify the most practical and effective projects, a robust and nuanced evaluation framework is required. The Fuzzy Logic Approach (FLA) offers a compelling solution to this challenge by addressing the limitations of traditional, rigid assessment methods.

Unlike conventional binary logic, which relies on strict true-or-false parameters, FLA accommodates ambiguity and uncertainty by incorporating "degrees of truth" (Eghbal Ahmadi et al., 2020). This analytical flexibility makes FLA exceptionally well-suited for handling imprecise data, especially in scenarios where definitive, black-and-white conclusions are difficult to establish. When applied to the winner selection process at innovation conferences, an FLA framework enables a more flexible, comprehensive, and detailed evaluation of multi-layered submissions.

By analysing complex data through a multi-factor lens, this system ensures that innovations with the highest potential for real-world impact are effectively highlighted (Awasthi et al., 2016). Furthermore, integrating fuzzy logic significantly enhances the fairness and accuracy of the judging process by replacing rigid metrics with flexible, adaptable criteria (Praharaj et al., 2022). Ultimately, this study aims to transform the quality of selection frameworks within innovation conferences, thereby optimising the overall performance and integrity of competition systems. Through this exploration, the research demonstrates the clear efficacy of fuzzy logic as an advanced decision-making support tool capable of elevating selection quality in high-stakes competitive environments.

8.0 OBJECTIVE

To enhance the transparency, accuracy, and overall quality of decision-making in innovation competitions, this study outlines the following specific objectives:

44. To design and develop a fuzzy logic-based framework aimed at optimizing the efficiency, fairness, and overall quality of the winner selection process at innovation conferences.
45. To systematically apply the Mamdani fuzzy inference system to evaluate, rank, and support decision-making for multi-faceted innovation project submissions.
46. To integrate the fuzzy logic algorithms into an interactive Graphical User Interface (GUI), empowering evaluators to make comprehensive, data-driven decisions by seamlessly blending qualitative and quantitative assessment criteria.

3.0 METHODOLOGY

Figure 1 shows the flowchart of the proposed approach, which shows the phases in which the domains have been processed, data refining, applying the fuzzy rules, and finally obtaining the results. In this model of the FLA, this study tries to figure out which is the best award for the winner of the innovation conferences. The marks obtained by evaluation are divided according to field and then implemented in MATLAB fuzzy toolbox. Therefore, an evaluation can be made, and the award can be obtained.

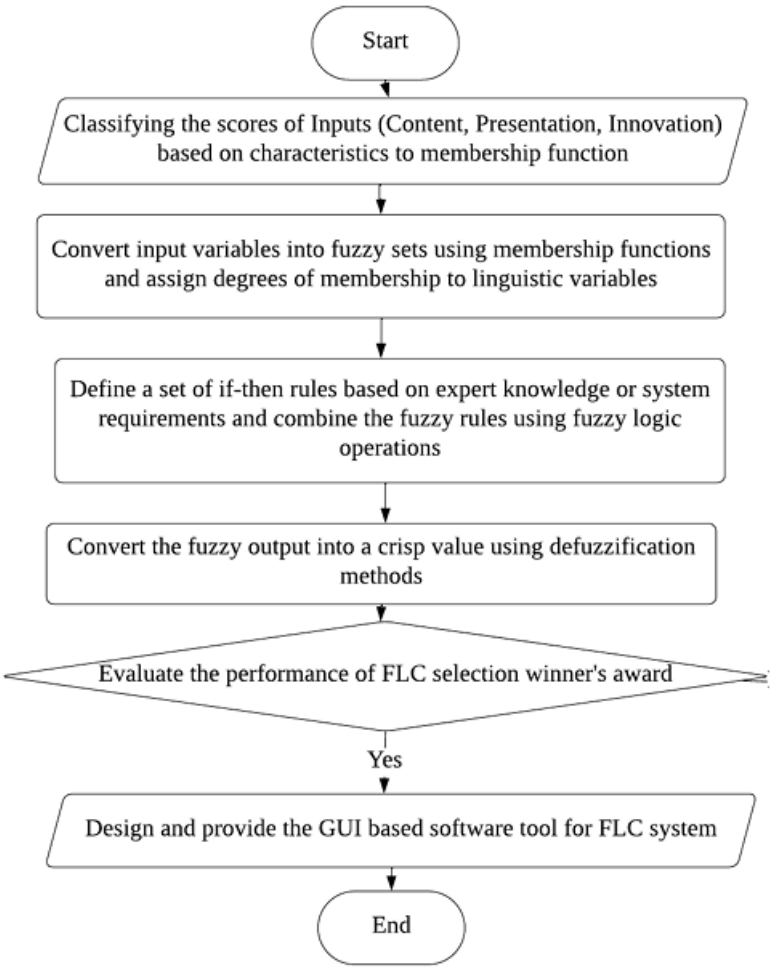


Figure 1: Flow Chart of Research Study

3.1 FUZZY SYSTEM

The fuzzy system concept is used in this study. Software called MATLAB is used to apply this concept to reality. Fuzzifier, defuzzifier, fuzzy inference engine, and fuzzy rule based are the four primary

components of a fuzzy system, which are knowledge-based or rule based. Figure 2 below illustrates a fuzzy system's process.

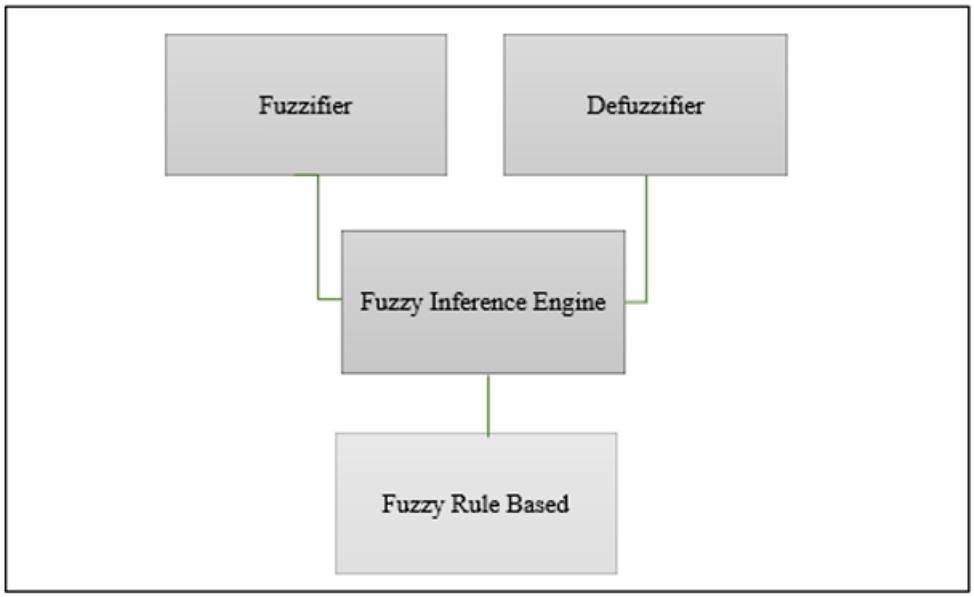


Figure 2: Flow Chart of Fuzzy Logic Approach

3.2 GUI DESIGN

For the GUI design and layout, these interfaces can be developed using tools in MATLAB such as `App Designer`, where components can be placed through custom script-based GUI development using `guide` as shown in Figure 3. These tools also offer and provide flexibility in designing it and allow for customised experiences that align with the specific project requirements, such as evaluating innovations at conferences.

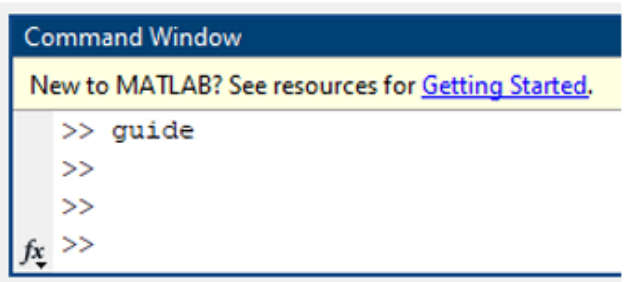


Figure 3: Command to open GUI

The Evaluate Button in a FLD GUI serves as a critical component and visualises the performance of the FIS that has been built. It initiates the fuzzy inference process, applying the input variables, membership functions, and rules defined to generate an output based on the current setup. This button provides immediate feedback on how the system works with various inputs, making it an essential tool for understanding and validating the fuzzy model. The Evaluate Button's command is in charge of executing an input, processing the system, and displaying the output based on the FIS. When the Evaluate Button is clicked, the command typically initiates a function call that gathers all necessary parameters from the GUI.

```
Editor - C:\GUI.m*
GUI.m*
175     % --- Executes on button press in evaluate1.
176     function evaluate1_Callback(hObject, eventdata, handles)
177     % hObject    handle to evaluate1 (see GCBO)
178     % eventdata  reserved - to be defined in a future version of MATLAB
179     % handles    structure with handles and user data (see GUIDATA)
180
181 -   paperId = get(handles.paperID, 'String');
182 -   participantName = get(handles.participantName, 'String');
183 -   idea = str2double(get(handles.idea1, 'String'));
184 -   presentation = str2double(get(handles.presentation1, 'String'));
185 -   innovation = str2double(get(handles.innovation1, 'String'));
186
187 -   if isempty(paperId) || isempty(participantName) || isnan(idea) || isnan(presentation) || isnan(innovation)
188 -           msgbox('Please fill in all fields with valid data.', 'Error', 'error');
189 -           return;
190 -   end
191
192 -   fis = readfis('Innovation Conferences');
193
194 -   result = evalfis([idea presentation innovation], fis);
195
196 -   set(handles.result,'String',result);
197
198 -   if result < 30{
199 -           msgbox('Congratulation! Bronze Award');
200 -           }
201 -   elseif result >= 30 && result <= 70{
202 -           msgbox('Congratulation! Silver Award');
203 -           }
204 -   else {msgbox('Congratulation! Gold Award');
205 -           }
206 -   end
207
```

Figure 4: Command Evaluate button

4.0 RESULT

Figure 5 presents the first stage of GUI developed in MATLAB for the evaluation and selection of winners in innovation conferences. The evaluators are able to input data systematically, as there are clear sections on the interface. The first form in GUI for the project evaluation is ensured by the user or the evaluator. Before evaluation, basic information like the participant's name and project ID to be evaluated should be put in. This section assists the evaluator in determining the projects and explicating the project data. It is also important to keep the project for reference and to organise the working process in a structured manner. Below these fields, the Evaluation section provides multiple evaluation criteria in categories of content, presentation, and innovation. Every criterion is associated with a numerical input box 58 so that the evaluator can rate the corresponding performance or characteristic of the project. These scores are important ingredients of the overall performance since they give the judgement of the evaluator on each aspect of the innovation.

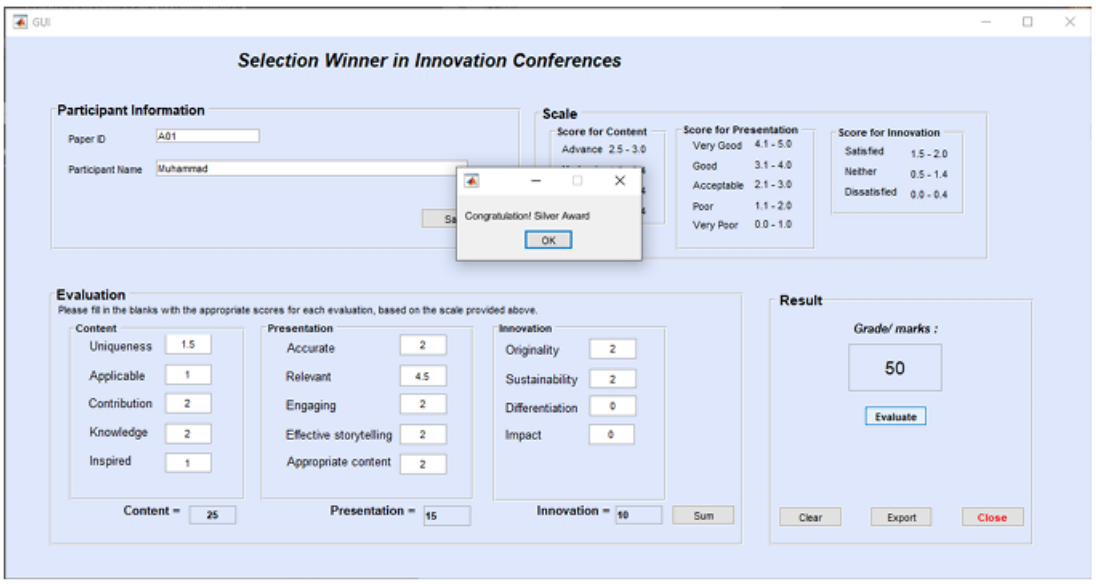


Figure 5: Evaluate Button

5.0 CONCLUSION

In conclusion, this study successfully constructed a fuzzy logic-based framework to enhance the selection process at innovation conferences. By employing Mamdani fuzzy logic, this study can demonstrate its efficacy in evaluating whether they receive a Gold, Silver, or Bronze Award based on their innovation performance and the criteria for awarding the winner. These fuzzy logic mechanisms can help to evaluate various fields by using different parameters, classified into linguistic variables, to define the range of the membership function. The GUI makes the evaluation system easier and more user-friendly for innovation conferences. It also reduces complicated procedures that are easier to the judges and the evaluators while using the system. Further, the GUI makes it possible for users too. The users can introduce inputs and immediately notice their effects online and perform assessments expeditiously. By explaining how the system is going to function by pointing at the illustration, GUI prevented favouritism and equal chances in decision-making. It also assists in making the evaluation process less complicated and has made it a handy tool in dealing with highly complex assessment tasks. In conclusion, the FLC and GUI are components of the system that assist in bridging the gap between technology and its practical application. Hence, it shows significant usefulness in enhancing the evaluations of innovation events and similar conferences.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to **Universiti Teknologi MARA (UiTM)** for providing the necessary facilities and financial support for our participation in this innovation project.

REFERENCES

Aazagreyir, P., Damnyag, J. B. K., & Kuuboore, M. 2019. Brilliant but Needy Students Selection Using Fuzzy Logic. In International Journal of Computer Engineering and Information Technology, SSRN Electronic Journal, 11(8): 178–185. https://doi.org/10.2139/ssrn.3433179

Ahmadi, M. H. E., Royaee, S. J., Tayyebi, S., & Boozarjomehry, R. B. 2020. A new insight into implementing Mamdani fuzzy inference system for dynamic process modeling: Application on flash separator fuzzy dynamic modeling. Engineering Applications of Artificial Intelligence, 90: Article 103485. https://doi.org/10.1016/j.engappai.2020.103485

Al-Nahhas, Y. S., Hadidi, L. A., Islam, M. S., Skitmore, M., & Abunada, Z. 2023. Modified Mamdani-Fuzzy influence system for predicting the cost overrun of construction projects. Applied Soft Computing, 151: Article 111152. https://doi.org/10.1016/j.asoc.2023.

Ali, M., Yudono, S., Faris, R. M., De Wibowo, A., Sidik, M., Sembiring, F., & Aji, S. F. 2022. Fuzzy Decision Support System for ABC University Student Admission Selection, 207: 144–149.

Agarwal, G., Gupta, S., & Agrawal, A. 2019. Evaluation of Student Performance for Future Perspective in terms of Higher Studies using Fuzzy logic Approach. International Journal of Computer Applications, 181(50): 9–14. https://doi.org/10.5120/ijca2019918640

AGROSENSE+: AN IoT-BASED SMART IRRIGATION SYSTEM FOR SUSTAINABLE COMMUNITY GARDENS

Siti Khadijah Alias[1], Muhammad Amir Mat Shah[1, *], Nor Fazlin Uteh[1], Syidatul Akma Sulaiman[1], Nurulnatisya Ahmad[1]

[1]Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Jalan Purnama, 81750 Masai Johor.

[*]Corresponding author: amir8776@uitm.edu.my

ABSTRACT

Urban community gardens play a crucial role in enhancing food security, protecting the environment and fostering community relationships. However, these gardens rely on volunteers and are not generally watered on a regular routine. This results in water loss, costly maintenance, and low crop yield. To resolve such problems, this paper introduces AgroSense+, a low-cost IoT enabled smart irrigation system to automate the irrigation process by monitoring the environmental conditions in real-time. The system is based on an ESP32 microcontroller and uses a number of sensors to continuously measure soil moisture, soil temperature, rainfall, humidity and water tank levels. Once the ideal moisture level is reached, the irrigation system will be turned on and off, if the soil moisture level is below a certain level. A cloud based dashboard allows users to remotely monitor field conditions and water levels, including quick updates and alarms on their mobile devices. The technology has been implemented and tested in a Community Garden in Taman Mawar, Pasir Gudang. AgroSense+ has been successfully field-tested for monitoring environmental changes, controlling irrigation based on the actual needs of the soil and providing reliable remote updates. This technology replaces the traditional manual watering techniques with automatic accuracy, avoids watering when it is not required, uses resources more efficiently and eliminates the need of hands-on labour greatly. Most notably, the system produced visibly more healthy plants, including nicely yielding eggplants, which created a surplus of high quality produce that allowed the volunteers to share the harvest with the surrounding neighbourhood. At the end of the day, AgroSense+ is a cost-effective and scalable system that simplifies crop management and promotes sustainable water practices. It is highly adaptable to schools, universities and small-scale urban farms and contributes directly to the Sustainable Development Goals (SDGs) for responsible water management and sustainable food production.

Keywords: internet of things (IoT), irrigation system, community agriculture

1.0 INTRODUCTION

Rapid urbanisation and increasing climate uncertainties have driven up the demand for sustainable food production and efficient water resource management. Community gardens have emerged as an important means of improving food security, promoting environmental awareness and encouraging community participation. Community gardens are not only sources of fresh vegetables but also promote social contact and contribute to sustainable urban development.

Despite these benefits, one of the greatest challenges is to maintain an efficient irrigation schedule, especially in volunteer-managed community gardens. Manual watering relies primarily on the availability of volunteers which results in uneven watering frequencies, overconsumption of water, fluctuating soil moisture and extra maintenance effort. These problems are damaging to the growth of crops, decrease the yield and increase the costs of operation.

The Internet of Things (IoT) has experienced recent innovations that have revolutionised agriculture with the implementation of automated sensing, wireless communication, and intelligent control systems. IoT-based smart irrigation systems allow for real-time monitoring of environmental variables and autonomous water distribution according to crop needs, enhancing irrigation precision and reducing labour and water usage (Kour & Arora, 2020; Kamienski et al., 2019). Furthermore, integrating these systems with advanced data analytics and intelligent control algorithms significantly optimises water resources in precision agriculture (Kashyap et al., 2021).

IoT irrigation systems have been developed by several researchers using Arduino, Raspberry Pi and ESP32 platforms integrated with soil moisture sensors, ambient sensors and cloud monitoring platforms (Jawad et al., 2017; Padiachy et al., 2025). The systems have shown great progress in the areas of irrigation efficiency and remote monitoring (Ayaz et al., 2019; Villa-Henriksen et al., 2020). Cloud computing also allows farmers and users to check agricultural conditions using smartphones, which helps to make decisions faster and reduces unnecessary site visits. (Khanna & Kaur, 2018). Furthermore, recent advancements have shown that coupling these intelligent automation systems with localised crop protocols directly supports rural development and sustainable resource management (Padiachy et al., 2025).

Many smart irrigation systems are reported, but most of them are geared for commercial agriculture and require rather expensive hardware, stable internet infrastructure or professional skills. Only a few studies have addressed economical and easy-to-operate technologies specifically developed for community gardens run by volunteers. This is an essential research need, as volunteer-based gardens are sometimes constrained by personnel and financial resources.

AgroSense+ was created to fill this gap as a low-cost Internet of Things (IoT)-based smart irrigation system for the Taman Mawar Community Garden in Pasir Gudang, Johor, Malaysia. The system consists of an ESP32 microcontroller, several environmental sensors and a cloud monitoring platform that enables automated watering via real-time soil and environmental data. The system monitors the soil moisture, soil temperature, rainfall, humidity and water level and activates the irrigation only when necessary, eliminating wasteful water consumption and consequently increasing the water-use efficiency. In addition, AgroSense+ allows for remote monitoring and real-time notification using mobile devices, allowing volunteers to effectively monitor the irrigation operations with minimum manpower. The suggested innovation will offer an easy-to-use and economical smart irrigation solution to reduce human work, improve crop management and advance sustainable community agriculture

2.0 OBJECTIVE

This study aims to develop AgroSense+, an IoT-based smart irrigation system for improving irrigation efficiency and sustainable water management in community gardens.

The specific objectives are:

47. Develop an IoT-based smart irrigation system
48. Automate irrigation using real-time environmental data and remote monitoring.
49. Reduce water wastage and manual labour.
50. Promote sustainable agriculture.

3.0 METHODOLOGY

3.1 SYSTEM DEVELOPMENT

AgroSense+ was developed for the Taman Mawar Community Garden, Pasir Gudang, Johor to automate irrigation using real-time environmental monitoring. The system integrates multiple sensors, an ESP32 microcontroller, cloud computing, and a mobile application to provide intelligent irrigation management.

3.2 SYSTEM ARCHITECTURE

Figure 1 illustrates the overall architecture of AgroSense+, which consists of six major components, which are sensor layer, ESP32 controller, decision engine, automatic water pump, cloud dashboard and mobile monitoring.



Figure 1: AgroSense+ system architecture

The ESP32 microcontroller was integrated with a variety of different environmental sensors to generate the AgroSense+. Environmental data is collected continually through the sensors that measure environmental elements, including soil temperature, soil moisture, rainfall, humidity, and water level. The incoming sensor data is processed by the ESP32 and the soil moisture readings are compared with the threshold value set.

3.2 SYSTEM OPERATION AND KEY FEATURES

AgroSense+ collects real-time environmental data constantly from soil moisture, soil temperature, humidity, rainfall and water level sensors. The data from the sensor is processed by the ESP32 microcontroller, which compares the level of moisture in the soil with a predefined threshold to decide if irrigation is necessary. If the moisture level is below the threshold, the controller activates the relay module and the water pump automatically. The irrigation is continued till the target soil moisture level is attained and then the pump is switched off. The sensor data and irrigation logs are sent wirelessly to a cloud platform over Wi-Fi. The users can monitor the system operation remotely and get notifications in real time through a mobile app.

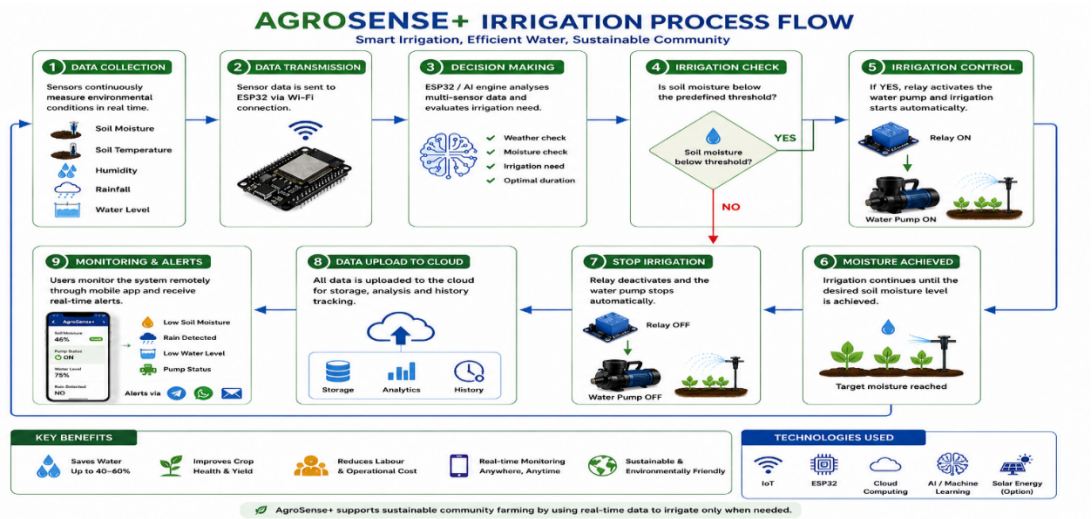


Figure 2: AgroSense+ irrigation process flow

The irrigation process flow is summarised in Figure 2. The system implements the ESP32 microcontroller, environmental sensors, a relay-operated water pump, cloud computing and mobile monitoring to provide a cost-efficient and intelligent irrigation solution. Automated irrigation, real-time monitoring, cloud data storage and instant alerting to smartphones reduce human work, water loss and improve irrigation efficiency. These features make AgroSense+ perfect for use in community gardens, schools, universities

and a wide range of small-scale urban agricultural projects, while also supporting sustainable agriculture and smart water management.

4.0 RESULT

Figures 3 and 4 show the development and installation of the AgroSense+ smart irrigation system in the Taman Mawar Community Garden, Pasir Gudang, Johor. Figure 3 shows the initial stage of the project before the installation of the smart irrigation system, while Figure 4 presents the complete prototype supporting healthy vegetable cultivation through automated irrigation and real-time environmental monitoring.

AgroSense+ integrates various environmental sensors, ESP32 microcontroller, cloud connectivity and mobile monitoring in one smart irrigation system. The prototype continually analyses soil moisture, soil temperature, humidity, rainfall, and water level before determining irrigation requirements. When the soil moisture is below a pre-defined level, the ESP32 turns the water pump on automatically and turns it off when the desired moisture is obtained. The use of multi-sensor data to drive these automated watering functions acts as a highly effective decision support system, preventing over-irrigation and protecting crop health (Navarro-Hellín et al., 2016). Similar results have been reported by Kour and Arora (2020), who found that an IoT-based irrigation system considerably improves water-use efficiency and enables intelligent decision-making through real-time environmental monitoring. Similarly, Villa-Henriksen et al. (2020) underlined that the integration of cloud-based monitoring with automated irrigation improves operational efficiency and lowers the demand for labour in agricultural applications.



Figure 3: Initial stage of the project



Figure 4: Complete prototype with healthy plants.

Current IoT-based irrigation systems are mainly targeted at commercial agriculture, but AgroSense+ has been developed for a volunteer-run community garden, making it a cost-effective and affordable solution for small-scale urban agriculture. Volunteers can remotely monitor irrigation status, environmental

conditions and water tank levels and receive real-time notifications using the online dashboard and mobile application. This feature supports efficient water management and less reliance on manual irrigation, in line with the results of Ayaz et al. (2019) that IoT technologies contribute to agricultural sustainability by automating and remotely monitoring. Successful deployment demonstrates AgroSense+'s potential to improve irrigation efficiency, prevent water waste, save manual labour and support sustainable community agriculture.

5.0 CONCLUSION

AgroSense+ was developed to show the feasibility of deploying an Internet of Things (IoT)-based smart irrigation system in Taman Mawar Community Garden in Pasir Gudang, Johor. Efficient irrigation management is possible using environmental sensors, ESP32 automation, cloud monitoring and smartphone notifications. Additionally, the system improves crop growth and saves water and manual labour. The successful deployment in Taman Mawar community garden proves that AgroSense+ is capable of improving sustainable community agriculture through advanced irrigation management. This method can be developed to be used in a broader environment such as community gardens, schools, urban farming projects and other small-scale farming projects.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Majlis Perbandaran Pasir Gudang (MPPG) for their financial support towards AgroSense+ project. Appreciation is extended to the Taman Mawar Community Garden Committee, Pasir Gudang, for their cooperation and for providing the project site. Special thanks to Zawfiq Enterprise for building the greenhouse infrastructure, roofing system and planting racks. The authors would also like to thank the Faculty of Mechanical Engineering (FKM), Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang for the design, development and installation of the IoT-based AgroSense+ smart irrigation system. The collaboration has been successful in supporting sustainable community agriculture with smart irrigation technologies.

REFERENCES

Ayaz, M., Ammad-Uddin, M., Sharif, Z., Mansour, A., & Aggoune, E. H. M. (2019). Internet-of-Things (IoT)-based smart agriculture: Toward making the fields talk. *IEEE Access, 7*, 129551–129583. https://doi.org/10.1109.

Barkunan, S. R., Bhanumathi, V., & Sethuram, J. (2019). Smart sensor for automatic drip irrigation system for paddy cultivation. Computers and Electrical Engineering, 73, 180-193. https://doi.org/10.1016/j.compeleceng.2018.11.013

Jawad, H. M., Nordin, R., Gharghan, S. K., Jawad, A. M., & Ismail, M. (2017). Energy-efficient wireless sensor networks for precision agriculture: A review. *Sensors, 17*(8), 1781. https://doi.org/10.3390

Khanna, A., & Kaur, S. (2019). Evolution of Internet of Things (IoT) and its significant impact in the field of precision agriculture. *Computers and Electronics in Agriculture, 157*, 218–231. https://doi.org/10.101.

Kour, V. P., & Arora, S. (2020). Recent developments of the Internet of Things in agriculture: A survey. *IEEE Access, 8*, 129924–129957. https://doi.org/10.1109.

Kamienski, C., Soininen, J. P., Taumberger, M., Dantas, R., Toscano, A., Salmon Cinotti, T., ... & Torre Neto, A. (2019). Smart water management platform: IoT-based precision irrigation for agriculture. Sensors, 19(2), 276. https://doi.org/10.3390/s19020276

Kashyap, P. K., Kumar, S., Jaiswal, A., Rajput, M., & Macon, A. (2021). Towards precision agriculture: IoT-enabled smart irrigation systems using machine learning. IEEE Sensors Journal, 21(16), 17479-17491. https://doi.org/10.1109/JSEN.2021.3069266

Navarro-Hellín, H., Martinez-del-Amor, P. A., Dominguez, J. R., & Rubio, J. (2016). A decision support system for managing irrigation in agriculture. Computers and Electronics in Agriculture, 124, 121-131. https://doi.org/10.1016/j.compag.2016.04.003

Padiachy, V., Prakasan, M., Prasad, K. A., Kumar, E., Nand, A., Kumar, P., & Chand, A. A. (2025). IoT based Smart Irrigation System for Sustainable Agriculture. Proceedings of the International Conference on Smart Innovations in Electrical Engineering (ICSIEE 2025), 179-193. https://doi.org/10.2991/978-94-6463-870-7_16

Villa-Henriksen, A., Edwards, G. T. C., Pesonen, L. A., Green, O., & Sørensen, C. A. G. (2020). Internet of Things in arable farming: Implementation, applications, challenges and potential. *Biosystems Engineering, 191*, 60–84. https://doi.org/10.1016.

IoT-NMD: AN IoT-BASED NUTRIENT MANAGEMENT AND DISPENSING SYSTEM FOR COMMUNITY AGRICULTURE

Mohd Noor Halmy Ab Latif[1,*], Muhammad Amir Mat Shah[1,], Afiq Othman[1], Firdaus Sukarman[1], Hazriel Faizal Pahroraji[1]

[1]Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Jalan Purnama, 81750 Masai Johor.

[*] Corresponding author: halmy@uitm.edu.my

ABSTRACT

Community-driven farming plays a vital role in strengthening local food security, promoting sustainable agricultural practices and encouraging shared resource management. However, collectively managed farms often struggle with varying levels of agricultural expertise, inconsistent volunteer scheduling and a lack of centralised accountability, which lead to uneven crop care and inefficient use of resources. To address these challenges, this paper presents IoT-NMD, an Internet of Things (IoT)-enabled nutrient management and dispensing system designed to automate fertilizer mixing for community agriculture. The system uses a multi-tank architecture consisting of dedicated nutrient concentrate tanks, a water source and a centralised mixing tank, together with automated pumps, solenoid valves and flow sensors that dispense precise nutrient ratios based on pre-programmed crop recipes. Within the mixing tank, integrated pH, electrical conductivity (EC) and liquid level sensors continuously verify the chemical balance of the solution before it is distributed. An IoT microcontroller transmits real-time sensor readings and system status to a shared cloud-based dashboard, allowing community members to remotely monitor tank levels, track fertilizer consumption and receive automated alerts through a mobile or web application. The system has been implemented and field-tested at the Taman Mawar Community Garden in Pasir Gudang, Johor. Field implementation showed that IoT-NMD reliably automated nutrient dosing and produced more consistent fertilizer solution quality compared to manual mixing practices, while reducing nutrient wastage and easing the workload of volunteers. IoT-NMD is a practical, low-cost and scalable solution that standardises nutrient preparation, improves transparency, and strengthens equitable resource management in community-driven precision farming.

Keywords: internet of things (IoT), nutrient management, fertilizer dispensing system, community agriculture, precision farming

1.0 INTRODUCTION

Rapid growth in community-based farming initiatives has highlighted the importance of shared resource management, food security and sustainable agricultural practices at the neighbourhood level. Community gardens are typically maintained by volunteers with different backgrounds and levels of technical or agricultural experience, and this often leads to inconsistencies in day-to-day operations.

One of the most persistent challenges in collectively managed farms is the preparation and dispensing of fertilizer solutions [1], [2]. Manual mixing depends heavily on the knowledge and availability of individual volunteers, resulting in inconsistent nutrient ratios, nutrient wastage, uneven crop care and a lack of centralised accountability over shared resources. These issues can directly affect plant health, yield and the overall sustainability of the garden [3], [4].

The Internet of Things (IoT) offers a practical way to standardise agricultural processes that would otherwise depend on manual judgement [5], [6]. By combining automated actuators, real-time sensing and cloud connectivity, IoT systems can enforce consistent operating procedures, provide a single source of data transparency, and allow distributed members to monitor and manage shared equipment remotely without requiring constant physical oversight.

Despite growing interest in smart agriculture, most automated nutrient dosing and fertigation systems are designed for large-scale commercial operations and require costly hardware, dedicated infrastructure or specialised expertise. Few solutions specifically target small, volunteer-run community farms where affordability, ease of use and shared accountability are essential.

To address this gap, this paper presents the design and implementation of IoT-NMD, an automated, IoT-enabled fertilizer mixing and dispensing machine developed for the Taman Mawar Community Garden in Pasir Gudang, Johor, Malaysia. The system automatically dispenses nutrient concentrates and water into a centralised mixing tank according to pre-programmed crop recipes, continuously verifies pH, electrical conductivity (EC) and liquid level, and reports system status to a shared cloud dashboard. By eliminating the guesswork involved in manual fertilizer mixing, IoT-NMD aims to reduce human error, prevent nutrient wastage, and support equitable and efficient resource management in community-driven precision farming.

2.0 OBJECTIVE

This study aims to develop IoT-NMD, an IoT-based nutrient management and dispensing system for improving fertilizer preparation accuracy and resource efficiency in community gardens.

The specific objectives are:

51. Develop an IoT-based automated nutrient mixing and dispensing system.
52. Automate fertilizer dosing using pre-programmed crop recipes and real-time sensor feedback.
53. Reduce nutrient wastage and manual mixing errors.
54. Promote transparent and equitable resource management in community agriculture.

3.0 METHODOLOGY

3.1 SYSTEM DEVELOPMENT

IoT-NMD was developed for the Taman Mawar Community Garden, Pasir Gudang, Johor to automate the preparation and dispensing of fertilizer solutions using real-time sensor feedback. The system integrates a multi-tank architecture, automated pumps and solenoid valves, water quality sensors, an IoT microcontroller, cloud computing and a mobile application to provide standardised nutrient management [7].

3.2 SYSTEM ARCHITECTURE

Figure 1 illustrates the overall architecture of IoT-NMD, which consists of six major components: the control panel with IoT controller, nutrient storage tanks, the centralised mixing tank with sensors, automated pumps and solenoid valves, a cloud dashboard and mobile monitoring.

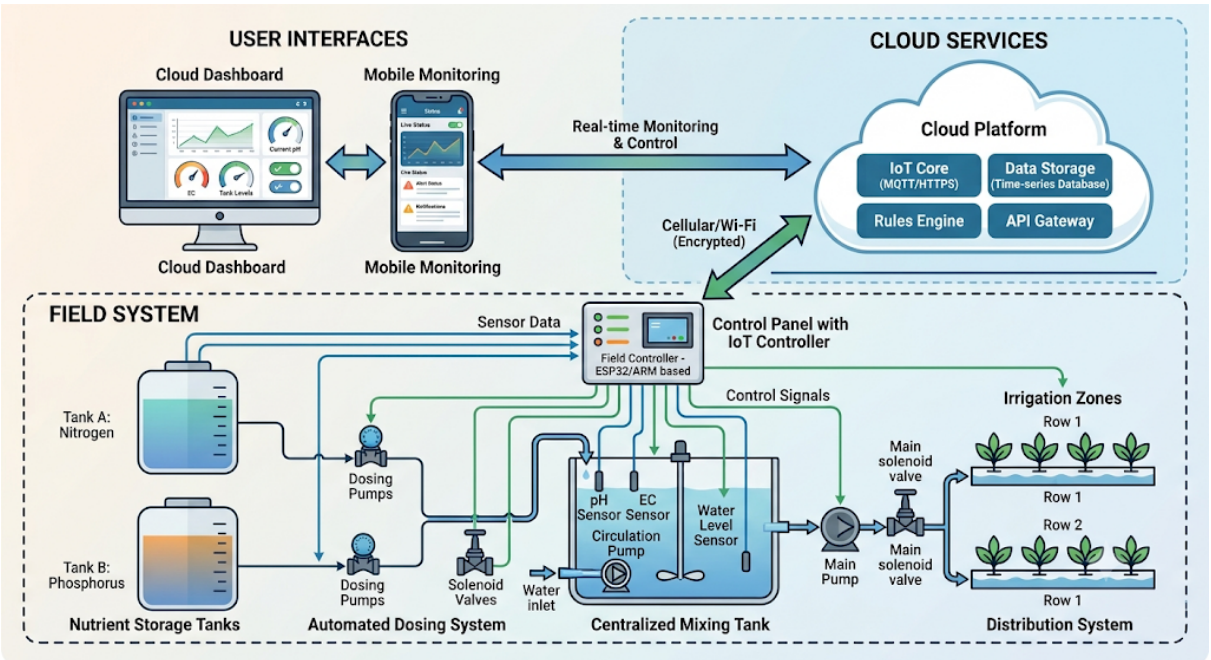


Figure 1: IoT-NMD system architecture

The IoT controller is connected to solenoid valves, pumps and flow sensors on each nutrient storage tank, as well as pH, electrical conductivity (EC) and liquid level sensors within the centralised mixing tank.

Based on a selected crop recipe, the controller opens the corresponding solenoid valves and activates pumps to dispense specific ratios of nutrient concentrate and water into the mixing tank.

3.3 SYSTEM OPERATION AND KEY FEATURES

IoT-NMD continuously monitors nutrient flow volume, pH, electrical conductivity and liquid level throughout the mixing process. Once the dispensing sequence for a selected crop recipe is completed, the mixing tank sensors verify that the resulting solution meets the target pH and EC range before it is released for distribution. If the readings fall outside the target range, the controller can trigger additional dosing or an alert for manual review. Sensor readings, dispensing logs and system status are transmitted wirelessly to a cloud platform, where community members can view tank levels, track fertiliser consumption and receive real-time alerts through a mobile or web application.

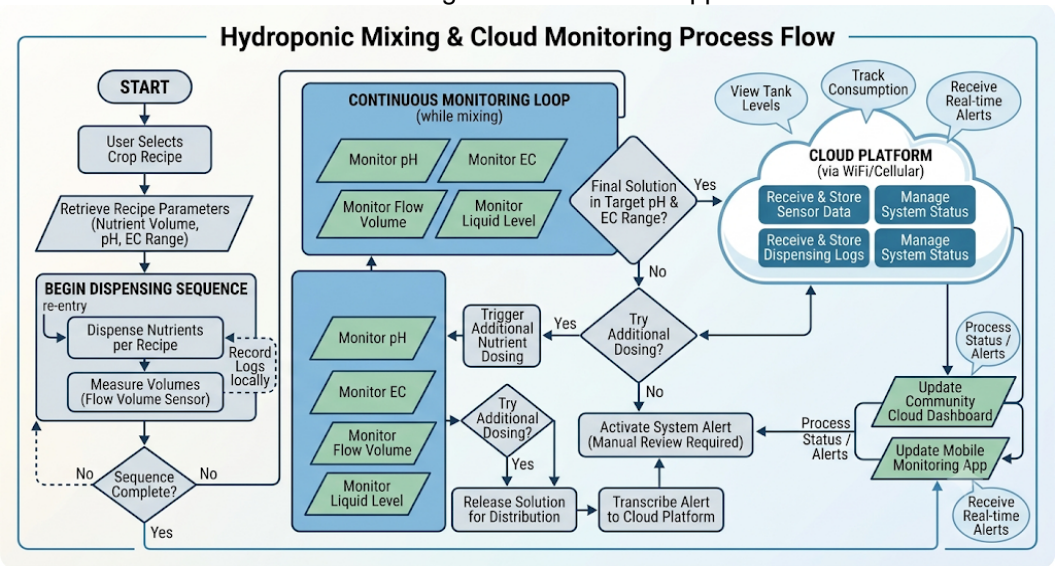


Figure 2: IoT-NMD nutrient mixing and dispensing process flow

The overall process flow is summarised in Figure 2. By combining recipe-based automation, sensor feedback, automated pumps and solenoids, cloud reporting and mobile monitoring, IoT-NMD reduces the dependency on individual volunteer expertise, minimises nutrient wastage, and provides a transparent, shared record of fertilizer usage across the community garden.

4.0 RESULT

IoT-NMD was implemented and field-tested at the Taman Mawar Community Garden in Pasir Gudang, Johor as in Figure 3. The prototype automatically dispensed nutrient concentrates and water into the mixing tank according to pre-programmed crop recipes and continuously verified pH, electrical conductivity and liquid level before the resulting fertilizer solution was distributed to the garden.



Figure 3: IoT-NMD System

Field implementation showed that IoT-NMD could reliably automate nutrient dosing and maintain a more consistent fertilizer solution quality compared to manual mixing practices. Reported benefits include reduced human error in fertilizer preparation, lower nutrient wastage, more consistent nutrient concentration delivery [8], improved operational efficiency for volunteers [9], and better transparency through shared remote monitoring of tank levels and fertilizer consumption [10].

Unlike many existing automated dosing systems that are designed for large-scale commercial operations, IoT-NMD is developed specifically for a volunteer-run community garden, making it an affordable and practical option for small-scale urban agriculture. Community members can remotely check tank levels, fertilizer usage and system status and receive automated alerts through the cloud dashboard and mobile application, reducing the need for constant physical supervision. Successful deployment demonstrates the potential of IoT-NMD to standardise fertilizer preparation, minimise resource wastage, and support equitable, sustainable community agriculture.

5.0 CONCLUSION

IoT-NMD was developed to demonstrate the feasibility of deploying an IoT-enabled fertilizer mixing and dispensing system in the Taman Mawar Community Garden, Pasir Gudang, Johor. By combining a multi-tank architecture, automated pumps and solenoids, pH and EC sensing, cloud connectivity and mobile monitoring, the system standardises nutrient preparation and reduces the human error associated with manual mixing. The successful deployment at Taman Mawar Community Garden shows that IoT-NMD can improve resource efficiency and strengthen shared accountability in community-driven agriculture. This approach can be extended to other volunteer-run community gardens, schools, and small-scale urban farming projects seeking a more consistent and transparent way to manage fertilizer preparation.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Taman Mawar Community Garden Committee, Pasir Gudang, for their cooperation and for providing the project site. The authors would also like to thank the Faculty of Mechanical Engineering (FKM), Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang, for the design, development and installation of the IoT-NMD nutrient management and dispensing system. The collaboration has been valuable in supporting sustainable community agriculture through IoT-based innovation.

REFERENCES/RUJUKAN

B. C. Preethi, G. Sugitha, and T. B. Sivakumar, “Optimized Fertilizer Dispensing for Sustainable Agriculture Through Secured IoT-Blockchain Framework IoT-Blockchain Framework for Sustainable Agriculture,” 2024. [Online]. Available: www.ijacsa.thesai.org

Z. Ren *et al.*, “Improving Wheat Yield, Fertilizer Use Efficiency, and Economic Benefits Through Farmer-Participation Nutrient Management,” *Sustainability (Switzerland)*, vol. 17, no. 8, Apr. 2025, doi: 10.3390/su17083481.

A. Ali, G. Niu, J. Masabni, A. Ferrante, and G. Cocetta, “Integrated Nutrient Management of Fruits, Vegetables, and Crops through the Use of Biostimulants, Soilless Cultivation, and Traditional and Modern Approaches-A Mini Review,” *Agriculture 2024*, vol. 14, p. 1330, 2024, doi: 10.3390/agriculture.

P. C. H. van de Vlasakker, K. Tonderski, and G. S. Metson, “A Review of Nutrient Losses to Waters From Soil- and Ground-Based Urban Agriculture—More Nutrient Balances Than Measurements,” Mar. 25, 2022, *Frontiers Media S.A.* doi: 10.3389/fsufs.2022.842930.

E. Roccatello, A. Pagano, N. Levorato, and M. Rumor, “State of the Art in Internet of Things Standards and Protocols for Precision Agriculture with an Approach to Semantic Interoperability,” Jun. 01, 2025, *Multidisciplinary Digital Publishing Institute (MDPI)*. doi: 10.3390/network5020014.

M. Dhanaraju, P. Chenniappan, K. Ramalingam, S. Pazhanivelan, and R. Kaliaperumal, “Smart Farming: Internet of Things (IoT)-Based Sustainable Agriculture,” Oct. 01, 2022, *MDPI*. doi: 10.3390/agriculture12101745.

“IoT_Innovations_in_Sustainable_Water_and_Wastewater_Management_and_Water_Quality_Monitoring_A_Comprehensive_Review_of_Advancements_Implications_and_Future_Directions”.

X. Chen, H. Zhang, and C. U. I. Wong, “Dynamic Monitoring and Precision Fertilization Decision System for Agricultural Soil Nutrients Using UAV Remote Sensing and GIS,” *Agriculture (Switzerland)*, vol. 15, no. 15, Aug. 2025, doi: 10.3390/agriculture15151627.

Dr. D. R. P. Rajarathnam, S. V. Thamaraiselvan, S. Srikanth, S. Poovitha, and R. .Karthick, “Smart Fertilizer Dispensing Robot Using Nutrient Map Data Fusion,” *INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT*, vol. 10, no. 04, pp. 1–9, Apr. 2026, doi: 10.55041/ijsrem59129.

M. N. Reza *et al.*, “Trends of Soil and Solution Nutrient Sensing for Open Field and Hydroponic Cultivation in Facilitated Smart Agriculture,” Jan. 01, 2025, *Multidisciplinary Digital Publishing Institute (MDPI)*. doi: 10.3390/s25020453.

AN INTERACTIVE TEACHING TOOL FOR BOUNDARY LAYER FLOW OF DUSTY CASSON FLUID

Nur Syamilah Arifin[1, *], Syazwani Mohd Zokri[2], Wan Munirah Wan Mohamad[3], Nurhazirah Mohamad Yunos[4], Nor Kamariah Kasmin@Bajuri[5]

[1,3,4,5]Faculty of Computer & Mathematical Sciences, Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus, 81750 Masai, Johor, Malaysia
[2]Faculty of Computer & Mathematical Sciences, Universiti Teknologi MARA (UiTM) Kuala Terengganu Branch, Kuala Terengganu Campus, 21080 Kuala Terengganu, Malaysia

[*]nursyamilaharifin@uitm.edu.my

ABSTRACT

Computational Fluid Dynamics (CFD) involves complex mathematical modelling and numerical techniques that often present learning challenges for students. This study presents a free web-based interactive teaching tool developed to facilitate the understanding of two-phase boundary layer flow through mathematical modelling, numerical computation, and graphical visualization. The teaching tool is based on a two-phase model describing the boundary layer flow of a binary mixture of Casson fluid and suspended dust particles over a stretching sheet with Newtonian heating boundary conditions. The governing equations are solved numerically using the Runge–Kutta–Fehlberg (RKF45) method in MAPLE, and the complete research procedure, numerical results, and physical interpretations are presented through an interactive website. The platform integrates theoretical concepts, mathematical formulation, numerical algorithms, simulation results, and self-learning activities into a user-friendly interface accessible via computers, tablets, and smartphones. By transforming a complex CFD model into an interactive digital learning platform, the proposed innovation bridges the gap between mathematical theory and computational implementation. The website provides a cost-effective educational resource for lecturers, researchers, and students while supporting independent learning without requiring laboratory experiments or commercial software.

Keywords: computational fluid dynamics, web-based learning, two-phase flow, numerical method, mathematical modeling, boundary layer flow

1.0 INTRODUCTION

Boundary layer flow is one of the fundamental phenomena in fluid mechanics and plays a significant role in numerous engineering applications, including aerospace, mechanical, chemical, and biomedical engineering. Fluid mechanics deals with the study of fluid behaviour in both motion and stationary states (Tu et al., 2018), where the governing flow phenomena are commonly described by a system of partial differential equations (PDEs). Owing to the highly nonlinear nature of these equations, analytical solutions are often difficult or impossible to obtain, particularly for complex boundary layer flow problems involving momentum and heat transfer. Consequently, Computational Fluid Dynamics (CFD) has become an indispensable tool that combines mathematical modelling with numerical methods to simulate fluid behaviour by using computer-based simulations. CFD enables the prediction of velocity and temperature distributions within the boundary layer, thereby supporting the analysis and design of engineering systems. This approach is employed to analyse various engineering applications, including blood flow, aerodynamics, mixing processes, and polymer processing (Versteeg and Malalasekera, 2007). Compared with experimental investigations, CFD offers a more economical and practical alternative by reducing research costs, shortening development time, and eliminating the risks associated with laboratory experiments involving hazardous materials or operating conditions.

Most theoretical studies in fluid dynamics have focused on single-phase flow, where the flow and heat transfer characteristics of Newtonian and non-Newtonian fluids are analysed using numerical methods such as the Keller–Box method, finite difference method, and Runge–Kutta–Fehlberg method (Kumari et al., 1997; Hsiao, 2010; Kasim et al., 2013; Mohamed et al., 2015; Al-Sharifi et al., 2017). However, many real-world applications involve suspended solid particles, resulting in two-phase flow. Examples include

combustion systems, fluidized beds, environmental pollutant transport, and petroleum engineering (Siddiqa et al., 2017). Unlike conventional single-phase models, two-phase flow models account for the interaction between the carrier fluid and dispersed particles, providing a more realistic representation of practical fluid flow phenomena. Among the various non-Newtonian models, the Casson fluid is widely used to describe yield-stress materials such as blood, chocolate, printing ink, and certain polymer suspensions (Lund et al., 2020; Raza, 2019). In this study, a two-phase dusty Casson fluid model, comprising a Casson fluid and suspended dust particles, is adopted to provide a more realistic representation of particulate flow encountered in engineering and biomedical applications. The governing equations are transformed into ordinary differential equations using similarity transformations and solved numerically in MAPLE using the Runge–Kutta–Fehlberg (RKF45) method. The numerical solutions enable the investigation of the effects of various physical parameters on the velocity and temperature distributions of both the fluid and particle phases.

Although CFD has become an essential component of engineering and applied mathematics education, students often find it difficult to relate complex mathematical formulations to their physical interpretations and numerical results. Existing educational resources mainly emphasise theoretical concepts and provide limited opportunities for interactive learning, particularly for two-phase flow problems. To address this challenge, this study develops a free web-based interactive teaching tool that integrates theoretical concepts, mathematical modelling, numerical solution procedures, graphical visualization, and physical interpretation into a single learning platform. The website also documents the complete research workflow, allowing users to explore the mathematical formulation, numerical methodology, simulation results, and parameter effects in a structured and interactive manner. Accessible through computers, tablets, and smartphones, the platform provides a safe, economical, and engaging learning environment for lecturers, researchers, and students.

2.0 OBJECTIVE

The objectives of this study are:

55. To develop a free web-based interactive teaching tool for learning two-phase boundary layer flow involving a dusty Casson fluid.
56. To integrate theoretical concepts, mathematical modelling, numerical solution procedures, and graphical visualization into a single interactive learning platform.
57. To provide an accessible website and cost-effective learning platform for lecturers, researchers, and students through an interactive simulation environment.

3.0 METHODOLOGY

The development of the proposed teaching tool consists of two main stages: research development and web-based learning platform development.

3.1 Research Development

A two-phase mathematical model describing the boundary layer flow of a binary mixture of Casson fluid and suspended dust particles over a stretching sheet with Newtonian heating is formulated. The governing partial differential equations are transformed into ordinary differential equations using similarity transformations and solved numerically using the Runge–Kutta–Fehlberg (RKF45) method in MAPLE. Next, the verification of the present study is performed by comparing with previous published results. The numerical solutions are then analysed to investigate the influence of selected physical parameters on the velocity and temperature distributions of both the fluid and particle phases. Figure 1 shows the research flow of the dusty Casson fluid flow.

3.2 Web-Based Teaching Tool Development

The complete research procedure is organised into a free web-based learning platform. The website contains modules covering theoretical background, mathematical formulation, numerical methodology, simulation results, graphical visualization, physical interpretation, and self-learning activities. Interactive navigation enables users to explore each stage of the research process, compare simulation results, and understand the influence of different physical parameters. The platform is designed to be responsive and accessible through computers, tablets, and smartphones without requiring software installation or programming knowledge. It is designed with colourful graphics and images of applications to attract students to read the content. Figures 2–4 illustrate the different sections of the website, which is accessible to all users.

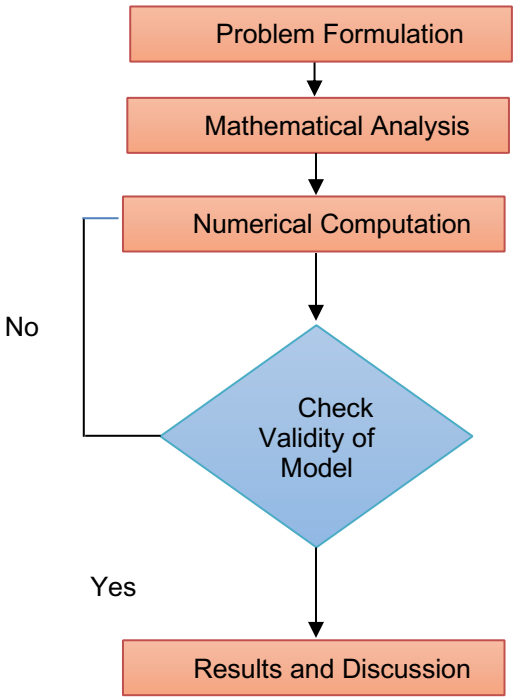


Figure 1: Research Flow

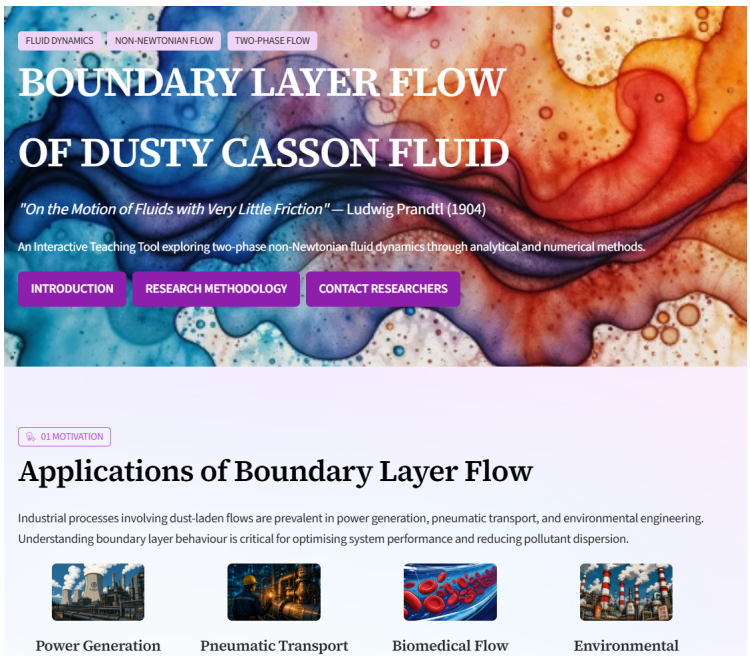


Figure 2: Homepage layout of the website.

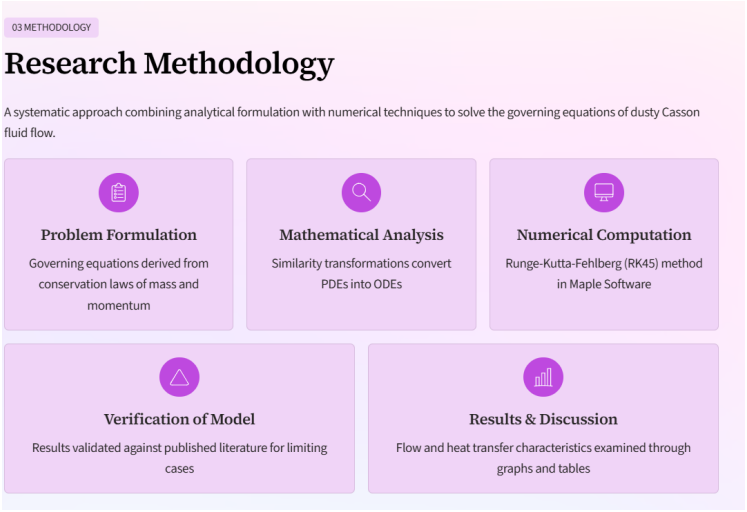


Figure 3: Website Interface (Research Methodology Page).

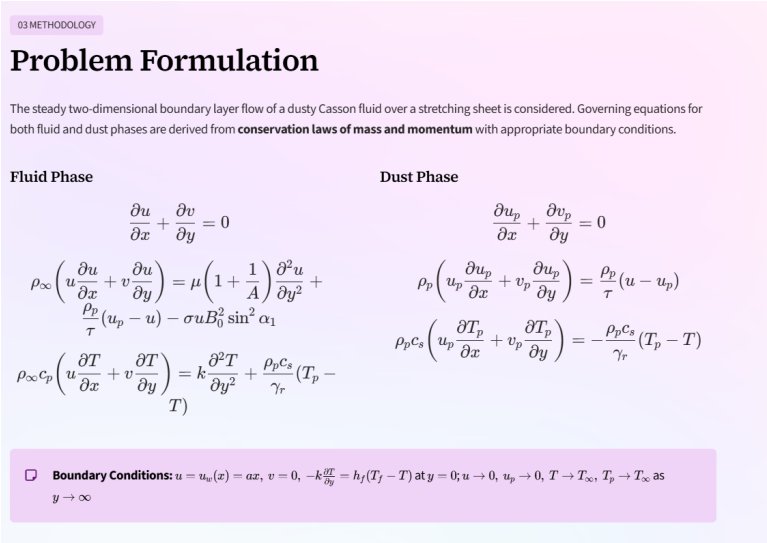


Figure 4: Website Interface (Research Methodology Page).

4.0 RESULT

The proposed innovation is a novel and comprehensive educational platform that uniquely integrates mathematical modelling, numerical methods, and interactive visualization of two-phase dusty non-Newtonian boundary layer flow into a single user-friendly system, addressing a significant gap in existing CFD educational tools. Unlike conventional learning resources that primarily focus on single-phase flow and theoretical derivations, this platform enables users to interactively modify physical parameters, observe real-time simulation results, and understand both the mathematical formulation and physical behaviour of complex fluid flow phenomena. By replacing costly and time-consuming laboratory experiments with efficient numerical simulations, the platform provides a safe, economical, and accessible learning environment while supporting self-directed learning, collaborative research, and practical engineering applications. Its compatibility across multiple devices, potential for web-based and standalone deployment, and applicability in engineering, applied mathematics, and computational science education further strengthen its innovation potential, commercial value, and long-term impact on teaching, research, and professional training.

5.0 CONCLUSION

The interactive teaching tool effectively bridges the gap between theoretical fluid mechanics and computational implementation by transforming a complex two-phase CFD model into an engaging learning platform. It offers a practical, low-cost educational resource that supports teaching and learning in Computational Fluid Dynamics, applied mathematics, and engineering courses. The tool has strong

potential to improve students' conceptual understanding, computational skills, and visualization of complex fluid flow phenomena.

ACKNOWLEDGEMENT

All the authors would like to express their gratitude to Universiti Teknologi MARA (UiTM) Johor Branch Pasir Gudang Campus for the support/facilities.

REFERENCES/RUJUKAN

Al-Sharifi, H. A. M., Kasim, A. R. M, Salleh, M. Z. and Shafie, S. (2017b). Effect of aligned magnetohydrodynamics on convective boundary layer flow of Jeffrey micropolar fluid with Newtonian heating across a stretching sheet. In AIP Conference Proceedings, volume 1830, pages 020049. AIP Publishing

Hsiao, K.-L. (2010). Heat and mass mixed convection for MHD visco-elastic fluid past a stretching sheet with ohmic dissipation. Communications in Nonlinear Science and Numerical Simulation, 15(7):1803-1812.

Kasim, A. R. M., Mohammad, N. F., Shafie, S. and Pop, I. (2013c). Constant heat flux solution for mixed convection boundary layer viscoelastic fluid. Heat and Mass Transfer, 49(2):163-171

Kumari, M., Pop, I. and Takhar, H. (1997). Free-convection boundary-layer flow of a non-Newtonian fluid along a vertical wavy surface. International Journal of Heat and Fluid Flow, 18(6):625-631

Lund, L. A., Omar, Z., Khan, I., Sherif, E. S. M., & Abdo, H. S. (2020). Stability analysis of the magnetized Casson nanofluid propagating through an exponentially shrinking/stretching plate: Dual solutions. Symmetry, 12(7), 1162.

Mohamed, M. K. A., Salleh, M. Z., Ishak, A. and Pop, I. (2015). Stagnation point flow and heat transfer over a stretching/shrinking sheet in a viscoelastic fluid with convective boundary condition and partial slip velocity. The European Physical Journal Plus, 130(8):171

Raza, J. (2019). Thermal radiation and slip effects on magnetohydrodynamic (MHD) stagnation point flow of Casson fluid over a convective stretching sheet. Propulsion and Power Research, 8(2), 138–146

Siddiqa, S., Begum, N. and Hossain, M. (2017a). Dynamic of two-phase dusty nanofluid flow past a vertical wavy surface. Technische Universität Dortmund, Fakultät für Mathematik, 1-16

Tu, J., Yeoh, G. H. and Liu, C. (2018). Computational fluid dynamics: a practical approach. Butterworth-Heinemann. Oxford.

Versteeg, H. K. and Malalasekera, W. (2007). An introduction to computational fluid dynamics: The finite volume method. Pearson Education. London.

INCLUSIVE JOB CONNECT (IJC): AN AI-ENABLED MOBILE APP FOR DISABILITY-INCLUSIVE EMPLOYMENT IN THE ACCOMMODATION SECTOR

N Alia Fahada W Ab Rahman[1,*], Kalsitinoor Set[1], Siti Hajar Najihah Marzuki[1]

[1] Faculty of Business, Economic and Social Department, Universiti Malaysia Terengganu, Terengganu, Malaysia

[*] Corresponding author: n.alia@umt.edu.my

ABSTRACT

In Malaysia, individuals with disabilities (PWDs) remain limited in employment participation within the accommodation sector, partly because existing recruitment platforms rarely address disability-inclusive employment requirements, workplace accommodations, and accessibility needs. To address this issue, Inclusive Job Connect (IJC) was developed to promote disability-inclusive employment. IJC is an AI-integrated mobile app that connects PWDs, employers, training providers, non-governmental organisations (NGOs), and government agencies on a single platform. The development of IJC aims to facilitate disability-inclusive recruitment, expand employment opportunities for PWDs, and strengthen collaboration among key stakeholders through a single accessible digital platform. Through qualitative research on the employment experiences of PWDs in the accommodation sector, IJC was developed to ensure the app's design addresses users' workplace challenges and expectations. Features such as an AI job-matching system, a training hub, and a support hub were incorporated in the mobile app. IJC functioned beyond recruitment, as this single app enables users to access comprehensive employment services, including skills development resources, stakeholder networking, advocacy communities, and information on government support. The novelty of IJC lies in its holistic and disability-centred approach. IJC combines AI-assisted personalised job recommendations with accessibility considerations and multi-stakeholder collaboration to support sustainable employment outcomes, which is completely different from conventional job portals that primarily match candidates based on their qualifications and experience. By reducing recruitment barriers, improving workforce readiness, facilitating inclusive hiring practices and strengthening collaboration among multi-stakeholders, this integrated approach benefits both job seekers and employers. IJC contributes to advancing Sustainable Development Goals (SDGs) 8 (Decent Work and Economic Growth) and 10 (Reduced Inequalities) by promoting equitable access to employment and supporting disability-inclusive workforce participation. The innovation offers a practical, scalable, and evidence-based digital solution to foster a more inclusive and sustainable accommodation industry.

Keywords: disability employment, persons with disabilities, accommodation sector, inclusive, employment app

1.0 INTRODUCTION

Employment remains one of the greatest challenges faced by persons with disabilities (PWDs) despite various initiatives aimed at promoting workplace inclusion such as 1% quota policy of PWDs job vacancies, job coach service program, and disability equality training (DET) (Jamil & Saidin, 2018). However, existing recruitment systems are often not designed to accommodate the diverse needs of PWDs. Many PWDs continue to encounter barriers such as limited access to equal job opportunities (Binyanya et al., 2025) and a lack of channels that facilitate the recruitment of PWDs (Tah et al., 2024), especially within the accommodation sector. Simultaneously, PWDs frequently struggle to identify and access jobs that are suitable for their abilities and conditions (Moore et al., 2017). To address these issues, this innovation proposes "Inclusive Job Connect", a mobile app that integrates job matching, training, and support within a single digital platform. The innovation was developed based on the data obtained through interview sessions with PWDs who work in the accommodation sector.

2.0 OBJECTIVE

The objective(s) of the innovation are:

58. To develop an accessible and AI-powered employment platform that supports disability-inclusive recruitment in the accommodation sector.
59. To facilitate disability-inclusive recruitment and hiring by connecting PWDs, employers, NGOs, and government agencies through an integrated digital platform.

60. To enhance employment opportunities and support sustainable labour market participation among PWDs in the accommodation sector.

3.0 METHODOLOGY

Prior to the development of Inclusive Job Connect (IJC), a qualitative study was conducted to explore the employment experiences and challenges faced by persons with disabilities (PWDs) in the hotel sector. Semi-structured interviews were carried out with PWD employees, and the data were analysed using thematic analysis. The findings revealed key employment barriers related to recruitment accessibility, workplace support systems, career development opportunities, and organisational inclusion practices. These insights informed the design and development of IJC as a user-centred, disability-inclusive employment platform.

Based on these findings, IJC was developed as an integrated mobile application comprising three core components: (i) an AI-assisted job matching system, (ii) a training and skills development hub, and (iii) a support and stakeholder engagement hub. The platform is designed to reduce employment barriers by centralising recruitment, training, and support services within a single accessible digital environment. This mobile-based solution enables wider accessibility and improves connectivity among PWDs, employers, training providers, NGOs, and government agencies.

3.1 JOB MATCHING SYSTEM

The job matching system incorporates an AI-powered mechanism that intelligently connects PWDs with suitable employment opportunities in the accommodation sector (Figure 1). Unlike conventional job portals that rely primarily on keyword searches, IJC applies AI to analyse multiple user attributes, including disability-based profiling, educational background, qualifications, skills, work experience, career interests, and preferred job roles. To support this process, a digital PWDs' profile was provided to enable users to showcase their information, allowing AI matching algorithms to generate more accurate and personalised employment recommendations. By evaluating both candidate profiles and employer requirements, the AI recommends positions that match with the applicant's competencies while considering their skills and needs (Nacheva, 2024). This integrated approach not only increases the efficiency of the recruitment process but also enhances job satisfaction, employee retention and long-term employment sustainability for PWDs within the accommodation sector.

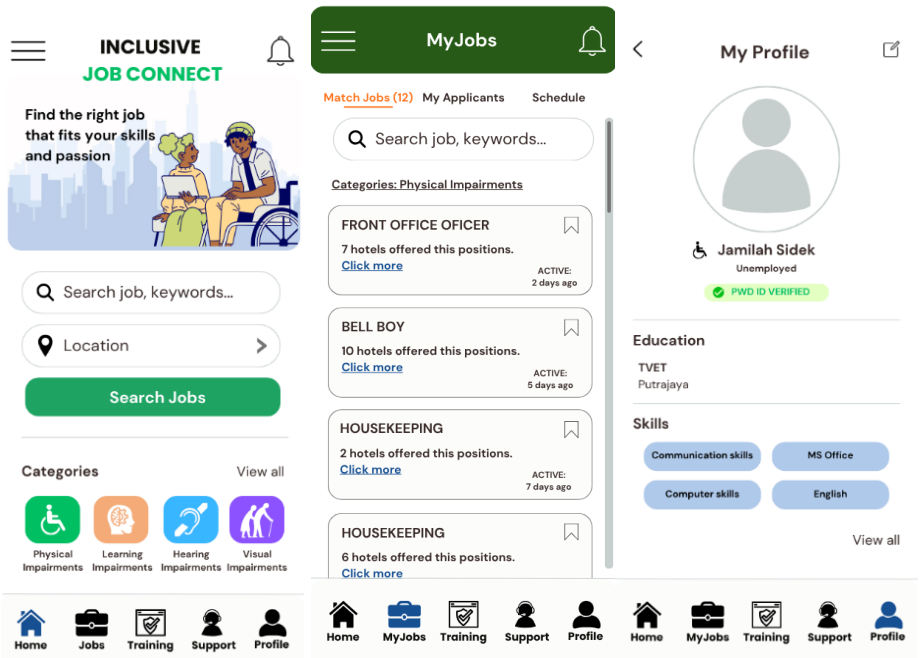


Figure 1: Job matching features

3.2 TRAINING HUB

To enhance employability, IJC provides a comprehensive training hub feature that serves as a centralised platform for continuous learning and professional development. This feature offers a wide range of learning opportunities such as self-paced online courses, vocational modules, industry-recognised certification programmes, webinars and hands-on practical classes specifically tailored to the

accommodation sector (Figure 2). The training content covers essential hospitality competencies such as digital literacy, soft skills, sustainability awareness, customer service, housekeeping and other employability skills. This feature enables PWDs to improve their qualifications and skills required. Upon successful completion of the courses that PWDs applied for, they receive digital certificates that are automatically added to their IJC profile, allowing employers to verify candidates' acquired skills and professional development.

ICJ is designed with accessibility features, including screen reader compatibility, captioned instructional videos, adjustable text sizes, high contrast display options, and simplified navigation to accommodate users with diverse disabilities. In addition, all training sessions are conducted in collaboration with accommodation establishments, vocational institutions, and industry experts. This collaborative approach ensures that the training content remains aligned with the current industry standards and employer expectations while providing PWDs with workplace exposure and practical experiences that strengthen their employability and long-term career development.

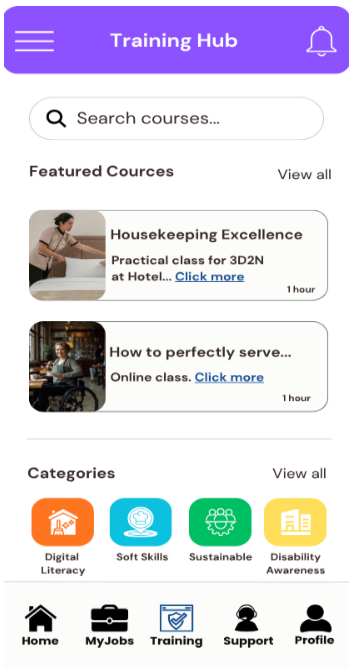


Figure 2: Training hub features

3.3 SUPPORT HUB

This feature provides users with access to essential employment support services and resources, which extend beyond job matching. The support hub offers up-to-date information on recruitment events, rehabilitation facilities, disability advocacy associations, and other services that assist PWDs in disability-inclusive employment. In addition, the platform connects users with disability communities, peer support networks, and disability advocacy groups, which enable them to share experiences, exchange career advice, seek mentorship, and build professional networks that foster social inclusion and emotional well-being. Furthermore, the support hub functions as a central information portal for disability employment opportunities and events. Users receive timely updates on career fairs and other employment-related events specifically organised for PWDs.

The platforms also facilitate collaboration among NGOs, employers, and government agencies through information-sharing systems, referral services, and employment support programmes. Through a single platform, stakeholders can disseminate employment opportunities, training programmes, financial assistance schemes, and support services. NGOS and rehabilitation facilities can refer suitable candidates to employers, while employers can connect with relevant organisations for consultation on disability inclusion, disability awareness guidelines, and suggested workplace accommodations. Government agencies can also use the platform to monitor disability employment statistics and promote inclusive hiring practices. This collaborative approach strengthens coordination among stakeholders and creates a more integrated and sustainable pathway to long-term employment in the accommodation sector.

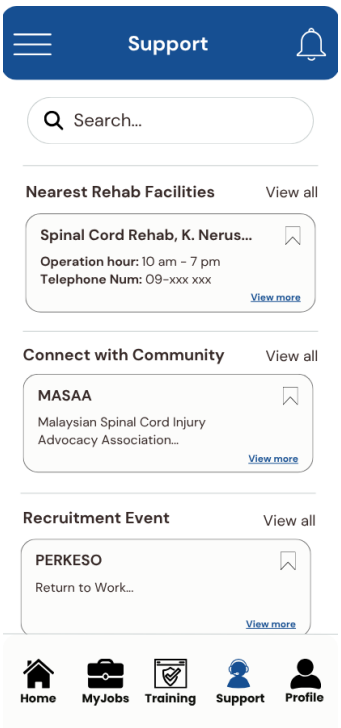


Figure 2: Support features

4.0 RESULT

This innovation offers several advantages and innovative contributions. First, before conceptualising the innovation idea, the data were obtained from interviews with PWDs employed in the accommodation sector. Based on the interview, PWDs stated that there is yet an app specifically focusing on employment channels for PWDs in Malaysia, particularly within the accommodation sector. Thus, this innovation is the first centralised recruitment platform for PWDs in the Malaysian accommodation sector.

Second, it provides a comprehensive solution by integrating recruitment, training, support, and stakeholder collaboration into a single platform. Unlike conventional job portals that focus solely on job vacancies, the proposed app addresses multiple challenges experienced by PWDs throughout the employment lifecycle. IJC incorporates disability-specific matching criteria, accessibility preferences, accommodation needs, and industry suitability to generate more inclusive employment recommendations.

Third, IJC also improves the network integration among the stakeholders such as PWD job seekers, employers, NGO and government agencies. By consolidating these stakeholders into a single platform, the app facilitates efficient sharing of information, coordinated employment support, and stronger collaboration in promoting inclusive employment hiring and practices.

Fourth, IJC enhances the recruitment process by matching employers with qualified PWD candidates based on skills, qualifications, type of disabilities and reasonable accommodation requirements. This not only reduces recruitment times, but also minimises the administrative workload and increases the likelihood of successful employment outcomes.

Finally, IJC significantly contributes to society, economics and policy. This innovation not only increased employment opportunities but also enhanced self-confidence, improved quality of life and encouraged PWDs to integrate into society. In the aspect of economy, IJC helps PWDs to be financially independent and contributes to a higher household income. On the policy impact, IJC supports national initiatives and policies that promote disability employment by providing a practical digital mechanism for implementation. This could help government agencies in monitoring disability employment statistics and promote inclusive hiring incentives.

5.0 CONCLUSION

Inclusive Job Connect represents an innovative digital solution that supports disability-inclusive employment by connecting key stakeholders within a single ecosystem. This app contributes to social inclusion, workforce diversity, and equal employment opportunities for PWDs, which is aligned with SDG 8: Decent work and economic growth and SGD 10: Reduced inequalities. IJC contributes significantly to the scientific community by bridging theory and practice in hiring and inclusive employment. This

innovation also extends knowledge in inclusive employment in terms of barriers in disability hiring. Economically, the platform has the potential to increase labour force participation, reduce unemployment among PWDs, and enhance workforce productivity. The innovation demonstrates how digital technology can be leveraged to create meaningful employment opportunities and foster a more inclusive society where PWDs can fully contribute to economic growth.

ACKNOWLEDGEMENT

This research was supported by the Ministry of Higher Education (MOHE) Malaysia through the Fundamental Research Grant Scheme FRGS/1/2024/SS01/UMT/02/6.

REFERENCES/RUJUKAN

Binyanya, B., Wandolo, M. A., & Kariuki, A. C. 2025. Disability demographics factors and employment inclusivity: A study of persons with disabilities in 4-5 star hotels in Mombasa City County, Kenya. Journal of Hospitality and Tourism Management, 8(1): 1-18. DOI:10.53819/81018102t4309.

Jamil, R., & Saidin, S. 2018. Employment of persons with disabilities (PWDs) in Malaysia: Moving policy rhetoric into action. Asian Journal of Management Cases, 15(2_suppl), S1-S16. DOI: 10.1177/0972820118804967.

Moore, K., McDonald, P., & Bartlett, J. 2017. Emerging trends affecting future employment opportunities for people with intellectual disability: The case of a large retail organisation. Journal of Intellectual & Developmental Disability, 43(3): 328–338. DOI:10.3109/13668250.2017.1379250.

Nacheva, R. 2024. Hired by artificial intelligence: Digital inclusion practices for people with disabilities. Journal of Underrepresented & Minority Progress, 8(2): 10-41. DOI:10.32674/66c03968.

Tah, I. H. M., Shuhaimi, M. F., Yusof, M. F. C., Othman, M. F., Rahmat, N. E., & Abdullah, W. A. W. 2025. Digitalising access to justice: Bridging the employment rights gap for persons with disabilities in Malaysia via the mobile application. International Journal of Research and Innovation in Social Science (IJRISS), 9(11): 4372-4376. DOI: 10.47772/IJRISS.

CATEGORY A2

PROFESSIONAL LEVEL

SOCIAL SCIENCE

Global Lingo Polyglot: A Gamified Geo-Political Language Learning Platform for Enhancing English Proficiency and Global Citizenship

Aisya Khadijah Binti Mohd Hamidi[1], Aida Zulaikha Binti Zulkefly[2], Marina Binti Mohammad Amir[3], Nur Atika Binti Hairi[4]

[1]Faculty in the Development of Students with Noble Characters (UNISEL), Selangor, Malaysia,
[2]Faculty of Communication, Visual Arts and Computing, Universiti Selangor (UNISEL), Selangor, Malaysia,
[3]Faculty in the Development of Students with Noble Characters (UNISEL), Selangor, Malaysia,
[4]Faculty of Education and Social Science (UNISEL), Selangor, Malaysia,

*Corresponding author: aisyakhadijah@unisel.edu.my

ABSTRACT

Traditional English learning often focuses on memorising grammar rules and vocabulary, making lessons less interesting and harder for students to apply in real life. Global Lingo Polyglot solves this problem by combining English language learning with knowledge about world geography, cultures, and global issues. Its goal is to improve students' English skills while developing critical thinking, global awareness, and intercultural communication. The platform is a gamified digital learning tool with an interactive world map. Students take on roles such as diplomats, journalists, or global representatives and complete English language challenges to unlock countries. These challenges include grammar, vocabulary, reading, speaking, and idioms, while introducing topics such as international relations, history, economics, and the United Nations Sustainable Development Goals (SDGs). To keep students motivated, the platform uses points, badges, and leaderboards. Global Lingo Polyglot makes English learning more fun, practical, and meaningful. It helps students become more confident in using English, improves their digital skills, and increases their understanding of different cultures. By supporting SDG 4 (Quality Education) and SDG 17 (Partnerships for the Goals), the platform prepares students to communicate effectively and succeed in today's connected world. It connects classroom learning with real-world global experiences.

Keywords: Global Lingo, Polyglot, gamified, language, learning platform

1.0 INTRODUCTION

Traditional English language learning often focuses on grammar exercises and memorisation, which can make learning less engaging and difficult to apply in real-life situations. As a result, many students struggle to develop confidence in communication and lack awareness of global issues. Global Lingo Polyglot is a gamified digital language learning platform designed to make English learning more interactive, meaningful, and enjoyable. Using an interactive world map, students complete language challenges while exploring countries, cultures, and global issues. The platform combines English language learning with geography, international relations, and the United Nations Sustainable Development Goals (SDGs), helping students improve their communication skills and global awareness. By incorporating game elements such as points, badges, and leaderboards, Global Lingo Polyglot motivates students to actively participate in learning. This innovative approach transforms English from a classroom subject into a practical tool for communication, critical thinking, and global citizenship, preparing learners for success in an increasingly interconnected world.

2.0 OBJECTIVE

1. To develop a gamified digital learning platform that enhances English language proficiency among university students through interactive and task-based learning activities.
2. To promote global citizenship and intercultural competence by integrating global cultures, traditional foods, world leaders, and contemporary international issues into English language learning.

3. To increase student engagement, motivation, and participation in language learning through gamification elements such as points, badges, leaderboards, missions, and achievement-based progression.

3.0 METHODOLOGY

Global Lingo Polyglot is a gamified digital learning platform designed to enhance English language proficiency while promoting global citizenship among lower proficiency learners. The platform combines language learning with geo-political knowledge through an interactive digital world map where learners assume the roles of diplomats, journalists, or global representatives. Users complete language-based missions to unlock countries, earn rewards, and progress through increasingly challenging levels. The platform integrates various English language tasks, including grammar correction, vocabulary application, translation exercises, reading comprehension, and interpretation of idiomatic expressions. These tasks are contextualised within authentic global issues such as international relations, cultural diversity, historical events, economic development, and the United Nations Sustainable Development Goals (SDGs). The learning environment is grounded in Communicative Language Teaching (CLT) and Task-Based Language Teaching (TBLT), emphasising authentic communication, collaboration, and problem-solving.



3.1 WHAT AM I? – GLOBAL CULTURE AND FOOD EDITION

One of the key gamified missions within Global Lingo Polyglot is the "What Am I? – Global Culture and Food Leaders Edition" challenge. This activity is designed to improve learners' English speaking, listening, questioning, critical thinking, and global awareness skills through an interactive guessing game that explores world cultures, traditional foods, and influential global leaders. In this mission, students become global explorers tasked with identifying a hidden identity using only grammatically correct yes/no questions. The hidden identity may represent a world leader, a traditional cultural practice, a famous landmark, a national symbol, or a traditional food associated with a particular country. Each learner receives a character card that is placed on their forehead or back without revealing the identity to them.

To discover their identity, learners interact with classmates by asking questions such as:

- Am I a person?
- Am I a type of food?
- Am I associated with Asia?
- Am I eaten during celebrations?
- Am I a political leader?
- Am I related to a cultural tradition?

• Am I famous around the world?
• Am I connected to a particular country?

The activity is organised into three categories:

Global Leaders
• Nelson Mandela
• Malala Yousafzai
• Kofi Annan
• Mahatma Gandhi
• Angela Merkel

Global Foods
• Sushi (Japan)
• Nasi Lemak (Malaysia)
• Kimchi (South Korea)
• Paella (Spain)
• Pizza (Italy)

Global Culture and Heritage
• Chinese New Year
• Diwali
• Carnival in Brazil
• Batik
• The Eiffel Tower

Gamification mechanics are incorporated through points, badges, leaderboards, and achievement levels. Students earn points for asking grammatically correct questions, using advanced vocabulary, making accurate guesses, and demonstrating cultural knowledge. Special power cards such as the Diplomat Card, Culture Expert Card, and World Explorer Card provide additional clues and strategic advantages during gameplay. Upon completing the challenge, learners participate in a Global Forum discussion where they explain the significance of the leader, food, or cultural element they identified. Students discuss its contribution to society, cultural importance, historical background, and relevance in today's interconnected world. This reflective component promotes intercultural understanding, global citizenship, and authentic English communication while encouraging learners to appreciate cultural diversity and international perspectives.



4.0 RESULT

The implementation of the “Who Am I? – Global Culture, Food and Leaders Edition” mission within the Global Lingo Polyglot platform produced positive outcomes in learner engagement, English language development, and global awareness. By integrating cultural practices, traditional foods, and influential world leaders into a gamified learning environment, students demonstrated higher levels of participation and enthusiasm compared to traditional language-learning activities. The mission-based structure encouraged active interaction and sustained engagement, consistent with studies highlighting the effectiveness of gamification in promoting learner motivation and participation (Deterding et al., 2011; Dindar et al., 2021).

The activity enhanced students’ questioning skills, speaking confidence, and vocabulary acquisition as learners formulated grammatically correct yes/no questions to identify hidden identities. Through repeated interaction and meaningful communication, students were able to apply English in authentic contexts, supporting the principles of Communicative Language Teaching and Task-Based Language Teaching (Dehghanzadeh et al., 2019). Learners also demonstrated improved listening skills as they interpreted responses and adjusted their questioning strategies accordingly.

In addition, the inclusion of global foods, cultural traditions, and international leaders increased students’ awareness of cultural diversity and global interconnectedness. Learners developed a greater appreciation for different societies, traditions, and historical contributions while strengthening intercultural competence and critical thinking skills. The use of points, badges, leaderboards, and achievement-based progression further increased motivation and encouraged healthy competition among participants (Kohnke & Moorhouse, 2022). Overall, the innovation supports Sustainable Development Goal (SDG) 4: Quality Education and SDG 17: Partnerships for the Goals by fostering inclusive, culturally responsive, and globally oriented language learning experiences that prepare students to communicate effectively in multicultural environments.

5.0 CONCLUSION

Global Lingo Polyglot is an innovative digital platform that makes English learning more fun, interactive, and meaningful. By combining language learning with geography, culture, and global issues through gamification, the platform helps students improve their English communication skills while developing critical thinking, intercultural awareness, and global citizenship (Dehghanzadeh et al., 2019; Deterding et al., 2011). Through gamified activities such as "What Am I? – Global Culture and Food Leaders Edition," students become more confident in speaking English, expand their vocabulary, and participate more actively in class. Research has shown that gamified learning increases student engagement, motivation, and self-regulated learning compared to traditional teaching methods (Dindar et al., 2021; Kohnke & Moorhouse, 2022). Overall, Global Lingo Polyglot provides a practical and engaging approach to language education by connecting classroom learning with real-world communication. The platform supports the achievement of Sustainable Development Goal (SDG) 4: Quality Education and SDG 17: Partnerships for the Goals, preparing students with the language skills, digital literacy, and global perspective needed to succeed in an increasingly interconnected world (Hamidi et al., 2026)

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Universiti Selangor (UNISEL) for its continuous support and encouragement throughout the development of Global Lingo Polyglot. Special thanks are extended to colleagues, students, and reviewers whose valuable feedback and participation contributed to the improvement of this innovation. The authors also acknowledge the inspiration gained from previous research on gamification, digital learning, and language education, which has guided the design and implementation of this platform. Finally, we are grateful to the organisers of the 7th Digitalised International Invention, Innovation and Design Competition (DIIID 2026), Universiti Teknologi MARA (UiTM) Cawangan Johor, for providing an opportunity to showcase this innovation and promote excellence in teaching, learning, and educational technology

REFERENCES

Dehghanzadeh, H., Fardanesh, H., Hatami, J., Talaee, E. & Noroozi, O. 2019. Using gamification in education: A review of state of the art. Journal of Computer Assisted Learning, 35(6): 669–688. DOI:10.1111/jcal.12368.

Deterding, S., Dixon, D., Khaled, R. & Nacke, L. 2011. From game design elements to gamefulness: Defining "gamification". Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, pp. 9–15. DOI:10.1145/2181037.2181040.

Dindar, M., Ren, L. & Järvelä, S. 2021. Interactive learning with a gamified mobile application: The role of gender and self-regulation. Journal of Computer Assisted Learning, 37(1): 175–185. DOI:10.1111/jcal.12478.

Hamidi, A.K.M., Zulkefly, A.Z., Amir, M.M. & Hairi, N.A. 2026. Global Lingo Polyglot: A gamified geo-political language learning platform for enhancing English proficiency and global citizenship. Extended Abstract. Proceedings of the 7th Digitalised International Invention, Innovation and Design Competition (DIIID 2026), Universiti Teknologi MARA Cawangan Johor.

Kohnke, L. & Moorhouse, B.L. 2022. Facilitating synchronous online language learning through gamification. In: The TESOL Encyclopedia of English Language Teaching, pp. 1–6. DOI:10.1002/9781118784235.eelt0983.

DEVELOPMENT OF E-SHOP KPTMBP: DIGITAL MARKETPLACE FOR THE KPTM BATU PAHAT COMMUNITY

Nur Ameera Natasha Binti Mohammad[1,*], Nurulain Binti Shariffudin[1], Noraisah Binti Kamarudin[1], Fairuzy Binti Ab Hadi[1], Nor Baizura Binti Mohamed[1]

[1]Kolej Poly-Tech MARA Batu Pahat, Johor, Malaysia

*Corresponding author: nurameera@kptm.edu.my

ABSTRACT

Digital entrepreneurship has become an essential component of higher education as institutions seek to equip students with entrepreneurial competencies and digital business skills that are aligned with the rapidly evolving digital economy. Although students actively utilise social media platforms such as WhatsApp, Facebook, Instagram, and TikTok to conduct online businesses, these platforms are not specifically designed to support structured business management, verified student entrepreneurship, or institution-based entrepreneurial ecosystems. Consequently, student business activities are often fragmented, making product discovery, inventory management, and seller credibility difficult to manage. This study presents e-Shop KPTMBP, a campus-based digital marketplace developed specifically for Kolej Poly-Tech MARA Batu Pahat (KPTMBP). The application aims to provide a secure and integrated platform that enables student entrepreneurs to register as verified sellers, manage products, communicate with customers, and conduct digital business activities within the campus community. The system was developed using the Agile Software Development methodology, allowing continuous refinement throughout the development process. Unlike commercial marketplace platforms, e-Shop KPTMBP is designed to complement entrepreneurship education by integrating experiential learning with digital business practice. The innovation enables students to gain practical experience in digital marketing, inventory management, customer relationship management, and online entrepreneurship while supporting the institution's digital transformation agenda. The proposed innovation demonstrates significant potential for implementation across other higher education institutions through institutional licensing and Software-as-a-Service (SaaS) deployment. Furthermore, the innovation supports the United Nations Sustainable Development Goals, particularly SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 9 (Industry, Innovation and Infrastructure). Overall, e-Shop KPTMBP contributes to strengthening entrepreneurship education by providing a dedicated campus digital marketplace that bridges academic learning with real entrepreneurial practice.

Keywords: mobile marketplace, entrepreneurship education, student entrepreneurship, campus innovation

1.0 INTRODUCTION

Digital transformation has significantly reshaped entrepreneurial activities by enabling businesses to leverage digital technologies for value creation, innovation, and market expansion (Kraus et al., 2021; Nambisan, 2017). This phenomenon has accelerated the emergence of digital entrepreneurship, where entrepreneurial processes increasingly rely on digital platforms, mobile technologies, and electronic commerce to establish and manage business ventures (Zaheer et al., 2023). Nambisan (2017) defines digital entrepreneurship as the intersection between entrepreneurship and digital technologies, highlighting its role in transforming entrepreneurial processes, business models, and market opportunities.

Higher education institutions are increasingly expected to prepare graduates with entrepreneurial competencies that meet the demands of the digital economy (Secundo et al., 2021). Contemporary entrepreneurship education extends beyond theoretical instruction by encouraging students to participate in authentic entrepreneurial activities through experiential learning and digital business platforms (Rippa & Secundo, 2019). Recent studies indicate that digital entrepreneurship education positively influences entrepreneurial intention by strengthening entrepreneurial alertness, innovation capability, and students' readiness to establish digital ventures (Hasanah, 2025; Wardana et al., 2020).

Despite the widespread adoption of social media platforms for online selling, student entrepreneurs continue to experience operational challenges (Safar & Halil, 2023). Products are often dispersed

across multiple platforms, seller verification is limited, business records are manually maintained, and buyers face difficulties identifying reliable student businesses (Ganesh & Kumar, 2026; Nasir & Ismail, 2024). Existing commercial marketplaces primarily target the general public and do not specifically support campus entrepreneurship ecosystems or entrepreneurship education. Similarly, social media platforms are designed mainly for communication rather than integrated business management (Kivuyo, 2025).

To address these limitations, this innovation introduces e-Shop KPTMBP, a dedicated campus digital marketplace developed specifically for the KPTMBP community. The application integrates seller verification, product management, customer engagement, and marketplace functions within a single mobile platform (Wang & Li, 2019). Beyond facilitating online transactions, the proposed innovation functions as an experiential learning platform that enables students to apply entrepreneurial knowledge in authentic business environments while strengthening the institution's digital entrepreneurship ecosystem (Rippa & Secundo, 2019; Secundo et al., 2021). The innovation aligns with current developments in digital entrepreneurship and contributes towards sustainable entrepreneurship education within higher education institutions (Kraus et al., 2021).

2.0 OBJECTIVE

The development of the e-Shop KPTMBP application is driven by the following key objectives:

1. To develop a dedicated mobile marketplace application that supports digital entrepreneurship among students at Kolej Poly-Tech MARA Batu Pahat.
2. To provide an integrated digital platform that enables verified student sellers to manage products, communicate with customers, and conduct business activities more efficiently.
3. To enhance experiential entrepreneurship education by providing students with practical exposure to digital business management, online marketing, and customer relationship management.
4. To strengthen the campus entrepreneurial ecosystem while supporting institutional digital transformation and future commercialisation opportunities.

3.0 METHODOLOGY

The development of e-Shop KPTMBP adopted the Agile Software Development (ASD) methodology due to its flexibility, iterative development process, and ability to accommodate continuous user feedback throughout the system development lifecycle (Beck et al., 2001; Pressman & Maxim, 2020). Agile is widely adopted in mobile application development because it enables rapid prototyping, continuous improvement, and collaborative development between developers and stakeholders (Wang & Li, 2019). The development process consisted of five iterative phases:

3.1 REQUIREMENT ANALYSIS

The initial phase focused on identifying operational challenges experienced by student entrepreneurs at KPTMBP. Findings indicated fragmented product promotion across social media (Kivuyo, 2025), lack of seller verification, manual inventory management, and absence of a dedicated campus marketplace (Ganesh & Kumar, 2026).

3.2 SYSTEM DESIGN

The application architecture and user interface were designed based on identified requirements (Zeng et al., 2021). The system includes user authentication, product management, marketplace transaction, and customer communication modules.

3.3 APPLICATION DEVELOPMENT

Core functionalities were developed iteratively (Pressman & Maxim, 2020), including seller registration, product upload, category filtering, seller profiles, ratings, and direct WhatsApp communication API integration.

3.4 SYSTEM TESTING

Functional testing was conducted to verify performance across registration, login, searching, notifications, and transactions (Pressman & Maxim, 2020).

3.5 DEPLOYMENT

Following functional testing, the prototype is prepared for pilot implementation within the KPTMBP community before broader deployment (Wang & Li, 2019).

4.0 RESULT

The development of e-Shop KPTMBP demonstrates the capability of integrating entrepreneurship education with digital marketplace technology (Nambisan, 2017; Rippa & Secundo, 2019). The application provides an institutional platform that enables student entrepreneurs to conduct online business activities in a structured, secure, and organised environment (Ganesh & Kumar, 2026).

Unlike conventional social media platforms that primarily facilitate communication, e-Shop KPTMBP integrates product management, seller verification, inventory management, customer interaction, and business promotion into a single mobile application (Kivuyo, 2025; Wang & Li, 2019). This integrated approach simplifies business operations while providing students with practical entrepreneurial experience (Laila et al., 2024; Nasir & Ismail, 2024). The application also strengthens the institutional entrepreneurial ecosystem by enabling lecturers and administrators to promote entrepreneurship activities in a controlled digital environment (Secundo et al., 2021).

4.1 NOVELTY OF INNOVATION

The application incorporates several innovative features designed specifically for student entrepreneurs, including verified student seller registration (Ganesh & Kumar, 2026), campus-exclusive digital marketplace (Safar & Halil, 2023), product categorization (Wang & Li, 2019), customer ratings (Ganesh & Kumar, 2026), and direct WhatsApp API communication. These features collectively create a secure digital business environment while enhancing entrepreneurial learning through practical experience (Wardana et al., 2020).

The uniqueness of e-Shop KPTMBP lies in its role as an institutional entrepreneurship platform rather than a commercial marketplace (Rippa & Secundo, 2019). Commercial platforms primarily focus on profit-oriented transactions for the general public, whereas e-Shop KPTMBP is specifically designed to support entrepreneurship education by integrating learning, business management, and institutional monitoring within a single digital ecosystem (Giones & Brem, 2021; Secundo et al., 2021). The innovation enables students to develop entrepreneurial competencies before expanding their businesses to larger commercial marketplaces (Mavlutova et al., 2026). Furthermore, the platform creates a verified entrepreneurial community that increases buyer confidence (Liu et al., 2025).

Table 1: Comparison between Existing Platforms and e-Shop KPTMBP

Features	Social Media	Commercial Marketplace	e-Shop KPTMBP
Verified Student Seller	✗	✗	✓
Campus Marketplace	✗	✗	✓
Product Categorization	Limited	✓	✓
Inventory Management	✗	✓	✓
Customer Rating	Limited	✓	✓
Entrepreneurship Learning	✗	✗	✓
Institution Monitoring	✗	✗	✓
Educational Purpose	✗	✗	✓

The comparison in Table 1 demonstrates that e-Shop KPTMBP provides several educational and institutional functions that are not available in existing commercial platforms or general social media applications (Ganesh & Kumar, 2026; Kivuyo, 2025; Wang & Li, 2019).

4.2 CONTRIBUTION

The proposed innovation contributes significantly to three primary stakeholders (Secundo et al., 2021):

i. Students: Students gain practical experience in digital entrepreneurship by managing products, communicating with customers, organising inventories, and conducting online business activities within a structured digital marketplace (Nasir & Ismail, 2024; Wardana et al., 2020).
ii. Institution: The application strengthens entrepreneurship education by providing an experiential learning platform that aligns academic knowledge with authentic business practice (Rippa & Secundo, 2019; Kraus et al., 2021).
iii. Campus Community: The campus community benefits from a trusted marketplace where products and services offered by verified student entrepreneurs can be accessed conveniently and securely (Ganesh & Kumar, 2026).

4.3 MARKET POTENTIAL

The innovation demonstrates strong potential for commercialisation due to its scalability and adaptability (Popkova, 2022). Rather than competing with commercial marketplaces such as Shopee or Lazada, e-Shop KPTMBP complements these platforms by providing a secure campus-based entrepreneurial ecosystem where students can gain practical business experience before expanding into larger digital marketplaces (Giones & Brem, 2021). The application can be commercialised through institutional licensing, Software-as-a-Service (SaaS), annual maintenance services, system customisations, and technical support.

4.4 SUSTAINABLE DEVELOPMENT GOALS (SDGs)

The e-Shop KPTMBP innovation directly aligns with and contributes to three United Nations Sustainable Development Goals (SDGs) (United Nations, 2015):

i. SDG 4: Quality Education
Providing experiential learning by integrating digital entrepreneurship into the curriculum (Rippa & Secundo, 2019; Wardana et al., 2020).
ii. SDG 8: Decent Work and Economic Growth
Supporting youth entrepreneurship, financial independence, and student income generation (Ganesh & Kumar, 2026; Nasir & Ismail, 2024).
iii. SDG 9: Industry, Innovation, and Infrastructure
Promoting digital innovation and modernising technological infrastructure within higher education institutions (Kraus et al., 2021; Popkova, 2022).

5.0 CONCLUSION

The development of e-Shop KPTMBP successfully demonstrates how mobile technology can bridge entrepreneurship education with authentic business practice by providing a dedicated campus-based digital marketplace that supports experiential learning and digital business management (Nambisan, 2017; Rippa & Secundo, 2019). By integrating essential business functions such as product management, seller verification, customer interaction, inventory management, and marketplace services into a single mobile platform, the application creates a structured, secure, and user-friendly entrepreneurial ecosystem that enables students to gain practical experience in operating digital businesses while pursuing their studies (Ganesh & Kumar, 2026; Wang & Li, 2019). The platform not only simplifies business operations but also encourages students to develop entrepreneurial confidence, digital competencies, and problem-solving skills through authentic business activities conducted within the institutional environment.

Unlike commercial marketplaces or general social media platforms that primarily focus on commercial transactions, e-Shop KPTMBP is specifically designed to complement entrepreneurship education by providing a controlled and supportive environment where students can learn, experiment, and improve their entrepreneurial capabilities before entering larger and more competitive digital marketplaces (Giones & Brem, 2021; Nasir & Ismail, 2024). This educational approach strengthens experiential learning by allowing students to apply entrepreneurial theories in real business situations while promoting collaboration among students, lecturers, and the institution. Consequently, the platform serves not only as a digital marketplace but also as an educational innovation that bridges classroom learning with practical entrepreneurial experience.

In addition, the innovation contributes to the institution's digital transformation agenda by fostering a technology-enabled entrepreneurial ecosystem that aligns with the objectives of Sustainable

Development Goals (SDGs) 4 (Quality Education), 8 (Decent Work and Economic Growth), and 9 (Industry, Innovation and Infrastructure) (Kraus et al., 2021; United Nations, 2015). The modular system architecture further enhances its scalability and adaptability, allowing future deployment through institutional licensing, customised implementation, or Software-as-a-Service (SaaS) models across higher education institutions in Malaysia (Popkova, 2022; Pressman & Maxim, 2020). Such flexibility provides opportunities for broader adoption while supporting institutional initiatives in digital innovation, entrepreneurship education, and sustainable campus development.

Future enhancements are expected to further strengthen the platform by integrating secure online payment gateways, artificial intelligence (AI)-based product recommendation systems, sales analytics dashboards, QR code verification, and multi-campus networking capabilities (Mavlutova et al., 2026; Oluwafemi et al., 2026). These improvements will enhance user experience, operational efficiency, and decision-making while increasing the long-term sustainability and commercial potential of the platform. Overall, e-Shop KPTMBP presents a practical and scalable model for empowering student entrepreneurs, strengthening institutional entrepreneurship ecosystems, and accelerating the digitalisation of campus commerce. The innovation demonstrates considerable potential to be adopted by other higher education institutions seeking to enhance entrepreneurship education through technology-driven solutions while preparing students to participate confidently in the evolving digital economy (Safar & Halil, 2023; Secundo et al., 2021).

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Kolej Poly-Tech MARA Batu Pahat (KPTMBP) for providing continuous support and facilities throughout the development of e-Shop KPTMBP. The authors also extend their gratitude to the Department of Information Technology, lecturers, students, and all individuals who contributed valuable ideas, constructive feedback, and cooperation during the planning, development, testing, and evaluation of this innovation. Their encouragement and support have been instrumental in the successful completion of this project.

REFERENCES

Ganesh, A. & Kumar, R. 2026. Campus Mart–Student Marketplace: A Secure and Authenticated Platform for Internal Peer-to-Peer Academic Exchanges. International Journal of Research and Technology Innovation, 11 (3): 102-114.

Hasanah, U. 2025. E-Commerce dan Kewirausahaan: Analisis Minat Mahasiswa dalam Memulai Bisnis Online. Jurnal Bisnis Digital, 3 (1): 124-138.

Kivuyo, R. B. 2025. Social media capital, facilitating conditions, and digital self-efficacy: an integrated model of internet entrepreneurship intention in India. Cogent Education, 12 (1): 2587492.

Kraus, S., Palmer, C., Kailer, N., Kallinger, F. L., & Spitzer, J. 2021. Digital entrepreneurship: A research agenda on new business models for the twenty-first century. International Journal of Entrepreneurial Behavior & Research, 27 (2): 353-375.

Laila, N., Sucia Sukmaningrum, P., Saini Wan Ngah, W. A., Nur Rosyidi, L., & Rahmawati, I. 2024. An in-depth analysis of digital marketing trends and prospects in small and medium-sized enterprises: utilizing bibliometric mapping. Cogent Business & Management, 11 (1): 2336565.

Liu, Z., Chung, Y., Li, Y., & Jia, J. 2025. How offline peers shape online purchasing? A guanxi and mianzi perspective. Electronic Markets, 35 (1): 12.

Nambisan, S. 2017. Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship. Entrepreneurship Theory and Practice, 41 (6): 1029-1055.

Nasir, M. F. & Ismail, Z. 2024. College Students as Sellers in the Digital Marketplace: Evaluating Participation, Profitable Platforms, and Market Trends. Semarak Proceedings of Applied Sciences and Engineering Technology, 8 (1): 55-63.

Oluwafemi, I., Raheem, W. A., Adekunle, A. A., & Ademola, M. Q. 2026. A Machine Learning-Driven Campus E-Commerce System for Fraud Detection and Financial Sustainability in Higher Institutions. Journal of Innovation Science and Technology, 5 (1): 152.

Rippa, P. & Secundo, G. 2019. Digital academic entrepreneurship: The transformative role of digital technologies in higher education institutions. Technology in Society, 58: 101140.

Safar, N. H. A. & Halil, N. H. A. 2023. Student Online Marketplace for University Community: Bridging Academic Entrepreneurship and Digital Ecosystems. Journal of Student Business and Technology, 15 (2): 215-227.

Secundo, G., Mele, G., Sansone, G., & Paolucci, E. 2021. Entrepreneurship education centers in universities: Evidence and insights from Italian case studies. International Journal of Entrepreneurial Behavior & Research, 27 (6): 1435-1460.
Wardana, L. W., Narmaditya, B. S., Wibowo, A., Mahendra, A. M., Wibowo, N. A., Harwida, G., & Rohman, F. 2020. The impact of entrepreneurship education in higher education: A determinants study of entrepreneurial intention. International Journal of Management Education, 18 (2): 100385.
Giones, F. & Brem, A. (Eds.). 2021. Digital Entrepreneurship: Resource Configurations, Business Models, and Strategy. Palgrave Macmillan.
Popkova, E. G. (Ed.). 2022. Digital Technologies for Entrepreneurship in Industry 4.0. Springer Cham.
Pressman, R. S. & Maxim, B. R. 2020. Software Engineering: A Practitioner's Approach. 9th Ed. McGraw-Hill Education, USA. ISBN: 9781259872976.
Wang, J. & Li, Y. 2019. Design and Research of Campus E-commerce System Based on B/S. Proceedings of the 3rd International Conference on Economic Development and Education Management (ICEDEM 2019), Dec. 6-10, Atlantis Press, pp: 6-10.
United Nations. 2015. Indicators of Sustainable Development: Guidelines and Methodologies. United Nations Publishing, New York.
Beck, K., Beedle, M., Bennekum, A. v., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., Thomas, D., Jeffries, R., Kern, J., Marick, B., Martin, R. C., Mellor, S., Schwaber, K., & Sutherland, J. 2001. Manifesto for Agile Software Development. Agile Alliance. http://agilemanifesto.org/ (Accessed on July 16, 2026)
Mavlutova, I., Silesky-Gonzalez, J., & Aditya, R. 2026. AI-Embedded Digital Tools in Business Education and Entrepreneurial Intention: Gender-Based Structural Modeling. https://doi.org/10.20944/preprints202602.1884.v1 (Accessed on July 16, 2026)

MyPARENTCARE (MPC): ENHANCING PARENT ENGAGEMENT THROUGH REAL-TIME STUDENT ACTIVITY MONITORING SYSTEM IN HIGHER EDUCATION INSTITUTIONS

Nor Baizura Mohamed[1], Hareena Hazlini M.Tahar[1,*], Nuramni Nadzirah A.Hamzah[1], Siti Najwa Arifin[1], M.Faizi M.Nazri[1]

[1]Kolej Poly-Tech MARA

*Corresponding author: hareena.hazlini@kptm.edu.my

ABSTRACT

Parental involvement is an important factor in supporting students' academic and personal development. However, communication between higher education institutions and parents is often limited, resulting in parents having insufficient information regarding their children's participation in campus activities. This lack of transparency may create uncertainty regarding students' attendance, engagement, and overall involvement in institutional programmes. To address this challenge, MyParentCare (MPC) was developed as an innovative student activity monitoring system that integrates activity management, QR code attendance verification, and automated notifications for parents. The system enables administrators to create and publish activities, while students can register and manage their participation through a mobile application. Once a student registers for an activity, an automatic notification containing the programme details is sent directly to the parent via email or WhatsApp. On the day of the event, attendance is verified through QR code scanning, and a second notification is automatically delivered to confirm the student's presence. The uniqueness of MyParentCare lies in its seamless integration with WhatsApp or email, eliminating the need for parents to install additional applications or create user accounts. This approach enhances accessibility, convenience, and real-time communication between institutions and parents. Furthermore, the system generates attendance and participation records that support institutional monitoring and reporting processes. MyParentCare contributes to greater transparency, strengthens parent institution engagement, and promotes student accountability in co-curricular and developmental activities. The innovation offers a practical and scalable solution for higher education institutions seeking to improve communication, student participation monitoring, and stakeholder engagement through digital technology. The proposed system has strong potential for wider implementation across educational institutions to support holistic student development and strengthen collaborative partnerships between parents and higher education providers.

Keywords: parent engagement, student activity monitoring, whatsapp notification system, QR code attendance, higher education institutions, MyParentCare (MPC)

1.0 INTRODUCTION

The rapid advancement of digital technology has transformed higher education institutions (HEIs) by improving academic administration, communication, and student management. Despite these advancements, communication between higher education institutions and parents remains limited once students enter tertiary education. Parents are often unaware of their children's participation in academic, leadership, entrepreneurship, community service, and co-curricular activities, despite these programmes playing an important role in students' holistic development.

In recent years, Malaysia has witnessed increasing public concern over cases involving young adults and higher education students, including online scams, cybercrime, drug abuse, missing persons, and safety-related incidents. While these issues are influenced by multiple factors, limited communication between institutions, students, and parents may reduce parental awareness of students' campus engagement and delay opportunities for early support or intervention. Strengthening parent–institution communication has therefore become increasingly important in creating a safer and more supportive higher education environment. At Kolej Poly-Tech MARA (KPTM) Batu Pahat, the Student Affairs Department, academic faculties, student clubs, and industry partners organise various student development programmes each semester, including leadership camps, industrial visits,

entrepreneurship activities, community service projects, sports, and academic enhancement programmes. These initiatives aim to develop graduates who possess not only academic excellence but also leadership qualities, employability skills, communication competencies, teamwork, and social responsibility.

However, information regarding students' participation is generally communicated only through internal institutional platforms, leaving parents with limited access to updates on their children's campus involvement. As a result, parents often depend solely on students for information, which may be delayed or incomplete. Existing Student Information Systems (SIS) and Learning Management Systems (LMS) primarily focus on academic administration and do not provide dedicated features that facilitate continuous parent engagement.

To address this gap, MyParentCare (MPC) is proposed as a Smart Parent Engagement Ecosystem that integrates student activity management, QR code attendance verification, automated WhatsApp or email notifications and predictive engagement analytics. Beyond informing parents of students' participation in institutional activities, enabling parents and institutions to monitor students' holistic development more effectively. By strengthening communication among higher education institutions, students, and parents, MyParentCare supports a more transparent, connected, and student-centred educational ecosystem. The platform aligns with Malaysia's digital transformation agenda in higher education while contributing to Sustainable Development Goal 4 (Quality Education) through enhanced stakeholder collaboration and holistic student development.

2.0 OBJECTIVE

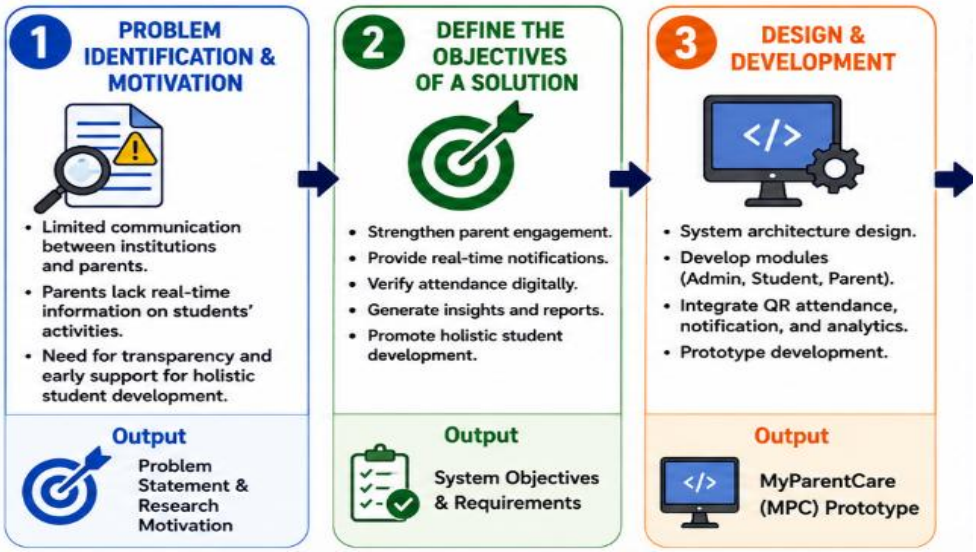
The objectives of MyParentCare (MPC) are:

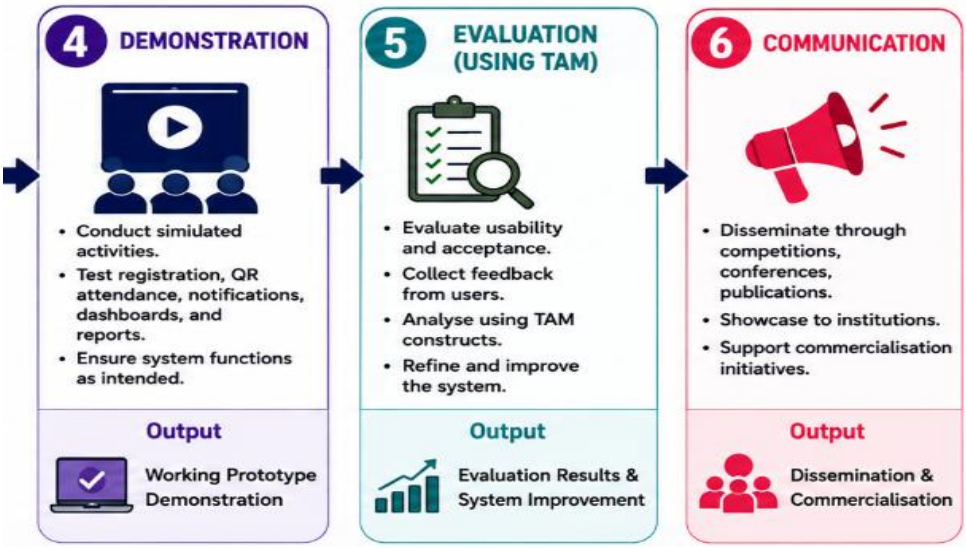
1. To develop a digital platform that strengthens communication between higher education institutions and parents.
2. To enable online student registration for institutional activities.
3. To provide real-time notifications to parents via WhatsApp or email.
4. To promote holistic student development through continuous parent engagement.

3.0 METHODOLOGY

This study adopted the **Design Science Research Methodology (DSRM)** proposed by Peffers et al. (2007). DSRM was selected because the primary objective of this research is to design, develop, and evaluate an innovative digital solution that addresses a real-world problem in higher education. The methodology provides a systematic framework for developing technology-based artefacts while ensuring that the proposed solution effectively meets user and institutional requirements.

The development of **MyParentCare (MPC)** involved six phases, as illustrated below.





Phase 1: Problem Identification & Motivation
Identify the communication gap between higher education institutions, students and parents through observations, discussions and feedback.

Phase 2: Define the Objectives of a Solution
Establish the objectives and system requirements to improve parent engagement, communication, and student activity monitoring.

Phase 3: Design & Development
Design and develop the MyParentCare (MPC) prototype, including the administrator, students and parent modules with QR code attendance and notification features.

Phase 4: Demonstration
Demonstrate the prototype by simulation of the complete process, from activity registration to attendance verification and parent notification.

Phase 5: Evaluation
Evaluate the system based on users' perceptions of usefulness, ease of use, user satisfaction and intention to use. Feedback is collected to improve the system.

Phase 6: Communication
Present the innovation through competitions, conferences and publications and explore commercialisation opportunities for wider implementation.

3.1 Literature Review

According to Nkomo, Daniel & Butson (2021), student engagement is widely recognised as a multidimensional construct encompassing behavioural, emotional, and cognitive participation. Digital technologies can enhance engagement when they are intentionally designed to support interaction, participation, and meaningful learning experiences rather than simply digitising existing processes (Bergdahl, Bond & Oxley, 2024).

Design Science Research Methodology (DSRM) provides a systematic framework for designing, developing, demonstrating, and evaluating innovative information systems that solve real-world organisational problems. Since MyParentCare is developed as a digital solution for improving parent engagement and student activity monitoring, DSRM provides an appropriate methodological foundation for this study (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007).

According to Gorard, El-Soufi, Siddiqui & Dong (2020), although parental involvement has traditionally been associated with primary and secondary education, recent studies suggest that meaningful family engagement continues to positively influence students' motivation, academic success, and overall educational outcomes. Moreover, based on discovered sustainability Peng et al.

(2026), systematic reviews also indicate that digital communication between educational institutions and families can strengthen partnerships and improve educational quality when communication is timely, personalised, and collaborative.

4.0 RESULT

Recently, concerns regarding the safety and well-being of higher education students in Malaysia have continued to grow due to the increasing number of online scams and other safety-related incidents involving young adults. According to the Royal Malaysia Police (PDRM), 61 higher education students in Perak became victims of online scams between January and April 2026, resulting in financial losses exceeding RM303,000. Authorities have also warned that university students are increasingly targeted through fraudulent job offers, fake scholarship schemes, investment scams, and impersonation phone calls. Furthermore, the Department of Statistics Malaysia (DOSM) reported that the national crime index increased by 11.1% in 2024, reflecting broader safety challenges that may affect young adults, including students. Although the Ministry of Higher Education (MOHE) reported that no criminal cases were associated with the 37 student deaths recorded at public universities between 2021 and 2025, it has reinforced campus safety measures and emphasised the importance of proactive monitoring and student welfare. These developments highlight the need for stronger collaboration and more effective communication between higher education institutions, students, and parents to enhance awareness, promote timely support, and strengthen students' holistic development. In this context, MyParentCare (MPC) is proposed as a digital platform that improves parent and institution communication through real-time student activity monitoring and participation updates.

5.0 CONCLUSION

MyParentCare (MPC) is more than a digital platform for monitoring student activities. It is an innovative solution that bridges the communication gap between higher education institutions, students, and parents. By providing real-time activity updates, QR code attendance verification, and meaningful participation reports, the platform enhances transparency, strengthens parent engagement, and supports holistic student development. Developed based on the needs of Kolej Poly-Tech MARA (KPTM) Batu Pahat, MyParentCare demonstrates how digital innovation can create a more connected and supportive educational ecosystem. The platform empowers parents to remain informed, enables institutions to improve student activity management, and encourages students to become more active, responsible, and engaged in campus life.

With its scalable architecture and practical implementation model, MyParentCare has strong potential to be adopted across universities, polytechnics, community colleges, TVET institutions, and other higher education providers in Malaysia. Ultimately, this innovation is not only about monitoring student participation. It is about strengthening trust, fostering collaboration, and building a safer, more transparent, and student-centred higher education environment where every stakeholder plays an active role in shaping future graduates.

ACKNOWLEDGEMENT

The authors would like to express their deepest gratitude to Kolej Poly-Tech MARA Batu Pahat (KPTMBP) for providing continuous support, facilities, and encouragement throughout the development of MyParentCare (MPC). We also extend our sincere appreciation to the management, academic staff, students, and all individuals who contributed their valuable insights, feedback, and cooperation during the planning, design, and development of this innovation. Their support has been instrumental in the successful completion of this project and its preparation for the Digitalised International Invention, Innovation and Design Competition (DIIID) 2026

REFERENCES

Bergdahl, N., Bond, M., Sjöberg, J., Dougherty, M., & Oxley, E. (2024). Unpacking Student Engagement in Higher Education Learning Analytics: A Systematic Review. International Journal of Educational Technology in Higher Education, 21, 63.

Department of Statistics Malaysia. (2025). Crime Statistics, Malaysia 2025. https://www.dosm.gov.my

Ministry of Higher Education Malaysia. (2026). Deputy minister: 37 student deaths at public universities in five years, no criminal cases recorded. Malay Mail.

Nkomo, L. M., Daniel, B. K., & Butson, R. (2021). Synthesis of Student Engagement with Digital Technologies: A Systematic Review of the Literature. International Journal of Educational Technology in Higher Education, 18, 34.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. Journal of Management Information Systems, 24(3), 45–77.
Royal Malaysia Police. (2026). 61 tertiary students fell victim to scams in first quarter, say cops. The Star.
See, B. H., Gorard, S., El-Soufi, N., Lu, B., Siddiqui, N., & Dong, L. (2020). A Systematic Review of the Impact of Technology-Mediated Parental Engagement on Student Outcomes. Educational Research and Evaluation, 26(3–4), 150–181.
Peng, Y., Alias, B. S., Wan, X., & Mansor, A. N. (2026). The impact of parental involvement on sustainable school in improving educational quality: a systematic review. Discover Sustainability, 7(1), 608.
Universiti Putra Malaysia. (2026). Online scammers: A threat to public university students in Malaysia.

GRADTRACKR PRO: AN ALL-IN-ONE PREDICTIVE PATHWAY NAVIGATOR AND MILESTONE AUDITOR FOR HIGHER EDUCATION

Zalina Kemat[1,*], Aidahani Ahmad [1]

[1]Kolej Poly-Tech MARA Batu Pahat, Johor, Malaysia

[*]Corresponding author: zalina@kptm.edu.my

ABSTRACT

Graduate underemployment and the absence of effective academic pathways remain persistent challenges for higher education institutions worldwide which affect both student retention and long-term employability. In Malaysia, official statistics indicate more than one-quarter of university graduates experience skill-related underemployment. This paper introduces GradTrackr Pro, an advanced pilot prototype designed to automate degree auditing while strengthening the alignment between academic progression and career readiness. Continuing from the award-winning conceptual framework which won the Best Extended Abstract and Silver Award at the 3MPIC 2025 competition, the platform integrates real-time academic tracking, AI-powered course recommendations, psychometric profiling, and employer engagement within a single digital ecosystem. Directed by the United Nations Sustainable Development Goals (SDG 4: Quality Education and SDG 8: Decent Work and Economic Growth), GradTrackr Pro combines Smart Progress Auditing, an Opportunity Engine based on Holland's RIASEC model, and Predictive Intervention Alerts to identify academic risks before they delay graduation. Developed using React Native, React.js, and Firebase, the prototype also incorporates a verified Skill Passport and an employer-facing talent discovery platform. Introductory evaluations indicate that transcript auditing can be reduced from hours to seconds, giving academic departments at KPTM Batu Pahat a reliable source of student progression data while enabling more timely academic interventions. Initial projections further suggest that graduates may achieve between 80 and 90% alignment between competencies and career pathways upon completion. GradTrackr Pro can be commercialised as a scalable software-as-a-service (SaaS) solution that aims to reduce administrative inefficiencies, minimise graduation delays, and strengthen the connection between higher education and workforce readiness.

Keywords: graduate employability, academic advising, predictive pathway, RIASEC model, software-as-a-service

1.0 INTRODUCTION

The transition from higher education to meaningful employment represents one of the most critical phases in a student's life, but for many diploma holders, this transition is fraught with uncertainty and structural misalignment. In Malaysia, data from the Department of Statistics Malaysia (DOSM, 2022) indicate that skill-related underemployment affects 26.9% of graduates, resulting in over 1.5 million individuals working in occupations that do not utilize their qualifications. Research by Krishnan and Salahudin (2023) further emphasizes that acute education-job mismatches, compounded by limited career clarity during tertiary study, significantly elevate graduate unemployment rates. While commercial platforms such as LinkedIn offer general professional networking, they fail to provide the structured, developmental guidance necessary to build foundational skills during a student's academic journey.

Concurrently, academic institutions face a severe administrative bottleneck on campus. Academic advising literature demonstrates that advisors play a vital role in student retention when focused on developmental mentorship. In practice, however, advisors routinely spend up to 70% of their working hours trapped in repetitive, manual transcript audits. A single overlooked elective or miscalculated prerequisite can force a student to remain enrolled for an extra semester, incurring thousands of Ringgit in unplanned tuition fees and delaying workforce entry.

To assist with the crisis on campus and in the labor market, our team conceptualised GradTrackr, which was initially presented as a theoretical framework that won the Best Extended Abstract and Silver Award at the 3MPIC 2025 event; the project has now evolved into a fully functional pilot prototype called GradTrackr Pro. By aligning directly with United Nations Sustainable Development Goal 4 (Quality Education) and Goal 8 (Decent Work and Economic Growth), GradTrackr Pro transforms passive degree monitoring into an active, predictive navigation experience that safeguards student progression and accelerates career readiness.

2.0 OBJECTIVE

The development of GradTrackr Pro is guided by three specific objectives:

1. To automate degree auditing workflows by integrating real-time campus data synchronisation, replacing manual spreadsheet reviews with instant algorithmic calculations.
2. To mitigate academic attrition and graduation delays by implementing predictive intervention alerts that notify counsellors and students of missing milestones before course registration deadlines.
3. To enhance graduate employability by uniting Holland's RIASEC psychometric profiling, targeted microlearning recommendations, and an employer-facing Talent Search module into a single digital platform.

3.0 METHODOLOGY

3.1 SYSTEM ARCHITECTURE AND SOFTWARE STACK

GradTrackr Pro was built using a human-centred design-thinking framework specifically tailored for educational software development. The front-end application is developed using React Native for cross-platform mobile compatibility and React.js for the administrative web interface. The backend relies on a Firebase cloud architecture that facilitates real-time data synchronisation between student profiles and institutional record databases.

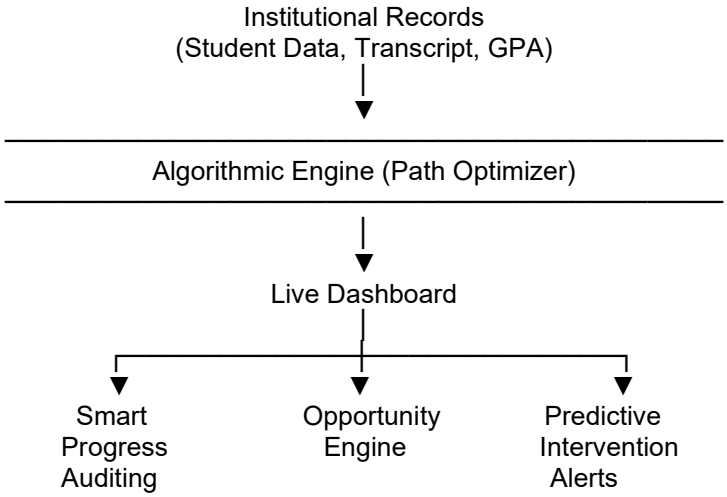


Figure 1: System architecture flow detailing data synchronisation across the three operational pillars.

3.2 THE THREE OPERATIONAL PILLARS

The platform's functional core is organised around three pillars:

Pillar One; the Smart Progress Auditing, links directly with institutional database records to eliminate manual transcript checks. It automatically tracks credit accumulation, identifies fulfilled programme requirements, and maps out the most direct pathway to graduation.

Pillar Two; the Opportunity Engine, grounded in Holland's (1997) RIASEC personality theory, evaluates student interests across Realistic, Investigative, Artistic, Social, Enterprising, and Conventional dimensions. The engine correlates RIASEC profiles with current labour market trends, suggesting specialised microlearning courses and scholarship opportunities.

Pillar Three; the Predictive Intervention Alerts, draws on early warning models evaluated in learning analytics literature (Taqatqeh & Agoyi, 2026); the system continuously tracks academic trajectory. If a student falls behind or faces a prerequisite conflict, automated flags alert advisors to initiate timely support.

3.3 WORKFORCE ALIGNMENT TOOLKIT

To ensure that students enter the job market with demonstrable competencies, GradTrackr Pro incorporates three specialised interfaces:

i. Skill Passport: A digital portfolio that awards shareable, verified badges upon the completion of specific academic and microlearning achievements.
ii. AI Career Match and Gap Analysis: An analytical module that evaluates current student transcripts against active industry job descriptions, highlighting exact skill gaps prior to graduation.
iii. Talent Search Interface: An employer portal that allows industry recruiters to discover graduating students based on verified skill badges and RIASEC career alignment.

Table 1: System Comparison: Traditional Advising Workflows vs. GradTrackr Pro

Functional Dimension	Traditional Advising Workflows	GradTrackr Pro System
Audit Speed	Hours per student transcript	Completed in seconds via algorithmic engine
Data Synchronization	Manual input / static spreadsheets	Direct database integration and real-time updates
Risk Detection	Reactive (handled after course failure)	Predictive (early warning intervention flags)
Career Integration	Isolated from academic auditing	Integrated RIASEC profiling and Skill Passport
Data Integrity	Vulnerable to manual oversight	Single, verifiable source of institutional truth

4.0 RESULT

Transforming GradTrackr Pro from a mere concept into a functional pilot prototype has produced significant structural and administrative perceptions:

i. Workflow Optimisation: Testing demonstrates that auditing a complete student transcript is compressed from several hours of manual checking to seconds, allowing academic advisors to reallocate their time toward meaningful mentorship.
ii. Institutional Governance: The centralised dashboard provides department heads and registrars with a unified, verifiable dataset on student progression and retention risks across diploma programmes.
iii. Projected Career Readiness: Bridging the gap between graduate competencies and industry needs aligns with national talent framework priorities outlined by TalentCorp Malaysia (2021). By addressing the broader employability dimensions highlighted by Yorke (2010), initial pilot projections estimate that graduating students achieve an 80% to 90% career-readiness alignment upon programme completion.

The primary novelty of GradTrackr Pro lies in unifying credit auditing, predictive advisor alerting, and industry skill verification into a single, cohesive software architecture.

5.0 CONCLUSION

GradTrackr Pro addresses long-standing operational inefficiencies in higher education by converting complex degree structures into transparent, manageable pathways. Moving successfully from a conceptual abstract to a functional pilot prototype, the platform demonstrates how data synchronisation

and early warning analytics can protect students from costly academic delays while reducing advisor burnout. Following full pilot deployment and software copyright registration, GradTrackr Pro is structured for commercialisation as a Software-as-a-Service (SaaS) model, offering colleges, universities, and workforce agencies a scalable tool to strengthen student retention and graduate employability.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to Kolej Poly-Tech MARA Batu Pahat for providing financial and institutional support for this research and to the 3MPIC2025 committee for recognizing the initial conceptual framework.

REFERENCES

Department of Statistics Malaysia. (2022). Labour market review fourth quarter 2022. Official Portal of Department of Statistics Malaysia. https://www.dosm.gov.my

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification." Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, 9–15. https://doi.org/10.1145/2181037.2181040

Drake, J. K. (2011). The role of academic advising in student retention and persistence. About Campus, 16(3), 8–12. https://doi.org/10.1002/abc.20062

Elliott, C. (2020). Academic advising as a developmental process in higher education. Journal of Academic Advising, 22(1), 34–49. https://doi.org/10.1080/08878730.2020.1752001

Holland, J. L. (1997). Making vocational choices: A theory of vocational personalities and work environments (3rd ed.). Psychological Assessment Resources.

Krishnan, H. K., & Salahudin, S. N. (2023). Factors that affect unemployment among graduates in Malaysia. Research in Management of Technology and Business, 4(1), 298–312. https://doi.org/10.30880/rmtb.2023.04.01.025

TalentCorp Malaysia. (2021). Annual review: A report on TalentCorp Group of Companies achievements for the year 2021. Talent Corporation Malaysia Berhad. https://www.talentcorp.com.my

Taqatqeh, S., & Agoyi, M. (2026). Early warning and recommendation system for undergraduate students at higher education institutions based on machine learning methods. PeerJ Computer Science, 12, e3792. https://doi.org/10.7717/peerj-cs.3792

Yorke, M. (2010). Employability: Aligning the message, the medium and academic values. Journal of Teaching and Learning for Graduate Employability, 1(1), 2–12. https://doi.org/10.21153/jtlge2010vol1no1art545

iMatchLI: A SMART INTERNSHIP MATCHING SYSTEM FOR HIGHER EDUCATION STUDENTS

Mohamad Faizi Bin Mohamad Nazri[1,*], Nurhannani Afiqah Binti Mustafa Kamal[1], Izzatul Amaleena Binti Abdullah[1], Noor Suhana Binti Mohd Zain[1], Mohammad Hafizudin Bin Md Jus[1]

[1]Department of General Studies, Kolej Poly-Tech MARA (KPTM) Batu Pahat, Johor

[*]Corresponding author: faizi.nazri@kptm.edu.my

ABSTRACT

Industrial training is an integral component of higher education that enables students to bridge academic learning with practical workplace experience while developing competencies required by industry (Caballero, 2026; Vlachopoulos, 2026). However, identifying suitable internship placements remains a persistent challenge, as students often rely on multiple recruitment platforms, institutional announcements, and personal networks to search for opportunities (Qu, 2026; Zhang, 2026). Existing platforms provide extensive internship listings but are primarily designed for general recruitment, requiring students to manually evaluate opportunities based on their academic background, skills, career interests, and preferred locations. This fragmented approach increases the likelihood of mismatched placements and prolongs the internship search process. To address these challenges, this paper proposes iMatchLI: A Smart Internship Matching System for Higher Education Students, an intelligent digital platform designed specifically to support internship placement within higher education institutions. The proposed system integrates a centralised internship database with a smart recommendation framework that aggregates multiple conflicting criteria (Canay, 2026; Jannach & Abdollahpouri, 2023), including students' academic programmes, technical skills, career interests, preferred internship locations, and organisational requirements. By consolidating internship information and automating the recommendation process, iMatchLI aims to provide a more systematic, transparent, and efficient approach to internship matching. In contrast to existing recruitment platforms that focus primarily on employment opportunities, the fundamental novelty of iMatchLI lies in its tripartite optimisation framework, which shifts the matching paradigm from a simple keyword-based job search to a structured alignment of institutional educational objectives, student career pathways, and real-time corporate parameters. iMatchLI is designed to support the unique requirements of higher education institutions by aligning internship recommendations with academic objectives and industry expectations. The proposed innovation is expected to reduce students' time and effort in identifying suitable internship organisations, improve the quality of internship placements, and assist institutions in managing internship processes more effectively. Overall, iMatchLI offers an enhanced approach to internship management by integrating intelligent recommendations, institutional coordination, and centralised information management within a single platform, thereby supporting graduate employability, strengthening university–industry collaboration, and contributing to the digital transformation of internship management (Otieno, 2026; Shambare, 2025; Valencia-Forrester, 2025).

Keywords: internship matching, recommendation system, industrial training, higher education, graduate employability

1.0 INTRODUCTION

Industrial training is essential in higher education, enabling students to apply academic knowledge in workplaces while developing professional competencies and employability skills. Yet, students face fragmented searches across portals, and text analytics reveal substantial skill mismatches in online recruitment frameworks (Canay, 2026; Tang, 2025). Effective internship placement enhances student career readiness and helps higher education institutions produce graduates whose competencies structurally align with industry expectations (Congna, 2025; Haryanta, 2026).

Despite its importance, finding suitable placements remains a significant challenge. Internship opportunities are scattered across multiple platforms and networks, forcing extensive manual searches to match academic programmes, technical skills, career interests, and locations (Faizin & Aziaka, 2024;

Wahrini, 2025). This fragmented process is time-consuming and often results in unsuitable placements that fail to support learning objectives.

While online recruitment platforms connect organisations with candidates, they prioritise general recruitment over academic internship management. Although general portals reduce search costs, empirical studies show inconsistent matching quality (Zheng et al., 2023). Their recommendation mechanisms typically emphasise commercial criteria and keywords rather than educational factors, such as learning outcomes, competencies, and institutional requirements (Demafeliz, 2025; Shambare, 2025). Consequently, students must manually evaluate options, leaving institutions with limited support in coordinating placements systematically.

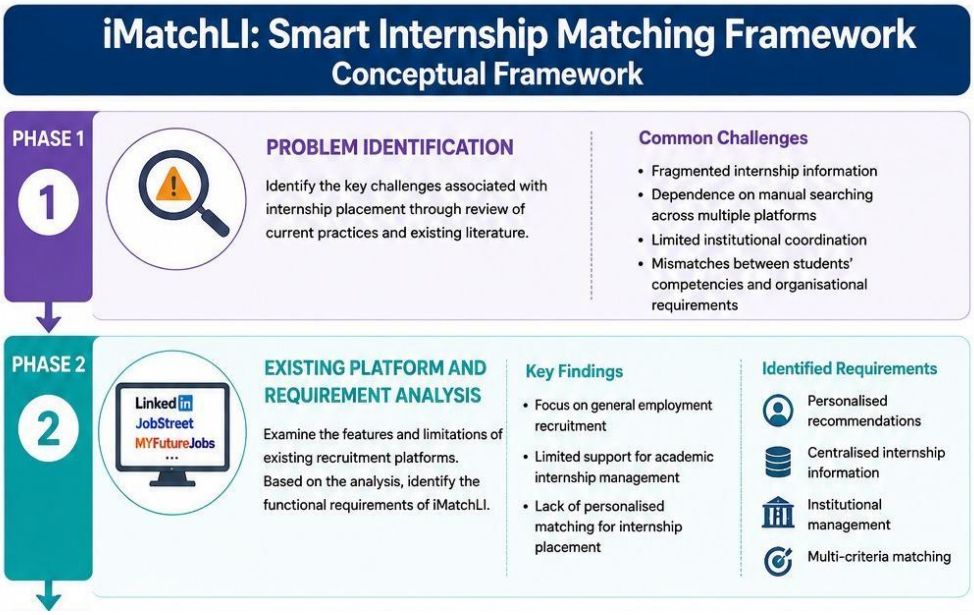
Recognising these limitations, this paper proposes iMatchLI: A Smart Internship Matching System for Higher Education Students. Unlike conventional systems, iMatchLI integrates a centralised database with a smart recommendation framework that analyses multiple student and organisational attributes for personalised matching. It addresses variables determining the long-term employment status of university graduates (Portocarrero Ramos, 2025; Shah, 2025) while accounting for rapid artificial intelligence integration in digital systems (Mohamed, 2026). Combining intelligent matching with institutional management improves placement efficiency, minimises academic mismatches, and aligns education with high-value labour market entry (Klausen, 2024).

2.0 OBJECTIVE

1. To propose a smart internship matching framework that generates personalised internship recommendations based on students' academic profiles, technical skills, career interests, preferred locations, and organisational requirements.
2. To design a centralised digital platform that consolidates internship opportunities and organisational information, thereby supporting internship placement within higher education institutions.
3. To enhance the efficiency, transparency, and effectiveness of internship placement by reducing manual searching and improving the alignment between students' competencies and industry requirements.

3.0 METHODOLOGY

The proposed iMatchLI framework was developed using a Design-Based Innovation (DBI) approach to systematically address the structural challenges of internship placement in higher education. This methodology encompasses five interconnected phases: problem identification, the analysis of existing internship practices and recruitment platforms, requirement analysis, conceptual framework design, and future validation planning. Together, these distinct phases guided the development of the proposed smart internship matching framework as illustrated in the conceptual workflow.



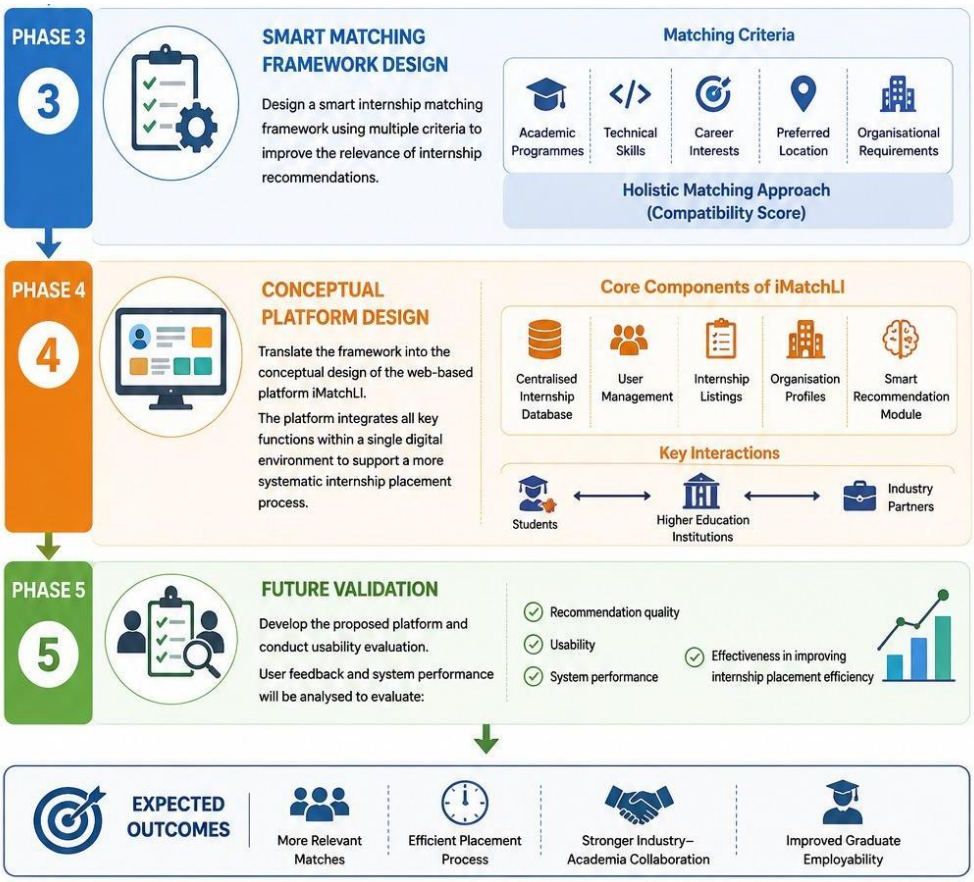


Figure 1: Conceptual Framework

3.1 SMART MATCHING ENGINE ARCHITECTURE

To calculate the compatibility score, the system uses a centralised hybrid engine that combines Sentence-BERT (SBERT) with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). The engine operates in two streamlined stages. First, an SBERT model converts qualitative text—such as academic programmes, technical skills, and career interests—into mathematical vector embeddings. A cosine similarity calculation then measures the semantic closeness between the student profile and company descriptions, ensuring the system captures true contextual meaning rather than basic keywords. Second, these semantic scores are integrated with location preferences and organisational requirements into a TOPSIS decision matrix. The engine calculates how close each internship is to a theoretical perfect solution versus the worst option, aggregating these variables into a single, transparent compatibility percentage. This provides institutional coordinators with a highly reliable, auditable metric to efficiently verify and approve optimal student placements.

4.0 RESULT

A preliminary requirement analysis was conducted through structured interviews with institutional internship coordinators to ground the development of the framework. The findings confirmed that 80% of their administrative time is spent manually verifying if student core competencies align with host company requirements, validating the immediate need for iMatchLI's automated compatibility scoring. The technological innovation of this framework lies in its departure from traditional binary talent acquisition workflows. By introducing a centralised multi-criteria matching engine that processes five heterogeneous qualitative data points simultaneously, iMatchLI introduces a predictive compatibility metric that accounts for academic progression. This system successfully digitises institutional oversight, a capability that is entirely absent in generic corporate recruitment platforms.

By directly addressing this administrative bottleneck, the proposed iMatchLI framework is expected to significantly optimise the internship placement process. The system provides a systematic, efficient,

and personalised approach to matching higher education students with suitable industrial training organisations. By integrating a centralised internship database with a smart recommendation framework, the system drastically reduces students' dependence on manual searching across multiple external recruitment platforms and improves overall placement accuracy.

The proposed framework generates these personalised recommendations by analysing multiple matching criteria simultaneously, including students' academic programmes, technical skills, career interests, preferred internship locations, and organisational requirements. Unlike conventional recruitment platforms that primarily rely on basic keyword-based searches, iMatchLI adopts a holistic multi-criterion matching approach. This ensures that recommended positions directly align with the students' educational pathways, institutional learning outcomes, and long-term career aspirations.

Ultimately, the implementation of the proposed framework is expected to benefit multiple stakeholders. Students will experience a streamlined internship search process with improved access to positions that match their qualifications. Higher education institutions will gain a centralised approach to coordination, which will enable efficient placement monitoring and stronger industry collaboration. Concurrently, host organisations will receive applicants whose competencies already structurally align with their operational requirements, leading to high-quality, mutually beneficial internship placements.

5.0 CONCLUSION

This paper proposes iMatchLI, a smart internship matching system designed to improve internship placement in higher education institutions through a centralised internship database and a multi-criteria recommendation framework. By matching students' academic profiles, skills, career interests, preferred locations, and organisational requirements, the proposed system aims to provide more efficient and relevant internship recommendations and support a more systematic placement process.

Unlike legacy systems that isolate academic performance from market hiring data, iMatchLI provides a novel, unified environment where university learning outcomes directly influence algorithmic recommendation weights. As a conceptual innovation, iMatchLI has the potential to enhance collaboration between higher education institutions and industry partners, improve graduate employability, and contribute to the digital transformation of internship management. Future work will focus on developing the platform and validating its effectiveness through empirical evaluation.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to Kolej Poly-Tech MARA (KPTM) Batu Pahat for its continuous support and encouragement throughout the conceptualisation and preparation of this proposed innovation. Appreciation is also extended to the Department of General Studies, fellow colleagues, and all individuals who shared valuable ideas, constructive feedback, and professional insights that contributed to the refinement of the iMatchLI framework. The authors are equally grateful to industry practitioners and higher education stakeholders whose perspectives on internship placement challenges inspired the development of this proposed solution. Their encouragement and support have been instrumental in strengthening the quality and relevance of this work.

REFERENCES

Caballero, C. L. (2026). Untangling graduate employability and work readiness to inform evidence-based practice in higher education. Higher Education Research & Development, 45(1), 12–29. https://doi.org/10.1080/07294360.2026.2615303

Canay, Ö. (2026). An interpretable CF-RL-TOPSIS fusion model for skills-aware talent recommendation. arXiv preprint arXiv:2605.24155, 1–15. https://arxiv.org/abs/2605.24155

Congna, H. (2025). The impact of human capital on employment quality: a scoping review. Cogent Education, 12(1), 1–18. https://doi.org/10.1080/2331186X.2025.2552352

Demafeliz, R. E. (2025). A tracer study on employment outcomes and career progression of Bachelor of Science in Information Technology (BSIT) graduates. Philippine E-Journals, 14(2), 89–104. https://ejournals.ph/issue.php?id=2210

Faizin, A., & Aziaka, D. S. (2024). Web-based decision support system for internship placement recommendations. JOKI: Journal of Computing and Informatics, 3(1), 149–159. https://ejournal.duniakampus.org/index.php/joki/article/view/375

Haryanta, D. (2026). Lecturer competence and internship programmes as catalysts for developing agricultural education graduates' competencies for the world of work. Cogent Education, 13(1), 1–21. https://doi.org/10.1080/2331186X.2026.2639260

Jannach, D., & Abdollahpouri, H. (2023). A survey on multi-objective recommender systems. Frontiers in Big Data, 6(1157899), 1–22. https://doi.org/10.3389/fdata.2023.1157899

Klausen, T. B. (2024). Graduate employment at a WIL-like university: Does student employment matter? Journal of International Work-Integrated Learning, 42(3), 201–217. https://publicera.kb.se/ciwil/article/download/64128/53716

Mohamed, E. A. S. (2026). Regulating artificial intelligence in digital media: governance, ethics, ownership, and democratic resilience (2023–2026 review). Frontiers in Communication, 11(1823630), 1–14. https://www.frontiersin.org/journals/communication/articles/10.3389/fcomm.2026.1823630/full

Otieno, L. (2026). Enhancing graduate employability through employers' engagement in work-integrated learning in Tanzanian technical and vocational education and training institutions. Journal of Research Innovation and Implications in Education, 10(1), 49–63. https://www.jriiejournal.com/wp-content/uploads/2026/03/JRIIE-10-1-049-.pdf

Portocarrero Ramos, H. C. (2025). Career paths and university education: factors that determine the employment status of university graduates. Frontiers in Education, 10(1664249), 1–13. https://www.frontiersin.org/journals/education/articles/10.3389/feduc.2025.1664249/full

Qu, H. (2026). User acceptance of a proposed static-dynamic employment recommendation approach among computer science graduating students. Information, 17(5), 479–495. https://www.mdpi.com/2078-2489/17/5/479

Shah, Z. (2025). Higher education linkage with industries in Pakistan: An analysis. International Journal of Social Sciences Bulletin, 1(1), 599–615. https://pjssrjournal.com/index.php/Journal/article/view/599

Shambare, B. (2025). Work-integrated learning in an AI-driven era: A bibliometric review of research themes and emerging trends. ERRCD Forum Books, 4(1), 112–135. https://pubs.ufs.ac.za/index.php/ijgs/article/view/2475

Tang, F. (2025). Explainable person–job recommendations: challenges, approaches, and comparative analysis. Frontiers in Artificial Intelligence, 8(1660548), 1–19. https://www.frontiersin.org/journals/artificial-intelligence/articles/10.3389/frai.2025.1660548/full

Valencia-Forrester, F. (2025). Enhancing student success in virtual work-integrated learning: The critical role of mental health and wellbeing support. International Journal of Work-Integrated Learning, 26(4), 683–700. https://www.ijwil.org/files/IJWIL_26_4_683_700.pdf

Vlachopoulos, D. (2026). Preparing university graduates for the labor market through employability skills development and university–industry collaboration: A systematic review. Education Sciences, 16(3), 426–448. https://doi.org/10.3390/educsci16030426

Wahrini, R. (2025). AI-driven career guidance to reduce vocational students' career path anxiety through skills mapping, adaptive mentoring, and labor market intelligence. F1000Research, 15(298), 1–12. https://journal.50sea.com/index.php/IJIST/article/view/1835

Zhang, J. (2026). The analysis of college students' employment information management system based on big data and artificial intelligence. International Journal of Information and Communication Technology Education, 22(1), 45–59. https://www.igi-global.com/article/the-analysis-of-college-students-employment-information-management-system-based-on-big-data-and-artificial-intelligence/406760

Zheng, Z., Qiu, Z., Hu, X., Wu, L., Zhu, H., & Xiong, H. (2023). Generative job recommendations with large language model. arXiv preprint arXiv:2307.02157, 1–11. https://arxiv.org/abs/2307.02157

E-DICTIONARY OF HADITH TERMINOLOGY APPLICATION (IS-HADIS)

Suriani Sudi[1,*], Siti Mursyidah Mohd. Zin[1], Phayilah Yama[1], Nor Musliza Mustafa[1]
Rosni Wazir[1], Nur Saadah Khair[2]

[1] Universiti Islam Selangor
[2] Universiti Sains Islam Malaysia

*Corresponding author: suriani@uis.edu.my

ABSTRACT

The integration of digital technology in Islamic studies has become a core requirement to ensure that knowledge dissemination remains dynamic and relevant to the 21st-century educational landscape. However, the current learning process for the Ulum Hadith discipline faces several critical issues. These include a heavy reliance on conventional, less-interactive, one-way lecture methods and major challenges faced by higher education institution (HEI) students in understanding original reference texts due to poor mastery of Arabic terminology. This problem is further compounded by the use of conventional physical dictionaries—spanning 631 pages—which are inefficient and time-consuming for the digital generation. Concurrently, educational institutions face constraints in meeting the digitalisation standards outlined by the Malaysia Education Blueprint (Higher Education) and the National e-Learning Policy (DePAN 2.0). In response, this study aims to modernise the referencing of Hadith terminology by shifting from manual methods to an authentic, rapid, and user-friendly mobile application. The developed innovative product is the E-Dictionary of Hadith Terminology Application (IS-HADIS), a bookless mobile learning platform based on authoritative texts published by INHAD, Universiti Islam Selangor (UIS). The application integrates a smart search function, responsive user interface, multimedia, and a gamification module containing five interactive games. The unique value lies in combining the literal meaning, scholarly definitions, and concise explanations for each entry, accessible for boundless self-paced learning. Ultimately, IS-HADIS successfully bridges the mastery gap in Hadith terms, enriches Islamic ICT research, and delivers a strategic impact on educational digitalisation.

Keywords: e-dictionary, hadith terminology, digital innovation, gamification, mobile learning

1.0 INTRODUCTION

The development of this digital innovation was conducted to meet the requirements of educational institutions. In line with the advancements of the 21st-century educational wave, the integration of digital technology within the field of Islamic studies has become a necessity to keep the delivery of knowledge dynamic, interactive, and relevant.

The innovative product developed in this research is the E-Dictionary of Hadith Terminology Application (IS-HADIS). This innovation is a mobile digital application that transforms the method of searching for Hadith terminology from a manual approach (based on physical textbooks) into a smart, rapid, and bookless search method.

The primary content of this application is sourced from the authoritative text of *Kamus Istilah Hadis* published by the Institute of Hadith and Aqidah Studies (INHAD), Universiti Islam Selangor (UIS), which is a translation of the original Arabic work titled *Mu'jam al-Mustalahat al-Hadithiyyah* by Dr. Syed Abd al-Majid al-Ghouri (Ghouri, S. A. M., 2012).

The IS-HADIS application is designed with user-friendly features utilising an m-learning (mobile learning) approach (Sudi S et al., 2026). Rather than functioning merely as a static dictionary, it integrates several interactive components to strengthen its overall functionality:

- **User Interface Component (Preface):** Provides a brief introduction, usage guide, and clear navigation (Figure 1)



Figure 1: Preface

- **Hadith Terminology Dictionary Component:** Houses term entries along with their literal meanings, technical definitions by Hadith scholars, and brief contextual explanations in the Malay language (Figure 2)



Figure 2: Hadith Terminology Dictionary Component

- **Interactive Gaming Component (Gamification):** Contains five educational game series—namely *Wira Kata* (Word Hero), *Token Ajaib* (Magic Token), *Teka Saya* (Guess Me), *Roda Syarat* (Wheel of Criteria), and *Kembara Hukum* (Ruling Adventure)—to reinforce user memory in a relaxed and enjoyable manner (Figure 3)



Figure 3: Interactive Gaming Component (Gamification)

The development of the IS-HADIS application is driven by several major issues in the current educational ecosystem. First, the integration of Information and Communication Technology (ICT) in Hadith studies is increasingly essential, as the use of technology has proved to enhance students' learning effectiveness, interest, and acceptance. The mobile learning approach also aligns with the aspirations of the Industrial Revolution 4.0, which demands that educators adopt more flexible, interactive, and technology-orientated teaching methods (Hoque et al., 2017; Dol Kawaid et al., 2018; Halim et al., 2018; Ujir et al., 2020).

Furthermore, most primary reference texts in the field of Ulum Hadith are written in Arabic, employing highly technical terminology that is difficult to comprehend for a large portion of higher education institution students in Malaysia. This language barrier hinders students from gaining a deep understanding of Hadith concepts, thereby signalling the need for digital reference sources in the Malay language that are more accessible and easier to comprehend (Azizan et al., 2014; Soroni, 2011; Kamaruddin et al., 2025; Halim et al., 2018).

In addition, utilising the physical printed version of the *Kamus Istilah Hadis* presents limitations in terms of size, weight, and search methods, which require users to look up terms manually, making the learning process less efficient. This reality necessitates the development of a digital application that offers quick search functionalities and a more user-friendly interface to support the teaching and learning process (Sudi et al., 2026).

The development of IS-HADIS also supports the national educational digitalisation agenda outlined in the Malaysia Education Blueprint (Higher Education) 2015–2025 and the National e-Learning Policy (DePAN 2.0). These policies promote the use of mobile technology to establish a more proactive, flexible, and student-centred learning environment (Ministry of Education Malaysia, 2015; Nerrahim & Hanif, 2022).

2.0 OBJECTIVE

- To modernise the reference process for Hadith terminology by replacing manual methods based on printed books with an authentic, fast, and user-friendly mobile digital application.
- To simplify the understanding and verification of Hadith terms through a centralised database that compiles literal definitions, scholarly expositions, concise explanations, and interactive games.
- To enhance Hadith literacy and digital awareness among students and lecturers by providing a systematic, interactive learning module that is relevant to the contemporary needs of Islamic education.

3.0 METHODOLOGY

The application was developed based on users' needs and expert consensus to provide an accessible, engaging, and effective digital learning environment for students and lecturers.

3.1 Main Features of the IS-HADIS Application

The application consolidates digital technology, interactive multimedia, and gamification elements into a single mobile platform. The summary of its primary features is as follows:

- **Comprehensive Database:** The application provides a database containing complete and authoritative Hadith terminology based on the *Kamus Istilah Hadis* published by INHAD, systematically arranged.
- **Keyword-Based Smart Search:** The system is equipped with an instant keyword search function that accelerates the information retrieval process, thereby increasing the efficiency of learning activities.
- **Clear & Easy-to-Understand Content:** All contained terms are presented in a concise format without compromising academic accuracy, allowing users to master the concepts thoroughly rather than relying on mere memorisation.
- **Interactive Multimedia Integration:** This innovation combines audio, graphics, animation, and interactive visuals to explain complex Hadith concepts visually.
- **Educational Gamification Module:** The development of this application includes a series of educational games that act as a formative assessment medium to test, reinforce understanding, and strengthen memory retention.

- **User-Centred Design (UCD):** The user interface design is developed based on user-centred design principles and expert evaluation to ensure that the navigation system can be operated intuitively without requiring specialised skills.

3.2 Additional Features & Proven Innovation Effectiveness

- **Boundless Mobile Learning:** The application can be used via smartphones and tablets at any time and place, thus supporting the concept of mobile learning and lifelong learning.
- **Scientifically Validated Effectiveness:** The effectiveness of the application was evaluated using the Design and Development Research (DDR) approach. The evaluation results showed that all major components (interface, dictionary, multimedia, games) achieved a usability score exceeding 85%, proving the practical quality of this digital product.

3.3 Product Novelty Value

Unlike printed Hadith terminology dictionaries, which are static, IS-HADIS integrates a digital dictionary, interactive multimedia, and gamification into a single mobile application. This combination facilitates rapid access and creates an interactive, flexible, and user-centred learning experience that supports the transformation of Islamic education.

3.4 Product Functionality

The IS-HADIS application functions as a comprehensive digital reference and mobile learning platform to support the teaching and learning (T&L) of Ulum Hadith. By integrating core informational components, the application successfully delivers the following strategic functionalities:

- **Rapid Hadith Term Search:** Provides a smart search system based on keywords to obtain instant definitions without manual browsing.
- **Authoritative Digital Reference:** Provides entries containing literal meanings, technical definitions, and centralised huraian to support the accuracy of academic content.
- **Self-Paced & Academic Learning Support:** Enables multimedia interaction to cater to diverse m-learning styles while serving as a formative assessment medium through gaming.

3.5 Product Usefulness

IS-HADIS benefits the academic community. The application helps enhance understanding, reduces misinterpretation of technical terms, and supports the preparation of lecture materials. It holds the potential to become a large-scale digital reference platform widely adopted by training institutions and Islamic educational organisations to broaden access to information regarding Ulum Hadith terms.

3.6 Product Practicality

From a practical perspective, users only require a smartphone or tablet without the physical burden of a thick book, making it flexible for use anywhere. The intuitive system layout allows operation without specialised training. In terms of implementation, the application is economical, free from high operational costs, easy to update, and ready for sustainable integration into the Islamic education ecosystem based on its robust DDR score (>85%).

4.0 PRODUCT NOVELTY

IS-HADIS is the first digital application in the Malay language that focuses interactively on Hadith terminology. Its distinctiveness lies in the simultaneous integration of three components (literal meaning, scholars' definitions, and expert explanations) alongside smart search modules and gamification. This innovation yields positive outcomes in bridging the term mastery gap among HEI students caused by Arabic language constraints. It brings a strategic impact in fulfilling the mandates of DePAN 2.0 and the MEB HE 2015-2025.

5.0 CONCLUSION

Overall, the development of the E-Dictionary of Hadith Terminology Application (IS-HADIS Dictionary) has successfully transformed a thick physical text into a smart, rapid, and bookless m-learning (*mobile learning*) platform. This innovation proves that the integration of digital technology and interactive gamification elements are capable of overcoming the constraints of manual searching, as

well as bridging the gap in Hadith terminology mastery among students caused by poor Arabic language proficiency.

From the perspective of scholarly contribution, this project enriches the ICT research ecosystem in Islamic studies, particularly within the Ulum Hadith discipline, which is rarely explored in the form of mobile applications. This development offers an authoritative reference model that combines expert explanations with interactive quiz elements to support a future-ready and student-centred learning agenda.

In terms of economic implications, this innovation offers high cost-effectiveness by reducing reliance on periodic physical book printing. The application also has substantial market potential for commercialisation as a high-value educational technology (*edutech*) product.

ACKNOWLEDGEMENT

This study expresses its highest gratitude to the Selangor State Research body for sponsoring this project through the Selangor State Research Grant (GPNS) under research code SUK/GPNS/2023/PKS/06.

REFERENCES

Azizan, K. F. K., Rahman, A. A., & Jamali, H. N. (2014). Tahap kemahiran asas bahasa Arab di IPT Malaysia. GSE e-Journal of Education, 1(2), 20–32. https://www.researchgate.net/profile/Ku-Ku-Azizan/publication/328928308_Tahap_kemahiran_Asas_Bahsa_Arab_di_IPT_MAlaysia/links/5bebe92992851c6b27bd4a4c/Tahap-kemahiran-Asas-Bahsa-Arab-di-IPT-MAlaysia.pdf

Dol Kawaid, A. I. S., Ismail, M. Y., Amin, M. F. M., Aziz, M. K. N A., & Omar, N. (2018). Pengintegrasian aplikasi ict berkaitan hadis di universiti awam Malaysia. Journal of Ma'alim al-Quran wa al-Sunnah, 14(2), 131–138. https://doi.org/10.33102/jmqs.v14i2.133

Ghouri, S. A. M. (2012). Kamus istilah hadis. Institut Kajian Hadis dan Akidah (INHAD). https://www.researchgate.net/publication/337059774_KAMUS_ISTILAH_HADIS

Halim, A. A., Anas, N., Zulkipli, S. N., Yaacob, Z., Noor, M. S. M., Ghazali, Z. M., Azmi, A. S., & Hassan, S. N. S. (2018). Popularity of digital hadith application (DHA) in Malaysia. International Journal of Civil Engineering and Technology, 9(10), 1382–1390. https://www.researchgate.net/publication/328653774_Popularity_of_Digital_Hadith_Application_DHA_in_Malaysia

Hoque, M., Rab, M., Said, W., Ghazali, N. M., Mohamed, Y., & Toure, A. K. (2017). Application of modern technology in the study of hadith and its sciences: A case study. Advanced Science Letters, 23(5), 4773–4776. https://doi.org/10.1166/asl.2017.8895

Kamaruddin, K., Bakar, M. A., & Aziz, N. I. (2025). Cabaran dan strategi penguasaan Bahasa Arab dalam program Diploma Pengajian Islam: Kajian di UNISHAMS. International Journal of Education, Psychology and Counseling (IJEPC), 10(57), 801–823. https://www.researchgate.net/publication/392270721_Cabaran_Dan_Strategi_Penguasaan_Bahasa_Arab_Dalam_Program_Diploma_Pengajian_Islam_Kajian_Di_UniSHAMS

Kementerian Pendidikan Malaysia. (2015). Pelan pembangunan pendidikan Malaysia pendidikan tinggi 2015-2025. https://www.mohe.gov.my/muat-turun/penerbitan-jurnal-dan-laporan/pppm-2015-2025-pt/103-pelan-pembangunan-pendidikan-malaysia-2015-2025-pendidikan-tinggi/file (Accessed on July 19, 2026)

Nerrahim, N. H., & Hanif, H. A. (2022). Penerimaan pelajar terhadap penggunaan telefon pintar sebagai alat pembelajaran. Jurnal Kejuruteraan, Teknologi dan Sains Sosial (JKTS), 8(1), 108–117. https://www.puo.edu.my/webportal/wp-content/uploads/2022/10/14.-PENERIMAAN-PELAJAR-TERHADAP-PENGGUNAAN-ID54.pdf

Soroni, M. K. (2011). Pemikiran dan kritikan Syeikh 'Abd al-Fattah Abu Ghuddah dalam beberapa isu 'Ulum al-Hadith. Jurnal Hadis, 1(2), 47–77. http://lms.kuis.edu.my/jurnal/wp-content/uploads/2013/11/HADIS_JURNAL_BIL_2_3.pdf

Sudi, S., Zin, M. M. M., Yama, P., Mustafa, N. M., Wazir, R., Ramli, F. Z. M., Hamisan@Khair, N. S., & Najihan, M. A. (2026). Pembangunan aplikasi E-Kamus Istilah Hadis (IS-HADIS) untuk pembelajaran hadis di Selangor. Penerbit Universiti Islam Selangor. ISBN 978-629-7839-65-3 https://www.researchgate.net/publication/410600286_PEMBANGUNAN_APLIKASI_E-KAMUS_ISTILAH_HADIS_IS-HADIS_UNTUK_PEMBELAJARAN_HADIS_

Ujir, H., Salleh, S. F., Marzuki, A. S. W., Hashim, H. F., & Alias, A. A. (2020). Teaching workload in 21st century higher education learning setting. International Journal of Evaluation and Research in Education (IJERE), 9(1), 221–227. http://doi.org/10.11591/ijere.v9i1.20419

COFFEELOOP: A SMART CIRCULAR COFFEE WASTE RECOVERY ECOSYSTEM

Sara Zulkifli[1,*], Aidil Bin Bachok[1], Muhammad Adil Bin Nor Azmi[1]

[1]Kolej Poly-Tech MARA Batu Pahat, Johor, Malaysia

*Corresponding author: sara_zulkifli@kptm.edu.my

ABSTRACT

The rapid growth of coffee consumption has significantly increased the amount of spent coffee grounds (SCG) generated by cafés, hotels, offices, restaurants, and home baristas. Although SCG can be reused for composting, mushroom cultivation, urban farming, and other sustainable applications, most are still disposed of in landfills due to the absence of a structured recovery system. This contributes to landfill accumulation, greenhouse gas emissions, and the loss of valuable bioresources. CoffeeLoop is proposed as a Smart Circular Coffee Waste Recovery Ecosystem that systematically connects coffee waste producers with circular economy users through a dedicated digital ecosystem. Unlike conventional marketplace or waste management platforms, CoffeeLoop focuses on creating a complete circular recovery ecosystem by integrating smart matching, local collaboration, resource recovery, and environmental impact monitoring into a single framework. The proposed ecosystem consists of four main stages: waste generation, smart matching, collection and transfer, and resource regeneration into value-added products such as compost, mushroom growing media, and urban farming materials. The novelty of CoffeeLoop is not in the mobile application. The real innovation is the dedicated circular ecosystem that systematically connects coffee waste producers with circular economy users, enabling efficient resource recovery while strengthening community participation and supporting green entrepreneurship. CoffeeLoop contributes directly to Sustainable Development Goal (SDG) 11: Sustainable Cities and Communities, SDG 12: Responsible Consumption and Production, and SDG 13: Climate Action. The proposed innovation demonstrates strong scalability and commercialisation potential, positioning CoffeeLoop as a sustainable ecosystem that can support future circular economy initiatives in Malaysia.

Keywords: circular economy, coffee waste, spent coffee grounds, sustainability, smart ecosystem

1.0 INTRODUCTION

Coffee consumption has grown steadily worldwide, leading to a significant increase in the generation of spent coffee grounds (SCG). Every day, cafés, restaurants, hotels, offices, and home baristas produce substantial amounts of coffee waste. Despite its high potential for reuse in composting, mushroom cultivation, urban farming, biofertiliser, and other sustainable applications, most SCG is still disposed of in landfills, contributing to environmental pollution and the loss of valuable organic resources (Lopes et al., 2023).

The concept of a circular economy encourages waste materials to be recovered, reused, and regenerated into valuable resources instead of being discarded (Geissdoerfer et al., 2017; Kirchherr et al., 2017). However, existing digital platforms mainly facilitate general buying and selling activities and are not specifically designed to connect coffee waste producers with circular economy users. As a result, spent coffee grounds remain underutilised while potential users continue to face difficulties in obtaining a consistent supply of reusable coffee waste.

To address this gap, CoffeeLoop is proposed as a Smart Circular Coffee Waste Recovery Ecosystem that systematically connects coffee waste producers with circular economy users through a dedicated digital ecosystem. By integrating smart matching, local collaboration, resource recovery, and environmental impact monitoring, CoffeeLoop promotes sustainable resource management while supporting the transition towards a circular economy. This innovation transforms spent coffee grounds from waste into valuable resources, creating environmental, social, and economic benefits for communities and supporting Sustainable Development Goals (SDGs) 11, 12, and 13.

2.0 OBJECTIVE

The development of CoffeeLoop is guided by the following objectives:

1. To develop a dedicated Smart Circular Coffee Waste Recovery Ecosystem that systematically facilitates the recovery, redistribution, and utilisation of spent coffee grounds based on circular economy principles.
2. To connect coffee waste producers with circular economy users through an integrated digital ecosystem that enables smart matching, efficient collection coordination, and local community collaboration.
3. To reduce coffee waste disposal while creating environmental, social, and economic value by transforming spent coffee grounds into valuable resources for composting, mushroom cultivation, urban farming, and other sustainable applications.
4. To promote sustainable resource management and support the Sustainable Development Goals (SDGs) by encouraging responsible consumption, reducing landfill waste, and strengthening community participation in circular economy initiatives.

3.0 METHODOLOGY

CoffeeLoop adopts a circular economy approach by integrating digital technology with a systematic resource recovery framework to establish a sustainable ecosystem for spent coffee grounds (SCG). Unlike conventional marketplace platforms, CoffeeLoop is specifically designed to facilitate the recovery, redistribution, and utilisation of coffee waste through a structured circular ecosystem that connects coffee waste producers with circular economy users (Geissdoerfer et al., 2017; Kirchherr et al., 2017).

The proposed ecosystem consists of four integrated stages, namely coffee waste generation, smart matching and local connection, collection and resource recovery, and resource regeneration.



Figure 1: Conceptual Framework of the CoffeeLoop Smart Circular Coffee Waste Recovery Ecosystem

As illustrated in Figure 1, CoffeeLoop establishes a systematic circular ecosystem that connects coffee waste producers with circular economy users through four core ecosystem functions: smart matching, local connection, resource recovery, and impact tracking.

3.1 COFFEE WASTE GENERATION

The ecosystem begins with the generation of spent coffee grounds by cafés, restaurants, hotels, offices, and home baristas. Instead of disposing of coffee grounds as general waste, producers register and list the available resources through the CoffeeLoop platform for recovery and redistribution. This initial stage ensures that reusable coffee waste is identified and made available for subsequent resource recovery.

3.2 SMART MATCHING AND LOCAL CONNECTION

CoffeeLoop performs smart matching by connecting coffee waste producers with nearby circular economy users based on location, resource availability, and user requirements. This matching process

improves resource accessibility, reduces transportation distance, and promotes local collaboration among compost producers, mushroom growers, community gardens, nurseries, educational institutions, and sustainability practitioners.

3.3 COLLECTION AND RESOURCE RECOVERY

Following successful matching, collection and transfer are coordinated through the platform. Scheduled collection improves operational efficiency while reducing unnecessary transportation and waste. The recovered coffee grounds are then transferred to suitable circular economy users for value recovery and further processing into sustainable products.

3.4 RESOURCE REGENERATION

Recovered spent coffee grounds are transformed into value-added products such as compost, mushroom growing media, soil enhancers, and urban farming materials. This regeneration process extends the lifecycle of coffee waste while promoting circular economy practices and reducing landfill dependency (Lopes et al., 2023). This final stage closes the circular economy loop by converting spent coffee grounds into valuable resources that generate environmental, social, and economic benefits. Figure 2 illustrates the operational workflow of the CoffeeLoop ecosystem from waste generation to resource regeneration.



Figure 2: Operational Workflow of the CoffeeLoop Circular Ecosystem

3.5 DIGITAL ECOSYSTEM SUPPORT

The CoffeeLoop platform supports the ecosystem through producer registration, resource listing, smart matching, collection scheduling, communication management, and environmental impact monitoring. The digital platform functions solely as an enabling technology that facilitates communication, coordination, and impact monitoring throughout the ecosystem.

The novelty of CoffeeLoop does not lie in the mobile application itself. Rather, it lies in the dedicated CoffeeLoop Circular Ecosystem, which systematically connects coffee waste producers with circular economy users through an integrated resource recovery framework. This ecosystem creates environmental, social, and economic value while supporting sustainable resource management, community collaboration, and future scalability.

4.0 RESULT

CoffeeLoop demonstrates the practical application of circular economy principles by transforming spent coffee grounds into valuable resources through a dedicated recovery ecosystem. Unlike conventional marketplace platforms, CoffeeLoop systematically connects coffee waste producers with circular economy users, enabling efficient resource recovery while reducing environmental impacts.

The proposed ecosystem creates environmental, social, and economic value by reducing landfill waste and greenhouse gas emissions, encouraging collaboration among stakeholders, and supporting

the production of value-added products such as compost, mushroom growing media, soil enhancers, and urban farming materials.

The novelty of CoffeeLoop lies not in the mobile application but in the dedicated Smart Circular Coffee Waste Recovery Ecosystem. Through smart matching, local collaboration, resource recovery, and impact tracking, the ecosystem enables sustainable resource circulation and long-term ecosystem development.

CoffeeLoop also demonstrates strong scalability and commercialisation potential, with applications across cafés, hotels, educational institutions, municipalities, waste management organisations, and urban farming communities. Furthermore, the innovation supports SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) by promoting sustainable resource management and responsible waste recovery.

Table 1: Summary of CoffeeLoop Innovation Advantages

Aspect	Contribution
Innovation	Dedicated Smart Circular Coffee Waste Recovery Ecosystem
Environmental	Reduces landfill waste and greenhouse gas emissions
Social	Strengthens collaboration among stakeholders
Economic	Creates value-added products and green entrepreneurship opportunities
Scalability	Applicable to cafés, institutions, municipalities, and industries
Sustainability	Supports SDG 11, SDG 12, and SDG 13

5.0 CONCLUSION

CoffeeLoop presents a sustainable solution for recovering and utilising spent coffee grounds through a dedicated Smart Circular Coffee Waste Recovery Ecosystem. By systematically connecting coffee waste producers with circular economy users, the ecosystem promotes efficient resource recovery, environmental sustainability, and community collaboration. The innovation demonstrates strong potential for scalability and commercialisation, while also supporting Sustainable Development Goals (SDGs) 11, 12, and 13. Overall, CoffeeLoop contributes to the advancement of circular economy practices by transforming coffee waste into valuable resources and encouraging more sustainable resource management.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Kolej Poly-Tech MARA Batu Pahat (KPTM Batu Pahat) for its continuous support and encouragement throughout the development of this innovation project. The authors also extend their gratitude to all individuals who provided valuable guidance, feedback, and support during the completion of the CoffeeLoop project.

REFERENCES

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy: A new sustainability paradigm? Journal of Cleaner Production, 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular economy: The concept and its limitations. Ecological Economics, 143, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

Lopes, M., Martins, S., & Teixeira, J. A. (2023). Spent coffee grounds as a sustainable resource: Current applications and future opportunities. Sustainability, 15(8), 6504. https://doi.org/10.3390/su15086504

Prieto-Sandoval, V., Jaca, C., & Ormazabal, M. (2018). Towards a consensus on the circular economy. Journal of Cleaner Production, 179, 605–615. https://doi.org/10.1016/j.jclepro.2017.12.224

SLIPPERY DETECTION APPS: A MOBILE-BASED HAZARD PREVENTION PROTOTYPE

Nor Baizura Mohamed[1,*], Fairuzy Binti Ab. Hadir[1], Noraisah Binti Kamaruddin[1], Muhamad Amirul bin Suari[1]

[1]Kolej Poly-Tech MARA

[*]Corresponding author: baizuramohamed@kptm.edu.my

ABSTRACT

Slip-and-fall accidents are among the most common yet underestimated causes of injuries in public and occupational environments worldwide. Despite the implementation of regulatory frameworks such as Malaysia's Occupational Safety and Health Act 1994 (OSHA), conventional safety methods such as warning signs, manual inspections, and reactive maintenance have proven inadequate in preventing such incidents. The Slippery Detection Apps project introduces a mobile-based, AI-enhanced hazard prevention prototype that transforms hazard detection into a proactive, real-time, and data-driven process. The prototype integrates smartphone sensors (accelerometer, gyroscope, and camera) with AI-based image recognition to detect moisture and low-friction surfaces. A Hazard Risk Percentage indicator quantifies the severity of detected hazards, while an alert system provides instant notifications through vibration, sound, and visual cues. Additionally, GPS-enabled mapping and reporting features allow users and facility managers to visualise and respond efficiently to high-risk zones.

Keywords: slip-and-fall prevention, artificial intelligence, safety innovation, occupational safety, proactive monitoring

1.0 INTRODUCTION

Slip-and-fall accidents remain among the most frequent yet underestimated causes of workplace and public injuries worldwide. Such accidents often result in significant productivity loss, medical expenses, and liability claims (Abdelhamid & Everett, 2000). Traditional preventive measures, including warning signage and manual inspections, are reactive in nature and frequently fail to prevent accidents before they occur (Haslam et al., 2005). This limitation underscores the urgent need for a proactive, intelligent, and real-time safety system. In this context, the Slippery Detection Apps project was developed as a mobile-based prototype that integrates smartphone sensors and artificial intelligence (AI) to detect hazardous slippery surfaces, evaluate risk severity, and issue real-time alerts to users and organisations. Comply with regulatory standards. This paper presents the conceptualisation, design, development, and evaluation of the Slippery Detection Apps prototype. It discusses the system's performance, usability, and scalability, and highlights its impact on the individual, organisational, and societal levels. Ultimately, the project demonstrates how mobile technology can be transformed into a proactive, intelligent, and scalable safety solution, contributing to the broader vision of digital transformation and accident prevention in the industry 4.0 era.

1.1 PROBLEM STATEMENT

Despite global regulatory efforts such as Malaysia's *Occupational Safety and Health Act (OSHA) 1994*, slip-related incidents persist due to the lack of continuous and real-time hazard detection systems. Environmental conditions (e.g., rainwater and cleaning activities), industrial factors (e.g., oil leakage), and human behaviours contribute to unpredictable slippery hazards (Leclercq et al., 2015). Conventional safety practices remain largely reactive, providing warnings only after incidents occur. Hence, this project aims to bridge the gap by providing an intelligent system capable of real-time hazard identification and proactive prevention.

2.0 OBJECTIVE

The project aims to design and implement a mobile-based prototype, *Slippery Detection Apps*, that proactively prevents slip-and-fall accidents. Its specific objectives include:

1. Designing a real-time hazard detection system using embedded smartphone sensors and AI algorithms.
2. Developing a quantifiable **Hazard Risk Percentage** indicator to assess risk severity.
3. Establishing multimodal alert systems (visual, audio, and vibration).
4. Integrating mapping and reporting tools for organisational safety management.
5. Evaluating the commercialisation potential and scalability across multiple sectors.

3.0 METHODOLOGY

The project adopted a six-phase methodology combining software engineering and applied research principles:

1. **Requirement Analysis and Problem Scoping** – identifying safety gaps through literature reviews, stakeholder consultations, and regulatory analysis.
2. **System Design and Architecture** – integrating smartphone sensors (accelerometer, gyroscope, camera) with AI-driven image recognition (TensorFlow Lite).
3. **Prototype Development** – implementing the system using Flutter and Firebase for cross-platform compatibility and real-time data synchronisation.
4. **Testing and Validation** – conducting controlled and real-world testing to evaluate detection accuracy and user acceptance.
5. **Data Analytics Integration** – enabling hazard trend visualisation through a centralised dashboard for facility managers.
6. **Commercialisation and Scalability Analysis** – exploring potential business models (freemium, subscription, and licensing) and sector adaptability.

4.0 RESULTS

Experimental evaluations revealed that the prototype achieved 87% detection accuracy under controlled conditions, with an average response time of under two seconds. The Hazard Risk Percentage successfully quantified risk levels, while multimodal alerts enhanced accessibility, particularly for elderly users. Organisational trials demonstrated strong alignment with OSHA requirements and potential for reducing compensation costs. However, challenges such as reduced performance in low-light conditions and battery consumption were noted, highlighting areas for refinement.

4.1 IMPACT AND DISCUSSION

At the individual level, the system enhances personal safety and confidence, especially among vulnerable populations. At the organisational level, it offers a data-driven approach to safety management, compliance, and productivity enhancement. At the societal level, it contributes to safer public environments and reduces strain on healthcare systems. Academically, the project advances the field of mobile-based hazard detection by integrating AI, environmental sensing, and real-time analytics previously treated as separate domains (Kim et al., 2019). The project's commercialisation potential further supports Malaysia's *MyDIGITAL* blueprint and the safety innovation objectives of Industry 4.0.

5.0 CONCLUSION

The *Slippery Detection Apps* project demonstrates that mobile technologies, when combined with AI and environmental sensors, can transform hazard prevention from a reactive to a proactive process. The system not only detects and communicates hazards in real time but also provides actionable data for long-term safety management. Despite certain technical limitations, its scalability, economic viability, and societal benefits establish it as a future-ready innovation that aligns technological advancement with occupational and community safety goals.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Kolej Poly-Tech MARA Batu Pahat (KPTM Batu Pahat) for its continuous support and encouragement throughout the development of the *Slippery Detection Apps: A Mobile-Based Hazard Prevention Prototype*. We are grateful to the management, colleagues, and students who provided valuable feedback during the conceptualisation, development, and evaluation of this innovation. We also extend our heartfelt gratitude to all individuals

who participated in the testing and validation process, providing constructive insights that significantly enhanced the functionality and usability of the prototype. Their contributions have been invaluable in refining this innovation into a practical and impactful safety solution. Finally, we acknowledge the dedication, collaboration, and commitment of all team members whose expertise and teamwork made this project possible. It is our hope that this innovation will contribute to creating safer workplaces and public environments through the adoption of intelligent, proactive, and technology-driven hazard prevention solutions.

REFERENCES

Abdelhamid, T. S., & Everett, J. G. (2000). Identifying root causes of construction accidents. Journal of Construction Engineering and Management, 126(1), 52–60.

Haslam, R. A., Hide, S. A., Gibb, A. G. F., Gyi, D. E., Pavitt, T., Atkinson, S., & Duff, A. R. (2005). Contributing factors in construction accidents. Applied Ergonomics, 36(4), 401–415.

Leclercq, S., Tisserand, M., & Saulnier, H. (2015). Slip, trip, and fall accidents: A review of causes and countermeasures. Safety Science, 75, 1–14.

Kim, S., Noh, Y., & Park, S. (2019). AI-based real-time hazard detection system using mobile sensors. IEEE Access, 7, 155749–155760.

Malaysia Department of Occupational Safety and Health (DOSH). (1994). Occupational Safety and Health Act 1994 (Act 514). Government of Malaysia.

GM HUB: A CREATIVE DIGITAL EDUCATION ECOSYSTEM FOR LEARNING, PORTFOLIO DEVELOPMENT AND INDUSTRY COLLABORATION

Aidil Bin Bachok[1,*], Sara Zulkifli[1], Mohamad Norfi Bin Ramli[1], Muhammad Haris Bin Sabtu[1]

[1]Kolej Poly-Tech MARA Batu Pahat, Johor, Malaysia

*Corresponding author: aidil@kptm.edu.my

ABSTRACT

The increasing demand for creative digital skills requires students to develop strong portfolios, industry exposure, and continuous access to quality learning resources. However, many graphic design students face challenges in showcasing their work professionally, accessing organised learning materials, and establishing meaningful connections with industry practitioners on a single integrated platform. GM HUB is proposed as a Creative Digital Education Ecosystem that integrates Structured Digital Learning Resources, Digital Portfolio Development, and Creative Industry Networking and collaboration into a unified digital platform. Unlike conventional learning management systems or portfolio websites, GM HUB functions as a dedicated creative education ecosystem that supports students' academic, professional, and career development throughout their learning journey. The proposed ecosystem consists of three integrated components: Structured Digital Learning Resources, Digital Portfolio Development, and Creative Industry Networking and Collaboration. Together, these components enable students to access organised educational resources, develop professional digital portfolios, engage with lecturers and industry practitioners, and enhance their employability through continuous learning and professional engagement. The novelty of GM HUB lies not in the digital platform itself but in the integration of learning, portfolio development, and industry collaboration within a dedicated Creative Digital Education Ecosystem. This integrated approach strengthens experiential learning, promotes industry–academia collaboration, and supports the development of highly skilled creative graduates. GM HUB demonstrates strong scalability and sustainability, with the potential to be implemented across Creative Multimedia programmes and other higher education institutions. The innovation also contributes directly to Sustainable Development Goal (SDG) 4: Quality Education, SDG 8: Decent Work and Economic Growth, and SDG 9: Industry, Innovation and Infrastructure by promoting inclusive digital learning, professional skills development, and stronger collaboration between academia and industry.

Keywords: creative education, digital portfolio, industry collaboration, educational technology, digital learning ecosystem

1.0 INTRODUCTION

The rapid advancement of digital technologies has transformed teaching and learning practices in higher education, particularly in creative disciplines such as graphic design and multimedia (Garrison & Vaughan, 2008). In addition to acquiring technical knowledge, students are expected to develop professional portfolios, enhance their creative competencies, and establish meaningful connections with industry practitioners to improve their employability after graduation.

Despite the increasing adoption of digital learning platforms, many existing systems primarily focus on course management and online content delivery. They provide limited support for portfolio development, creative collaboration, industry networking, and organised access to discipline-specific learning resources. Consequently, students often rely on multiple disconnected platforms to manage their academic work, showcase their creative achievements, and engage with industry professionals.

To address these challenges, GM HUB is proposed as a Creative Digital Education Ecosystem that integrates learning resources, digital portfolio development, and industry collaboration within a single platform. By bringing together students, lecturers, alumni, and industry practitioners, GM HUB creates a structured environment that supports continuous learning, professional portfolio development, and stronger academia–industry engagement. This integrated ecosystem aims to enhance students' academic experience, strengthen graduate employability, and contribute to Sustainable Development

Goals (SDGs) 4, 8, and 9 through quality digital education, industry collaboration, and innovation (UNESCO, 2021).

2.0 OBJECTIVE

The following objectives guide the development of GM HUB:

1. To develop an integrated Creative Digital Education Ecosystem that supports learning, portfolio development, and industry collaboration within a single digital platform.
2. To provide students with a structured platform for showcasing their creative portfolios, accessing organised digital learning resources, and enhancing their professional competencies.
3. To strengthen collaboration between students, lecturers, alumni, and industry practitioners through continuous networking and knowledge sharing.
4. To improve graduate employability and support sustainable digital education by promoting experiential learning, lifelong learning, and industry engagement in alignment with the Sustainable Development Goals (SDGs).

3.0 METHODOLOGY

GM HUB was developed as a Creative Digital Education Ecosystem that integrates learning resources, portfolio development, and industry collaboration within a single digital platform. Rather than functioning solely as a repository of educational materials or a portfolio website, GM HUB creates an interconnected environment where students, lecturers, alumni, and industry practitioners can engage in continuous learning, professional development, and creative collaboration. The ecosystem consists of five interconnected components that collectively support students throughout their academic and professional journey. Figure 1 illustrates the overall Creative Digital Education Ecosystem of GM HUB.

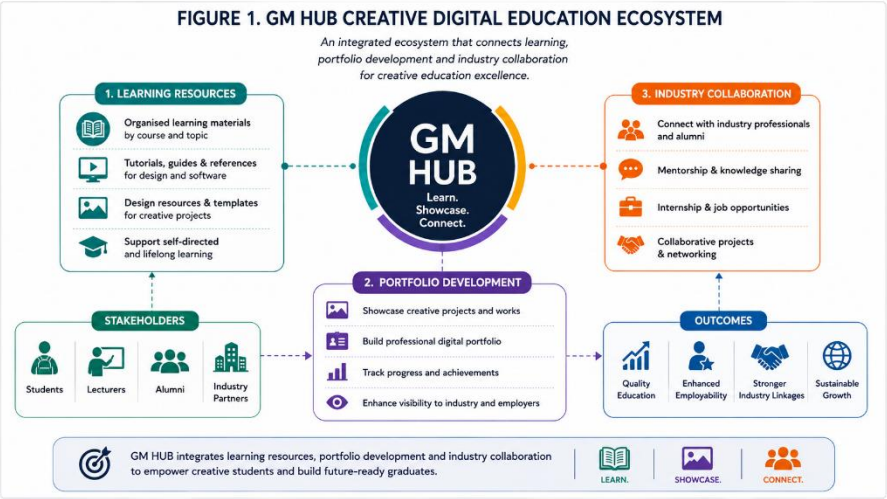


Figure 1: GM HUB Creative Digital Education Ecosystem

3.1 STRUCTURED DIGITAL LEARNING RESOURCES

The first component focuses on providing students with organised digital learning resources that support both academic and practical learning. Educational materials, including lecture notes, tutorials, design references, software guides, and project examples, are systematically organised according to relevant courses and design disciplines. This enables students to access reliable learning resources efficiently while encouraging self-directed and lifelong learning (Redecker, 2017).

3.2 DIGITAL PORTFOLIO DEVELOPMENT

The second component enables students to develop professional digital portfolios throughout their studies. Students can showcase academic projects, creative artworks, multimedia productions, and design achievements within a structured portfolio environment. This continuous portfolio development allows students to document their learning progress while establishing a professional identity that can be presented to prospective employers and industry partners (Carter, 2021).

3.3 CREATIVE INDUSTRY NETWORKING AND COLLABORATION

The third component strengthens collaboration between academia and industry by connecting students with lecturers, alumni, and creative industry practitioners. The ecosystem facilitates knowledge sharing, mentorship, internship opportunities, industry engagement, and collaborative activities that expose students to current professional practices and industry expectations. This interaction enhances students' professional readiness while fostering stronger partnerships between higher education institutions and the creative industry (Mitchell et al., 2021).

3.4 INTEGRATED CREATIVE DIGITAL EDUCATION ECOSYSTEM

The three core components are interconnected to create a comprehensive educational ecosystem. Learning resources support students in developing high-quality creative works, which are subsequently presented through their digital portfolios. These portfolios become valuable assets for networking with industry professionals, opening opportunities for mentorship, collaboration, internships, and future employment. This integrated approach ensures that learning, portfolio development, and professional engagement continuously reinforce one another throughout the students' educational journey. Figure 2 illustrates the operational workflow of GM HUB from learning resources to career opportunities.

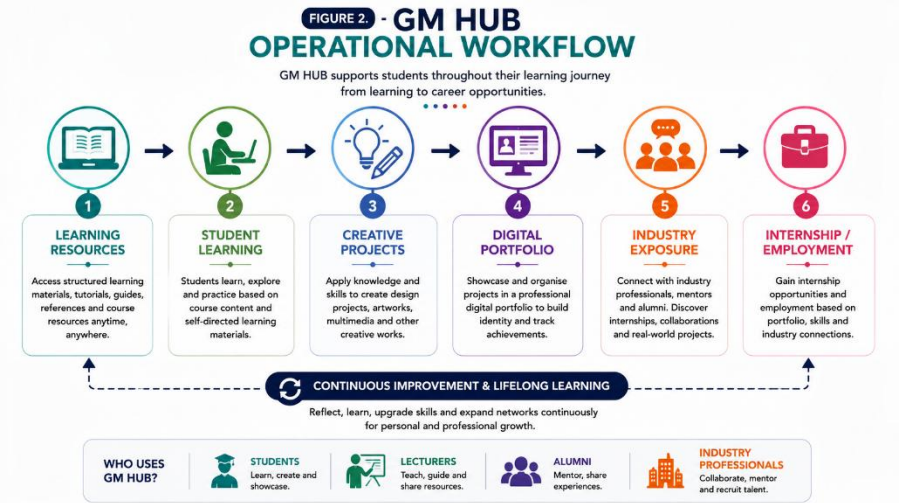


Figure 2: GM HUB Operational Workflow

3.5 PLATFORM SUPPORT AND SUSTAINABILITY

GM HUB is supported by a digital platform that facilitates content management, portfolio presentation, communication, and information sharing among all stakeholders. The innovation does not lie in the digital platform itself, but in the integration of learning, portfolio development, and industry collaboration within a dedicated Creative Digital Education Ecosystem. Its modular architecture allows for future expansion across Creative Multimedia programmes and adaptation by other higher education institutions, ensuring long-term sustainability and scalability (UNESCO, 2021).

4.0 RESULT

The proposed implementation of GM HUB demonstrates its potential to strengthen creative digital education by integrating learning resources, portfolio development, and industry collaboration within a single ecosystem. The platform enables students to organise learning materials, develop professional digital portfolios, and establish meaningful connections with lecturers, alumni, and industry practitioners, thereby creating a more comprehensive learning experience than conventional educational platforms.

The integration of these components is expected to enhance students' creative competencies, encourage self-directed learning, and improve graduate employability through continuous portfolio development and professional engagement. By providing a dedicated environment for showcasing creative works and facilitating industry interaction, GM HUB supports students in developing both academic and career-related skills throughout their educational journey (Mitchell et al., 2021).

The novelty of GM HUB lies not in the digital platform itself but in the integration of learning, portfolio development, and industry collaboration within a dedicated Creative Digital Education Ecosystem. This holistic approach creates added value for students, higher education institutions, and industry partners

by promoting continuous knowledge sharing, experiential learning, and stronger academia–industry collaboration.

Furthermore, the modular architecture of GM HUB provides strong scalability and sustainability, enabling future implementation across Creative Multimedia programmes and adaptation by other higher education institutions. The innovation also supports Sustainable Development Goals (SDGs) 4 (Quality Education), 8 (Decent Work and Economic Growth), and 9 (Industry, Innovation and Infrastructure) by fostering digital learning, professional skills development, and collaborative innovation (Vlachopoulos & Pachni Tsitiridou, 2026).

Table 1: Expected Outcomes of GM HUB

Aspect	Expected Outcome
Educational	Provides structured learning resources that support self-directed and lifelong learning.
Professional Development	Enables students to build professional digital portfolios and document creative achievements.
Industry Collaboration	Strengthens networking, mentorship, internships, and collaboration with industry practitioners and alumni.
Graduate Employability	Enhances students' career readiness through continuous portfolio development and professional engagement.
Institutional Impact	Promotes stronger academia–industry collaboration and supports digital transformation in creative education.
Scalability & Sustainability	Can be expanded across Creative Multimedia programmes and adopted by other higher education institutions.

5.0 CONCLUSION

GM HUB presents an innovative approach to creative digital education by integrating structured learning resources, portfolio development, and industry collaboration within a dedicated Creative Digital Education Ecosystem. By connecting students, lecturers, alumni, and industry practitioners through a unified platform, GM HUB supports continuous learning, professional portfolio development, and stronger academia–industry engagement. The innovation demonstrates strong potential to enhance graduate employability, promote lifelong learning, and facilitate digital transformation in creative education. Furthermore, its modular and scalable design enables future implementation across Creative Multimedia programmes and other higher education institutions, contributing to Sustainable Development Goals (SDGs) 4, 8, and 9 through quality education, innovation, and collaborative partnerships (UNESCO, 2021; Vlachopoulos & Pachni Tsitiridou, 2026).

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Kolej Poly-Tech MARA Batu Pahat (KPTM Batu Pahat) for its continuous support and encouragement throughout the development of this innovation. The authors also extend their gratitude to the lecturers, colleagues, students, alumni, and industry partners whose valuable insights, constructive feedback, and continuous support contributed significantly to the conceptualisation and development of GM HUB.

REFERENCES

Carter, S. (2021). ePortfolios as a platform for evidencing employability and building professional identity: A literature review. International Journal of Work-Integrated Learning, 22(4), 463–474.

Garrison, D. R., & Vaughan, N. D. (2008). Blended learning in higher education: Framework, principles, and guidelines. Jossey-Bass.

Mitchell, L., Campbell, C., Somerville, M., Cardell, E., & Williams, L. T. (2021). Enhancing graduate employability through targeting ePortfolios to employer expectations: A systematic scoping review. Journal of Teaching and Learning for Graduate Employability, 12(2), 82–98. https://doi.org/10.21153/JTLGE2021VOL12NO2ART1003

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu. Publications Office of the European Union. https://doi.org/10.2760/159770

UNESCO. (2021). Reimagining our futures together: A new social contract for education. UNESCO Publishing.

Vlachopoulos, D., & Pachni Tsitiridou, O. (2026). Preparing university graduates for the labour market through employability skills development and university–industry collaboration: A systematic review. Education Sciences, 16(3), Article 426. https://doi.org/10.3390/educsci16030426

SMART BIZ PLANNER: AN INTEGRATED WEB-BASED FINANCIAL PLANNING AND PROFIT DECISION SUPPORT SYSTEM

Nor Azlina Binti Rais[1,*], Norhidayah Binti Samat[1], Armuni Binti Mohd Najid[2], Noor Izzati Binti Ahmad Fuad[1], Norsuhana Binti Idris[1]

[1]Kolej Poly-Tech MARA Batu Pahat
[2]Kolej Poly-Tech Mara Kota Bahru

[*]Corresponding author: azlina_r@kptm.edu.my

ABSTRACT

Financial management has become increasingly important due to rising living costs, inflation, and economic uncertainty, particularly among fresh graduates, employees, and small business entrepreneurs. Many individuals struggle to allocate their income effectively, while entrepreneurs often experience difficulties in forecasting business profits and making informed financial decisions. Existing financial applications generally focus on either personal budgeting or business accounting and are often too complex for users with limited financial knowledge. Therefore, SMART BIZ PLANNER was developed as an integrated web-based financial planning and profit decision support system to simplify personal and business financial management. The system consists of two main modules: the Personal Financial Planner and the Smart Profit Calculator. Users only need to enter their monthly income and preferred commitment percentage, and the system automatically allocates 25% for savings and 75% for expenses based on Kiyosaki's financial management principle (Kiyosaki, 2022). Additionally, the system provides financial recommendations related to emergency funds, debt management, insurance, retirement planning, and investment. The Smart Profit Calculator enables entrepreneurs to estimate gross profit, net profit, and profit margin by entering projected sales, selling price, cost price, and operating expenses. The system assists users in identifying potential cost reductions, improving financial planning, and supporting data-driven decision-making. The novelty of SMART BIZ PLANNER lies in the integration of personal financial planning and business profit forecasting within a single web-based platform. The innovation promotes financial literacy, encourages responsible financial behaviour, and provides an accessible financial planning solution that is suitable for users from all backgrounds.

Keywords: financial planning, financial literacy, profit forecasting, decision support system, web-based system

1.0 INTRODUCTION

Financial literacy is widely recognised as one of the essential competencies required to achieve financial stability and sustainable economic wellbeing. However, many Malaysians continue to experience financial difficulties due to inadequate budgeting practices, limited savings, and ineffective financial planning (OECD, 2023). Fresh graduates frequently encounter challenges in managing their first salary, while entrepreneurs often make business decisions without accurate profit estimation, increasing the risk of financial loss (Bank Negara Malaysia, 2024).

Although numerous budgeting and accounting applications are available, many require extensive financial knowledge or focus only on a single financial aspect. As a result, users often need multiple applications to manage personal finances and business profitability.

To address these limitations, SMART BIZ PLANNER was developed as a web-based financial decision support system that integrates personal financial planning and business profit forecasting within a single platform. The system simplifies financial calculations through an intuitive interface, enabling users to plan their income allocation, estimate business profitability, and receive practical financial recommendations to support better financial decision-making.

2.0 OBJECTIVE

1. To develop a web-based financial planning and profit decision support system for personal and business financial management.

2. To assist users in making informed financial decisions through automated financial calculations and financial recommendations.
3. To improve financial literacy and encourage sustainable financial management among individuals and entrepreneurs.

3.0 METHODOLOGY

SMART BIZ PLANNER was developed using a web-based architecture to ensure accessibility across various devices while maintaining simplicity and ease of use. The system consists of two integrated modules that support both personal financial management and business profit forecasting.

3.1 PERSONAL FINANCIAL PLANNER

Users enter their monthly income and preferred commitment percentage. Based on the financial allocation principle proposed by Kiyosaki (2022), the system automatically allocates 25% of income for savings and 75% for daily expenses. The system also generates financial recommendations related to emergency funds, debt management, insurance, investment, and retirement planning to encourage responsible financial behaviour.

3.2 SMART PROFIT CALCULATOR

Entrepreneurs enter estimated sales, selling price, cost price, and operating expenses. The system automatically calculates gross profit, net profit, and profit margin while projecting expected business profitability. These calculations assist entrepreneurs in evaluating financial performance and identifying opportunities for cost optimisation.

3.3 SYSTEM WORKFLOW

The workflow begins with user input, followed by automated financial calculations performed by the calculation engine. The processed information is then displayed through an interactive dashboard, along with personalised financial recommendations, enabling users to make informed financial decisions efficiently.

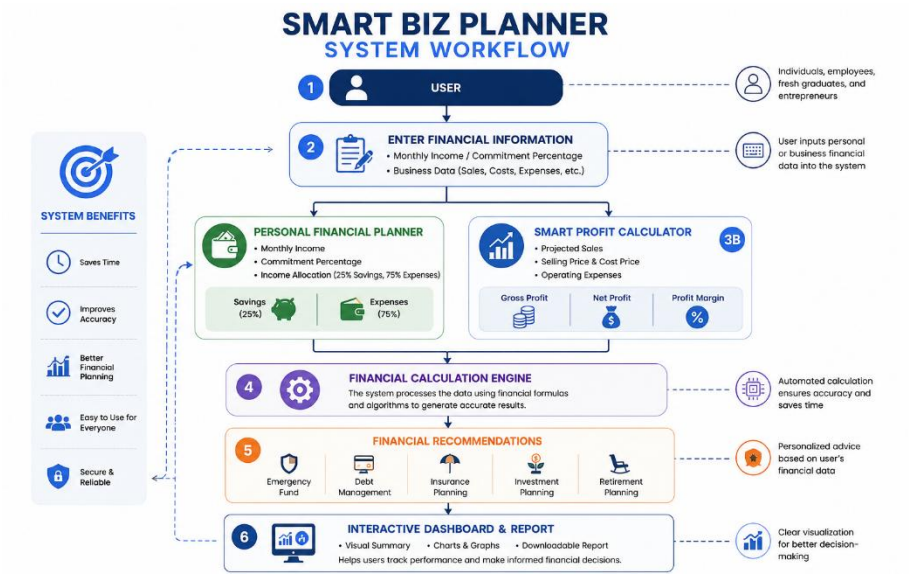


Figure 1: SMART BIZ PLANNER System Workflow

Figure 1 illustrates the overall workflow of SMART BIZ PLANNER. The system begins by allowing users to enter their personal or business financial information. The calculation engine processes the data and generates financial recommendations, along with dashboard visualisations, to support better financial decision-making.

3.4 SMART BIZ PLANNER MODULES



Figure 2: SMART BIZ PLANNER System Modules

As shown in Figure 2, SMART BIZ PLANNER consists of six integrated modules that collectively support personal financial planning and business decision-making. The Personal Financial Planner assists users in managing income, savings, and expenses, while the Smart Profit Calculator estimates business profitability. The Financial Recommendation module provides personalised financial advice, whereas the Profit Forecasting module projects future business performance. In addition, the Budget Allocation module encourages effective spending management, while Dashboard Analytics presents financial information through interactive visualisations to facilitate informed decision-making.

3.5 SYSTEM FUNCTIONALITIES

SMART BIZ PLANNER integrates six core modules that collectively support personal financial planning and business decision-making. As presented in Table 1, the Personal Financial Planner enables users to allocate their monthly income efficiently by calculating savings and expenses based on predefined financial allocation principles. The Smart Profit Calculator estimates business profitability by calculating projected gross profit, net profit, and profit margin using user-provided sales and expense data. The Financial Recommendation module provides personalised guidance on savings, debt management, emergency funds, insurance, investments, and retirement planning. Meanwhile, the Budget Allocation module assists users in managing their spending by promoting balanced financial distribution according to their income level. Finally, the Dashboard Analytics module presents financial information through interactive charts, key performance indicators (KPIs), and visual reports, allowing users to monitor their financial performance and make informed financial decisions effectively.

Table 1. System Functionalities of SMART BIZ PLANNER

Module	Function
Personal Financial Planner	Performs automated income allocation for savings and expenses to support effective budgeting.
Smart Profit Calculator	Estimates gross profit, net profit, and profit margin based on projected business data.
Financial Recommendation	Provides personalised financial guidance on savings, investments, debt management, insurance, emergency funds, and retirement planning.

Budget Allocation	Assists users in managing spending by distributing income according to financial priorities.
Dashboard Analytics	Displays financial summaries through interactive charts, KPI cards, and visual reports for better decision-making.

4.0 RESULT

SMART BIZ PLANNER successfully integrates personal financial planning and business profit forecasting into a single web-based platform. The system simplifies financial management through automated calculations and personalised financial recommendations while requiring minimal financial knowledge from users.

The main novelty of SMART BIZ PLANNER lies in combining personal financial planning and business profit forecasting within a single integrated decision support system. Unlike conventional financial calculators, the system performs financial calculations and provides practical financial guidance that promotes long-term financial sustainability.

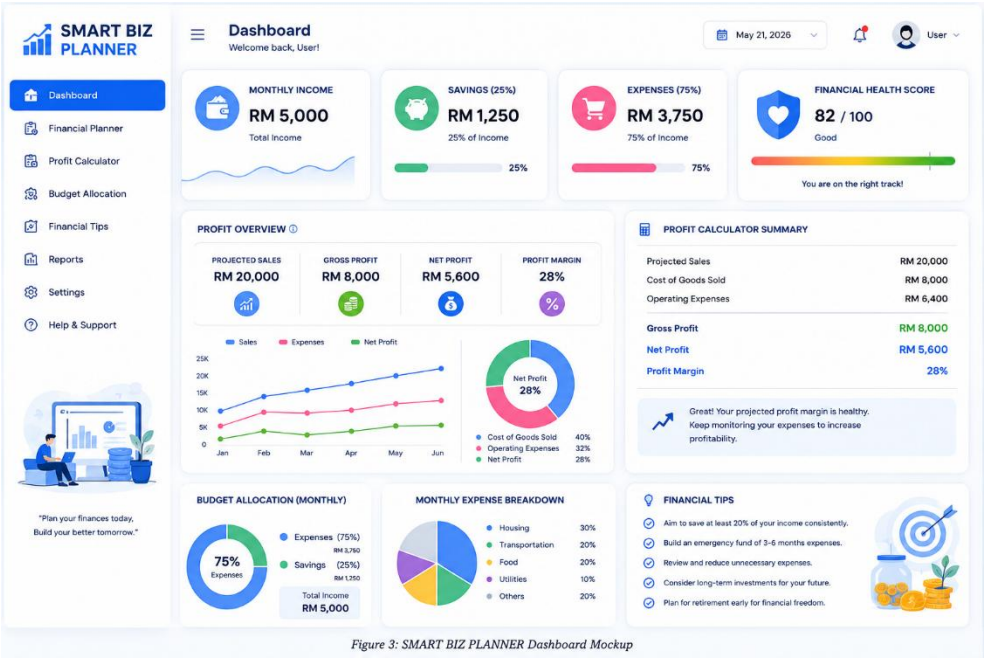


Figure 3: SMART BIZ PLANNER Dashboard Mockup

Figure 3: SMAT BIZ PLANNER Dashboard

Figure 3 presents the prototype dashboard of SMART BIZ PLANNER. The dashboard displays key financial indicators, including monthly income, savings allocation, expenses, projected sales, gross profit, net profit, profit margin, financial health score, and personalised financial tips. The visual dashboard enables users to monitor their financial performance efficiently and supports data-driven financial planning.

5.0 CONCLUSION

SMART BIZ PLANNER successfully integrates personal financial planning and business profit forecasting into a single web-based platform. By combining automated budgeting, profit estimation, and personalised financial recommendations, the system enables users to make informed financial decisions and manage their finances more effectively. This innovation promotes financial literacy, encourages responsible financial behaviour and supports sustainable financial management for individuals and entrepreneurs. Future enhancements may incorporate artificial intelligence (AI), predictive analytics, and personalised financial insights to further improve the system's functionality and user experience.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Kolej Poly-Tech MARA (KPTM) for its continuous support, guidance, and encouragement throughout the development of SMART BIZ

PLANNER. The authors also extend their gratitude to all team members and individuals whose dedication, collaboration, and valuable contributions have been instrumental in the successful completion of this innovation project.

REFERENCES

Bank Negara Malaysia. (2024). Financial Stability Review: Second Half 2024. https://www.bnm.gov.my

Gitman, L. J., Juchau, R., & Flanagan, J. (2022). Principles of Managerial Finance (8th Asia-Pacific ed.). Pearson.

Hasan, R., Yusof, S., & Rahman, N. A. (2023). Financial literacy and personal financial management among Malaysian young adults. International Journal of Academic Research in Business and Social Sciences, 13(7), 110–124. https://doi.org/10.6007/IJARBSS/v13-i7/17620

Kiyosaki, R. T. (2022). Rich Dad Poor Dad: What the Rich Teach Their Kids About Money. Plata Publishing.

Lusardi, A., & Mitchell, O. S. (2023). The importance of financial literacy: Theory and evidence. Journal of Economic Literature, 61(3), 1–39. https://doi.org/10.1257/jel.20211652

Malaysian Financial Planning Council. (2023). Financial Planning Guide for Malaysians. https://www.mfpc.org.my

OECD. (2023). OECD/INFE International Survey of Adult Financial Literacy 2023. https://www.oecd.org/finance

Rahman, M. N., Abdullah, N., & Ismail, N. (2022). Financial behaviour and budgeting practices among university graduates in Malaysia. International Journal of Business and Society, 23(2), 956–972.

Salehuddin, M., & Hamid, A. (2023). Web-based financial management systems for SMEs: Enhancing business sustainability through digital innovation. Journal of Information Systems and Digital Technologies, 5(2), 45–59.

World Bank. (2022). Financial Inclusion Overview. https://www.worldbank.org

FROM SLANG TO SCHOLARSHIP

Nur Fadzilah Muhamad Zamani[1], Nur Sherina Zainal Abidin[1,*], Susanna Bithiah Varma[1]

[1]Akademi Pengajian Bahasa, Universiti Teknologi MARA (UiTM) Cawangan Johor Kampus Segamat

[*] Corresponding author: nurfadzilahzamani@uitm.edu.my

ABSTRACT

The use of Gen Z slang and informal communication on the internet adds another layer of communication to students' mode of expression and understanding. The current media environment is a digital media where continuing media trends have affected the development of language perception. When it comes to different generations, slang can offend people if they aren't aware of what you're saying. With the wide spread of slang on social media, the pace of language change is accelerated. Slang can be a glue in online conversations but can also be a divisive element. This situation is problematic in many English Medium Instruction (EMI) contexts where many students struggle with the ability to shift informal ideas into appropriate academic language. The research that has been conducted on tool consultation has been limited, with most writing tools correcting grammatical errors and not teaching the student how to alter the register or meaning of their writing. To fill this need, the research in this study explored the potential of "From Slang to Scholarship", a new web-based learning tool to help students convert slang into academically proper English without altering the original intended message. The platform adopts the fundamental concepts of register awareness, paraphrasing pedagogy and scaffolded learning to enhance students' academic literacy and communicative competence in different discourse contexts. The innovation adds to the field of English language instruction by offering a realistic approach to teaching register transformation, which is a relatively unstudied aspect of EMI teaching. From Slang to Scholarship has the potential to improve paraphrasing skills, enhance academic writing skills, and develop greater confidence in academic communication by bridging the gap between the everyday language use of students and the requirements of academic communication.

Keywords: gen Z's slang, paraphrasing, communication

1.0 INTRODUCTION

In the rapidly evolving communication landscape, social media has become a crucial platform where Generation Z (Gen Z) express themselves, gain connections, and create linguistic trends. Born as digital natives, Gen Z (1997-2012) (Giancaterino, 2023) have mainly used TikTok, Instagram, YouTube, WhatsApp, and Facebook as communication platforms. Their pattern of social media use differs, but in subtle ways. Gen Z prefers fast-paced, visually stimulating platforms such as TikTok and Instagram (Pew Research Center, 2023). These, among others, define their preferences and differences in terms of technological familiarity and distinct social priorities. They intentionally use slang to break the seriousness of the conversation and foster congeniality between them. The use of this informal language, or slang, enables the implementation of social functions like instilling humour, fostering closeness between users, easier social interaction, and creating relaxed communication atmospheres (Budiasa et al., 2021). Slang could act as a bridge between collaborative culture and expression among individuals.

As English slang is not a standardised and structured language, overusing it may ruin their grammar and linguistic skills, such as listening, reading, speaking, and writing, especially when the English language is not their first language. For instance, language learners tend to use slang in the academic writing context and thus can confuse the readers' understanding of their writing content (González & Chang, 2024; Gusnayetti, 2021).

In order to facilitate the breakdown of slangs into suitable academic discourse, this innovation is built upon a structured five-stage register transformation framework. Learners first identify slang and informal expressions, analyse the intended meaning, reconstruct the message using more formal language, transform it into an academic register, and finally engage in guided reflection on the linguistic and rhetorical changes made. This systematic sequence helps to build further metalinguistic awareness and cultivates conscious language choices in relation to audience, purpose and context. Therefore, it is

crucial to understand the perceptions and usages of slang words amongst Gen Z. In response to that, this innovation sought to fill this void by guiding and balancing the ways language is used in the digital communications landscape of Malaysia. One of the unique aspects of the platform is the step-by-step instructional support combined with a guided practice lab offering scaffolded opportunities for application and self-assessment. It is conveniently accessible via the web and provides for flexible and independent learning.

2.0 OBJECTIVE

1. To create a user-friendly website to change Gen Z slang to academic English.
2. To enhance students' paraphrasing skills by a simple five-step learning model.
3. To improve students' academic writing proficiency and confidence in English Medium Instruction (EMI)

3.0 METHODOLOGY

This idea of innovation was born from the author's observation of their students' language use in the classroom. Most Gen Zers (generation Z) are unable to convey and carry the meaning of their Gen Z slang into proper academic written English sentences. Hence, this website is an initiative from the authors to create a register-based paraphrasing framework for academic writing to help students overcome their writing challenges. This website aims to empower students with an easy way to learn how to retain the original meaning of words while paraphrasing them.

3.1 The 5 Stage Register Framework

The most credible method to help students avoid being entangled with plagiarism, especially when it comes to writing, is to educate them to master the technique of paraphrasing (Zhang, 2020). Alongside this concern is the growing reliance on AI-based paraphrasing tools, which are widely available in the market. While these tools are known for precision and speed in generating results, they impede the cognitive abilities of our students in the long run (Alammar & Amin, 2024). To address this issue, a beginner-level framework was constructed to ease the students into the application process. The following table explains each stage of paraphrasing.

Table 1: 5 Stage Register Framework

Stage 1: Slang Expression Sentence written in informal Gen Z language.
Stage 2: Meaning Extraction Explain what the sentence really means. Focus only on meaning.
Stage 3: Neutral Reformulation Restate meaning in clear, neutral English. Removes informality.
Stage 4: Academic Paraphrase Rewrite the sentence for academic writing (reflection, assignment, report). Target register.
Stage 5: Reflection on Register Reflect briefly: what changed, what stayed the same, and why the academic version is appropriate.

The website also offers a few examples for students to familiarise themselves after understanding the concept of each stage. The following table demonstrates how a paraphrasing example is carried out within each stage.

Table 2: Example of the Paraphrasing Process using the 5 stages Register Framework

Stage 1 – Slang Expression: "I'm so rad, I'm like, 'I'm not even mad'"
Stage 2 – Meaning Extraction: The speaker is impressed and remains calm despite a potentially upsetting situation.
Stage 3 – Neutral Reformulation: I am very impressed and am not upset by what happened.
Stage 4 – Academic Paraphrase: The individual expressed strong approval and maintained emotional composure regarding the circumstances.
Stage 5 – Reflection on Register: Slang terms like 'rad' were replaced with formal descriptors like 'approval' and 'composure' to suit a scholarly tone.

4.0 RESULT

Based on the author's observation during the pilot test conducted, students of beginner levels(LCC111, etc.) were widely able to follow the concept explained at each stage of the paraphrasing process. After a few trials, students began to create their own examples with ease and found the activity engaging. An advantage of this website is that it offers examples that are easy for Gen Zers to relate to, as it utilises a broader vocabulary that is common with youngsters. Via the open access website https://nurfadzilahzamani.wixsite.com/englishcraftlab, students are able to easily access and view to learn directly without complicated instructions or advertisements. This website is also free of charge for students, and it offers free exercises incorporated in a layout that prioritises simplicity in design

5.0 CONCLUSION

In sum, this innovation project is rewarding for students experimenting with the technicalities of paraphrasing and also for those who are determined to harness their cognitive skills without help from AI tools. While this website is appropriate for level 1 beginners of the language, further ideas will be developed to enrich the scope of this website to cater to level 2 and 3 students in the future.

ACKNOWLEDGEMENT

The authors would like to thank the students involved with the pilot testing sessions. Truly, this project would not have been able to be completed without your voluntary participation.

REFERENCES

Alammar, A., & Amin, E. (2024). EFL Students' Perception of Using AI Paraphrasing Tools in English Language Research Projects. 14(3), 166–181.

Budiasa, I. G., Weddha Savitri, P., & Shanti Sari Dewi, A. A. Sg. (2021). Penggunaan bahasa slang di media sosial. Humanis, 25(2), 192. https://doi.org/10.24843/JH.2021.v25.i02.p08

Di Zhang, E. (2020) An investigation of novice ESL writers' cognitive processes and strategy use of paraphrasing. Lang Test Asia 10, 9. https://doi.org/10.1186/s40468-020-00104-3

Giancaterino, C. (2023). Gen Z vs. Millennials: How to target both audiences. Five CRM. https://www.fivecrm.com/blog/marketing-to-gen-z-vs-millennials/

González, V. P. V., & Chang, Y. H. (2024). Social media as a hindrance to the writing skills of English learners. Ciencia Latina Revista Científica Multidisciplinar, 8(1), 12056–12069. https://doi.org/10.37811/cl_rcm.v8i3.11322

Gusnayetti. (2021). The impact of slang among youth on Indonesian language. Encyclopedia Social Review, 3(3), 275–281

Pew Research Center. (2023). Teens, social media and technology 2023. https://www.pewresearch.org/internet/2023/11/15/teens-social-media-and-technology-2

AI-SLR VALIDATOR: A SMART TOOLKIT FOR TRANSPARENT AI-ASSISTED SYSTEMATIC LITERATURE REVIEW SCREENING

Nor Hapiza Mohd Ariffin[1,*]

[1]Faculty of Business, Sohar University, Sohar, Oman

[*]Corresponding author: nariffin@su.edu.com

ABSTRACT

Artificial intelligence (AI) is increasingly used to support systematic literature review (SLR) screening, especially when researchers manage large datasets from multiple academic databases. However, AI-assisted screening may raise concerns about transparency, reproducibility, auditability, and the risk of excluding relevant studies. This innovation introduces AI-SLR Validator, an Excel-based research audit and decision-support toolkit for transparent, human-supervised, and PRISMA-ready AI-assisted SLR screening. The toolkit consolidates review criteria, AI prompt use, concept-block detection, fixed Boolean filtering rules, manual screening decisions, validation audit results, and dashboard evidence into a single structured workbook. The prototype was demonstrated using an SLR case on digital workforce transformation competencies in the Gulf Cooperation Council countries. The case involved 700 records from Scopus, IEEE Xplore, ACM Digital Library, Web of Science, and ScienceDirect. AI-assisted concept-block detection filtered records that did not contain all required concepts: digital skills and competencies, workforce transformation, and GCC geographical scope. To reduce the risk of false exclusions, 116 AI-filtered exclusions were manually audited, and a second reviewer reviewed 50 records. The audit identified no potentially eligible records among the sampled exclusions, while 75 studies were retained for final synthesis. The toolkit contributes a practical mechanism for responsible AI use in evidence synthesis by ensuring that AI detects, deterministic rules filter, and humans validate. It benefits researchers, postgraduate students, supervisors, journal authors, and review teams by improving screening documentation, strengthening reviewer confidence, and supporting PRISMA-style reporting.

Keywords: AI-assisted screening, systematic literature review, PRISMA, validation audit, research transparency

1.0 INTRODUCTION

Systematic literature reviews are essential for synthesising evidence, identifying knowledge gaps, and informing academic, professional, and policy decisions. Yet the screening stage is often labor-intensive because researchers must assess large numbers of titles and abstracts against predefined inclusion and exclusion criteria. The emergence of large language models offers an opportunity to accelerate early relevance filtering. However, the use of AI in SLR screening must be carefully governed because systematic reviews depend on traceability, transparent decision-making, and reproducible documentation (Page et al., 2021).

The motivation for this innovation came from a practical methodological problem. Researchers may use AI to screen records, but they may not document the prompt, matched terms, filtering rules, or validation process in a way that can be checked by supervisors, journal reviewers, or innovation judges. This creates a black-box screening problem: the researcher may know that AI was used, but the evidence trail may not show how the AI supported filtering, which records were removed, and whether human reviewers verified the excluded records.

AI-SLR Validator was therefore developed to transform AI-assisted screening into a controlled, auditable, and human-supervised workflow.

2.0 OBJECTIVE

The objectives of AI-SLR Validator are as follows:

- To provide a reusable Excel-based toolkit for documenting AI-assisted SLR screening decisions.
- To record inclusion and exclusion criteria, AI prompts, concept-block matches, and fixed filtering rules in a transparent format.
- To support human validation of AI-filtered exclusions through manual audit and reviewer-check fields.
- To generate dashboard evidence that can support PRISMA-style methodology reporting and academic innovation evaluation.
- To reduce reviewer concern by showing that AI supports the process, while final inclusion decisions remain under human review.

3.0 METHODOLOGY

The innovation was designed as a practical research governance toolkit rather than as an autonomous AI reviewer. Its design follows four principles: predefined criteria, limited AI role, deterministic rule-based filtering, and human validation. The AI component is used only to detect whether predefined concept blocks are present in the title and abstract. It does not independently judge article quality or final eligibility.

The prototype workflow consists of six operational steps. First, database records are exported and entered into the Master Screening Sheet. Second, the AI identifies terms that are associated with predefined concept blocks. Third, a fixed Boolean rule is applied: a record proceeds only when all required concept blocks are present. Fourth, retained records are manually screened by title and abstract. Fifth, AI-filtered exclusions are validated using a manual audit sample and a second-reviewer check. Sixth, the dashboard summarises the screening flow, validation coverage, false-exclusion indicators, and the status of human oversight.

Table 1: Core components of AI-SLR Validator.

Toolkit component	Function	Academic value
Master Screening Sheet	Stores records, abstracts, AI-matched terms, screening decisions, exclusion reasons, and notes.	Creates a traceable record-level audit trail.
Criteria Bank	Stores inclusion criteria, exclusion criteria, and concept-block definitions.	Improves consistency and transparency.
AI Prompt Log	Records the model role, prompt, output format, date, and reproducibility notes.	Supports prompt transparency and repeatability.
Validation Audit	Records manual audit decisions, second-reviewer checks, potential false exclusions, and agreement.	Shows human validation of AI-filtered records.
Validator Dashboard	Summarises PRISMA counts, validation coverage, exclusion indicators, and oversight evidence.	Provides quick evidence for judges, reviewers, and supervisors.

The toolkit is implemented in Excel because most researchers can use it without programming knowledge. This makes the innovation practical for postgraduate researchers, supervisors, journal authors, and review teams.

3.1 TOOLKIT INPUT AND SCREENING LOGIC

Users mainly enter data in the Master Screening Sheet. Columns A to G store bibliographic and screening source information, including record ID, title, author, year, database, DOI, and abstract. Column H stores the AI-matched concept-block terms—columns I to K record the screening decision, exclusion reason, and reviewer notes. Supporting input sheets are used for review information, criteria, prompts, PRISMA numbers, full-text screening, validation audits, and risk review queues.

Table 2: User input and output structure in the toolkit.

Sheet type	Sheet name	User action	Purpose
Main input	Master Screening Sheet	Paste records and enter AI output and decisions.	Main working sheet.
Supporting input	Criteria Bank	Enter concept blocks and criteria.	Defines screening rules.
Supporting input	AI Prompt Log	Record AI model, prompt, and output format.	Supports reproducibility.
Supporting input	Validation Audit	Enter audit sample and reviewer decisions.	Checks false-exclusion risk.

Supporting input	PRISMA Numbers	Enter screening flow counts.	Feeds dashboard evidence.
Auto-generated output	Validator Dashboard	Do not edit formulas.	Shows indicators and charts.
Auto-generated output	DIIID Evidence Report	Use for presentation and reporting.	Summarises innovation value.

In this design, the AI role is deliberately narrow. It identifies whether the title and abstract contain evidence of the required concept blocks, such as digital skill terms, workforce transformation terms, and GCC geographical terms. The AI's retention decision is not made freely. Instead, a fixed Boolean rule retains records only when all required concept blocks are present. This separation between AI detection and rule-based filtering improves explainability and reduces uncontrolled AI judgement.

3.2 CASE IMPLEMENTATION

The toolkit was demonstrated using a systematic review case on digital workforce transformation competencies in Gulf Cooperation Council countries. Searches were conducted across Scopus, IEEE Xplore, ACM Digital Library, Web of Science, and ScienceDirect. The case began with 700 identified records. AI-assisted concept-block detection reduced the dataset to 119 records before deduplication. After removing 28 duplicates, 91 unique records proceeded to manual title and abstract screening. A total of 80 reports were assessed for eligibility, and 75 studies were retained for final synthesis.

4.0 RESULT

The main result of the innovation is a transparent AI-assisted SLR validation workflow that produces both record-level traceability and summary-level evidence. Instead of only reporting that AI was used, the toolkit documents what the AI detected, which rule was applied, which records were retained or filtered, and how human reviewers validated the process.

Table 3: Case evidence generated from the prototype implementation.

Evidence indicator	Result	Interpretation
Records identified	700	Initial records from five databases.
AI concept-block exclusions	581	Records lacking at least one required concept block.
Records after concept-block filtering	119	Records retained for deduplication.
Duplicates removed	28	Duplicate records removed before manual screening.
Manual screening pool	91	Unique records manually screened by title and abstract.
Reports assessed for eligibility	80	Full-text reports assessed against research questions.
Final included studies	75	Final corpus used for synthesis.
Manual validation sample	116	Approximately 20 percent of AI-filtered exclusions.
Second-reviewer check	50	Independent check of the validation sample subset.
Potentially eligible records found in audit	0	No sampled AI-filtered record was returned to the manual screening pool.

The validation audit is the most important quality-assurance element. In the prototype, 116 of the 581 AI-filtered exclusions were manually rechecked using stratified sampling across the five databases. A second reviewer independently checked 50 records. The audit found no potentially eligible records among the sampled exclusions, and agreement in the independently checked subsample was 100 percent. These indicators were displayed in the Validator Dashboard to help reviewers quickly assess validation coverage and the risk of false exclusion.

The novelty of AI-SLR Validator lies in its transparency-first design. Many AI screening tools emphasise speed, whereas this toolkit emphasises accountable speed: AI improves efficiency, but human judgement, validation, and evidence reporting remain central.

4.1 ADVANTAGE, IMPACT, AND PRACTICALITY

The toolkit offers several advantages for academic users. First, it improves screening efficiency by helping researchers manage large record sets in a structured workbook. Second, it strengthens methodological transparency by recording criteria, prompts, matched terms, rules, decisions, and audit comments. Third, it supports PRISMA-style reporting by aligning screening counts with identification, filtering, screening, eligibility assessment, and inclusion stages (Page et al., 2021). Fourth, it promotes

quality assurance by incorporating human validation and reviewer-check fields. Fifth, it is reusable because researchers can change the concept blocks, criteria, databases, and validation sample for different SLR topics.

The toolkit can benefit postgraduate students, supervisors, journal authors, research teams, and evidence synthesis practitioners. It is also useful for viva preparation and manuscript review because researchers can clearly explain how AI was used and how the process was verified. Where quality appraisal is required, the workflow can be combined with established appraisal tools such as the Mixed Methods Appraisal Tool (MMAT) (Hong et al., 2018).

5.0 CONCLUSION

AI-SLR Validator demonstrates how academic innovation can combine AI capability with rigorous research governance. By integrating prompt documentation, predefined concept blocks, deterministic filtering rules, manual validation, reviewer agreement checks, and dashboard reporting, the toolkit converts AI-assisted screening into transparent and auditable evidence. Its main contribution is not to replace human reviewers, but to strengthen responsible AI use in systematic literature reviews. The toolkit is practical, reusable, and suitable for supporting manuscripts, postgraduate research, review supervision, and innovation competition evaluation.

ACKNOWLEDGEMENT

The author acknowledges Sohar University for supporting academic innovation and research development activities.

REFERENCES

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. Education for Information, 34(4), 285-291. https://doi.org/10.3233/EFI-180221

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., Stewart, L. A., Thomas, J., Tricco, A. C., Welch, V. A., Whiting, P., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71

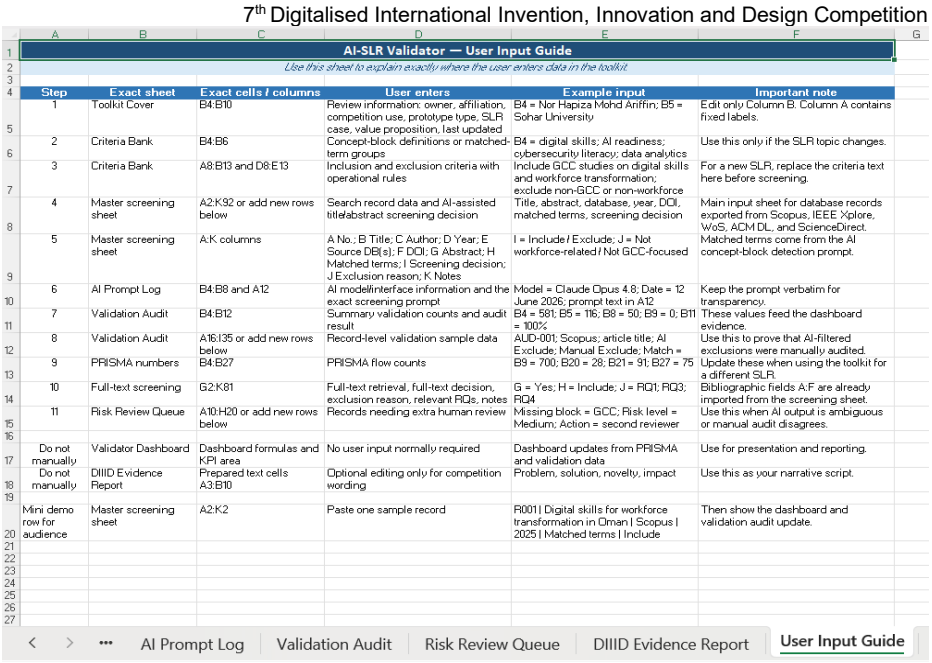
Note: The appendix pages below provide visual evidence of the toolkit interface and are attached as supplementary appendix materials, not counted as part of the five-page extended abstract body.

APPENDIXES

The following appendix pages provide interface evidence for the AI-SLR Validator Toolkit. These appendixes are attached after the five-page extended abstract body.

APPENDIX A: USER INPUT AND TOOLKIT NAVIGATION DEMO

Appendix A shows the user navigation logic, including the distinction between main input sheets, supporting input sheets, and auto-generated output sheets.



AI-SLR Validator — User Input Guide

Use this sheet to explain exactly where the user enters data in the toolkit.

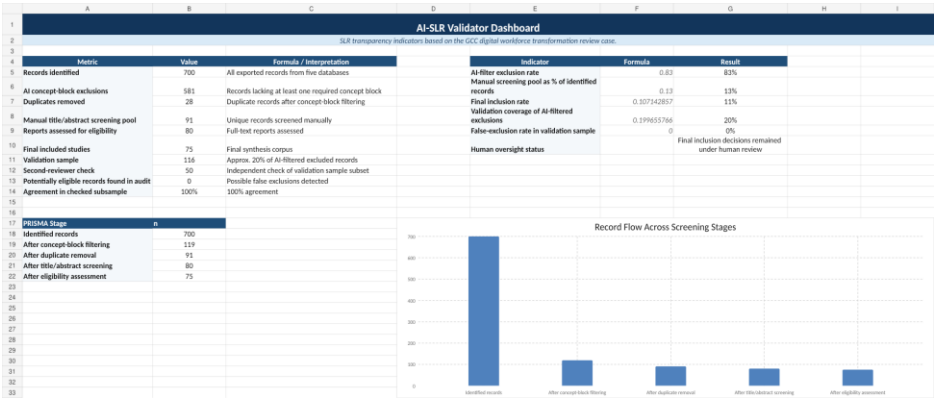
Step	Exact sheet	Exact cells / columns	User enters	Example input	Important note
1	Toolkit Cover	B4:B10	Review information: owner, affiliation, competition use, prototype type, SLR case, value proposition, last updated	B4 = Nor Hapiza Mohd Ariffin; B5 = Sohar University	Edit only Column B. Column A contains fixed labels.
2	Criteria Bank	B4:B6	Concept-block definitions or matched-term groups	B4 = digital skills; AI readiness; cybersecurity literacy; data analytics	Use this only if the SLR topic changes.
3	Criteria Bank	A8:B13 and D8:E13	Inclusion and exclusion criteria with operational rules	Include GCC studies on digital skills and workforce transformation; exclude non-GCC or non-workforce	For a new SLR, replace the criteria text here before screening.
4	Master screening sheet	A2:K92 or add new rows below	Search record data and AI-assisted title/abstract screening decision	Title, abstract, database, year, DOI, matched terms, screening decision	Main input sheet for database records exported from Scopus, IEEE Xplore, WoS, ACM DL, and ScienceDirect.
5	Master screening sheet	A:K columns	A No.; B Title; C Author; D Year; E Source DB(s); F DOI; G Abstract; H Matched terms; I Screening decision; J Exclusion reason; K Notes	I = Include / Exclude; J = Not workforce-related / Not GCC-focused	Matched terms come from the AI concept-block detection prompt.
6	AI Prompt Log	B4:B8 and A12	AI model/interface information and the exact screening prompt	Model = Claude Opus 4.8; Date = 12 June 2026; prompt text in A12	Keep the prompt verbatim for transparency.
7	Validation Audit	B4:B12	Summary validation counts and audit result	B4 = 581; B5 = 116; B8 = 50; B9 = 0; B11 = 100%	These values feed the dashboard evidence.
8	Validation Audit	A16:I35 or add new rows below	Record-level validation sample data	AUD-001; Scopus; article title; AI Exclude; Manual Exclude; Match =	Use this to prove that AI-filtered exclusions were manually audited.
9	PRISMA numbers	B4:B27	PRISMA flow counts	B9 = 700; B20 = 28; B21 = 91; B27 = 75	Update these when using the toolkit for a different SLR.
10	Full-text screening	G2:K81	Full-text retrieval, full-text decision, exclusion reason, relevant RQs, notes	G = Yes; H = Include; J = RQ1; RQ3; RQ4	Bibliographic fields A:F are already imported from the screening sheet.
11	Risk Review Queue	A10:H20 or add new rows below	Records needing extra human review	Missing block = GCC; Risk level = Medium; Action = second reviewer	Use this when AI output is ambiguous or manual audit disagrees.
Do not manually	Validator Dashboard	Dashboard formulas and KPI area	No user input normally required	Dashboard updates from PRISMA and validation data	Use for presentation and reporting.
Do not manually	DIIID Evidence Report	Prepared text cells A3:B10	Optional editing only for competition wording	Problem, solution, novelty, impact	Use this as your narrative script.
Mini demo row for audience	Master screening sheet	A2:K2	Paste one sample record	R001 | Digital skills for workforce transformation in Oman | Scopus | 2025 | Matched terms | Include	Then show the dashboard and validation audit update.

AI Prompt Log | Validation Audit | Risk Review Queue | DIIID Evidence Report | User Input Guide

Figure A1: User Input Guide showing exact sheets, columns, and user actions.

APPENDIX B: AI-SLR VALIDATOR SCREEN INTERFACE

Appendix B presents selected screenshots from the Excel toolkit interface, showing the dashboard, evidence report, and key input areas used during the prototype demonstration.



AI-SLR Validator Dashboard

SLR transparency indicators based on the GCC digital workforce transformation review case.

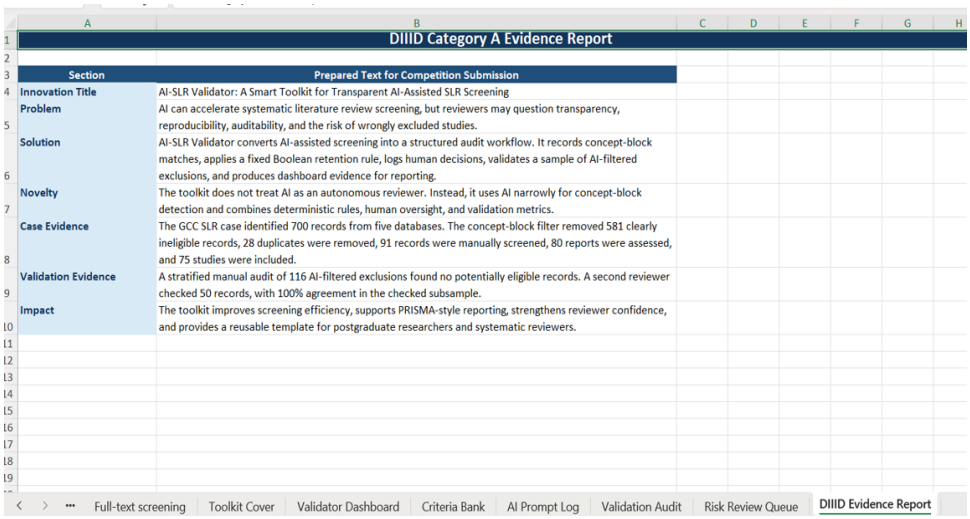
Metric	Value	Formula / Interpretation
Records identified	700	All exported records from five databases
AI concept-block exclusions	581	Records lacking at least one required concept block
Duplicates removed	28	Duplicate records after concept-block filtering
Manual title/abstract screening pool	91	Unique records screened manually
Reports assessed for eligibility	80	Full-text reports assessed
Final included studies	75	Final synthesis corpus
Validation sample	116	Approx. 20% of AI-filtered excluded records
Second-reviewer check	50	Independent check of validation sample subset
Potentially eligible records found in audit	0	Possible false exclusions detected
Agreement in checked subsample	100%	100% agreement

Indicator	Formula	Result
AI-filter exclusion rate	0.83	83%
Manual screening pool as % of identified records	0.13	13%
Final inclusion rate	0.107142857	11%
Validation coverage of AI-filtered exclusions	0.199655766	20%
False-exclusion rate in validation sample	0	0%
Human oversight status		Final inclusion decisions remained under human review

PRISMA Stage	n
Identified records	700
After concept-block filtering	119
After duplicate removal	91
After title/abstract screening	80
After eligibility assessment	75

Record Flow Across Screening Stages

Figure B1: Validator Dashboard summarising screening flow, validation indicators, and record flow chart.



DIIID Category A Evidence Report

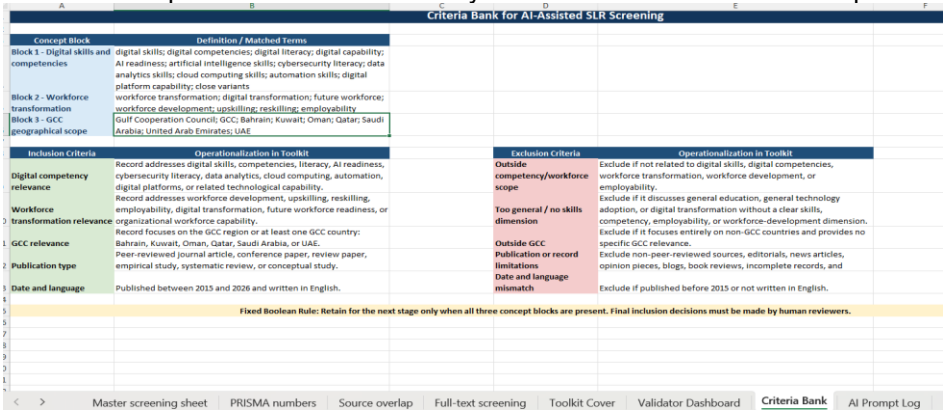
Section	Prepared Text for Competition Submission
Innovation Title	AI-SLR Validator: A Smart Toolkit for Transparent AI-Assisted SLR Screening
Problem	AI can accelerate systematic literature review screening, but reviewers may question transparency, reproducibility, auditability, and the risk of wrongly excluded studies.
Solution	AI-SLR Validator converts AI-assisted screening into a structured audit workflow. It records concept-block matches, applies a fixed Boolean retention rule, logs human decisions, validates a sample of AI-filtered exclusions, and produces dashboard evidence for reporting.
Novelty	The toolkit does not treat AI as an autonomous reviewer. Instead, it uses AI narrowly for concept-block detection and combines deterministic rules, human oversight, and validation metrics.
Case Evidence	The GCC SLR case identified 700 records from five databases. The concept-block filter removed 581 clearly ineligible records, 28 duplicates were removed, 91 records were manually screened, 80 reports were assessed, and 75 studies were included.
Validation Evidence	A stratified manual audit of 116 AI-filtered exclusions found no potentially eligible records. A second reviewer checked 50 records, with 100% agreement in the checked subsample.
Impact	The toolkit improves screening efficiency, supports PRISMA-style reporting, strengthens reviewer confidence, and provides a reusable template for postgraduate researchers and systematic reviewers.

Full-text screening | Toolkit Cover | Validator Dashboard | Criteria Bank | AI Prompt Log | Validation Audit | Risk Review Queue | DIIID Evidence Report

Figure B2: DIIID Evidence Report generated for innovation presentation.

APPENDIX C: MASTER SCREENING AND VALIDATION INPUT SHEETS

Appendix C provides examples of the main data-entry and validation sheets used to operate the toolkit.



Criteria Bank for AI-Assisted SLR Screening

Concept Block	Definition / Matched Terms
Block 1 - Digital skills and competencies	digital skills; digital competencies; digital literacy; digital capability; AI readiness; artificial intelligence skills; cybersecurity literacy; data analytics skills; cloud computing skills; automation skills; digital platform capability; close variants
Block 2 - Workforce transformation	workforce transformation; digital transformation; future workforce; workforce development; upskilling; reskilling; employability
Block 3 - GCC geographical scope	Gulf Cooperation Council; GCC; Bahrain; Kuwait; Oman; Qatar; Saudi Arabia; United Arab Emirates; UAE

Inclusion Criteria	Operationalization in Toolkit
Digital competency relevance	Record addresses digital skills, competencies, literacy, AI readiness, cybersecurity literacy, data analytics, cloud computing, automation, digital platforms, or related technological capability.
Workforce transformation relevance	Record addresses workforce development, upskilling, reskilling, employability, digital transformation, future workforce readiness, or organizational workforce capability.
GCC relevance	Record focuses on the GCC region or at least one GCC country: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, or UAE.
Publication type	Peer-reviewed journal article, conference paper, review paper, empirical study, systematic review, or conceptual study.
Date and language	Published between 2015 and 2026 and written in English.

Exclusion Criteria	Operationalization in Toolkit
Outside competency/workforce scope	Exclude if not related to digital skills, digital competencies, workforce transformation, workforce development, or employability.
Too general / no skills dimension	Exclude if it discusses general education, general technology adoption, or digital transformation without a clear skills, competency, employability, or workforce-development dimension.
Outside GCC	Exclude if it focuses entirely on non-GCC countries and provides no specific GCC relevance.
Publication or record limitations	Exclude non-peer-reviewed sources, editorials, news articles, opinion pieces, blogs, book reviews, incomplete records, and
Date and language mismatch	Exclude if published before 2015 or not written in English.

Fixed Boolean Rule: Retain for the next stage only when all three concept blocks are present. Final inclusion decisions must be made by human reviewers.

Master screening sheet | PRISMA numbers | Source overlap | Full-text screening | Toolkit Cover | Validator Dashboard | Criteria Bank | AI Prompt Log

Figure C1: Main input screen showing Master Screening Sheet.



No.	Title	Author	Year	Source DB(s)	DOI	PDF retrieved	Full-text decision	Exclusion reason	Relevant RQs (e.g. RQ1; RQ3)	Notes
1	Bridging the Digital Skills Divide: Evaluating Tech-Education, Corporate Programs, and Policy Instruments	Danish F.; Hassan R.; Ateeq A.; Ebrahim S.B.	2026	Scopus	10.1007/978-3-032-04378-8_20				RQ1; RQ2; RQ4 (suggested from	
2	Innovative technologies and workplace collaborations in	Boath J.C.; Gilani S.A.M.; Tiemo T.H.; Tantry A.	2026	Scopus; Web of Science	10.3389/frai.2026.1798647				RQ1; RQ3; RQ4 (suggested from	
3	Enhancing employability through digital transformation: a strategic approach to strengthening the competitiveness of	Alotaibi E.K.	2026	Scopus; Web of Science	10.3389/feduc.2026.1788967				RQ1; RQ2; RQ4 (suggested from	
4	From Analog to Digital: A Frugal Framework for Digital Transformation in Manufacturing Microenterprises Under	Omer M.; Buxbaum-Conradi S.; Moritz M.; Redlich T.	2026	Scopus	10.1007/978-3-032-03538-7_17				RQ1; RQ2; RQ3; RQ4 (suggested from	
5	Nurses' digital competency and task performance in Saudi healthcare settings: the mediating role of work	Moafa H.; Nahari A.; Almotairy M.	2026	Scopus; Web of Science	10.1186/s12909-026-09043-8				RQ1; RQ2; RQ4 (suggested from	
6	Digital proficiency: a self-assessment of eHealth literacy and informatics competencies among nursing students	Loutfy A.; Elzeiny A.; Van Belkum C.; El-Monshed A.H.; Al-Helali A.;	2026	Scopus	10.1080/17538157.2025.2605554				RQ1 (suggested from abstract)	
7	Cybercrime regulation in the Arab world: Comparative analysis of Saudi Arabia and UAE frameworks towards	Alhajhamad H.	2026	Scopus	10.1063/5.0318202				RQ1; RQ3; RQ4 (suggested from	
8	Digital marketing capabilities as drivers of SME innovation and performance: a systematic literature review and	Elkhoudary A.; Yadav J.K.; Alam M.M.D.	2026	Scopus; Web of Science	10.1057/s41599-026-07126-x				RQ1; RQ2; RQ3; RQ4 (suggested from	
9	Empowering Women Through Education: The Impact of Lifelong Learning and Skills Development on Female	Danish F.; Hashem M.; Ateeq A.	2026	Scopus	10.1007/978-3-032-07220-7_27				RQ1; RQ3; RQ4 (suggested from	
10	Assessing OT Cybersecurity Readiness in Critical Infrastructure: Global Frameworks and GCC Applications	A. K. Al Araimi; J. Mani; M. S. Yousuf; A. V. Singh; V. P.	2026	IEEE Xplore	10.1109/iciptm69057.2026.11466034				RQ1; RQ3; RQ4 (suggested from	
11	National Cyber Shield Platform: A Scalable Framework for Sustainable Digital Governance	H. Nael; M. Almulla; A. Fenjan	2026	IEEE Xplore	10.1109/icaiset66439.2026.11441514				RQ3; RQ4 (suggested from	
12	The Role of Digital Literacy in Shaping Cybersecurity Awareness Across Young Generations in the United Arab Emirates	Thani S.M.S.A.; Raut J.; Tomašević V.	2026	Scopus; Web of Science	10.3390/app16105027				RQ1; RQ2; RQ4 (suggested from	
13	Empowering sustainability through digital transformation: the hedging power of digital capabilities and innovation	Abdelwaheed N.A.A.; Shah N.; Soomro R.A.; Al Doghan M.A.	2025	Scopus	10.1108/bpmj-11-2024-1879				RQ1; RQ4 (suggested from	
14	Future workforce skills for Saudi Arabia: A PLS-SEM analysis of vision 2030 readiness	Alrashedi A.K.	2025	Scopus	10.1177/02666669251357311				RQ1; RQ3; RQ4 (suggested from	
15	The Mediating Role of Agility in the Relationship Between Digital Transformation and Organisational Resilience in	Bamasoud S.S.; Shannak R.O.	2025	Scopus	10.1108/978-1-83662-518-620251004				RQ1; RQ4 (suggested from	
16	Unpacking the pathways from digital leadership to competitive advantage: mediating insights from digital	Alhelal A.A.; Alshiha A.A.; Al-Romeedy B.S.	2025	Scopus	10.1108/md-07-2025-2168				RQ1; RQ3; RQ4 (suggested from	
17	AI-Driven Sustainable Competitive Advantage in Tourism	Alhelal A.A.; Alshiha A.A.; Al-	2025	Scopus; Web of Science	10.3390/su17198903				RQ1; RQ2; RQ3;	

Full-text screening | Toolkit Cover | Validator Dashboard | Criteria Bank | AI Prompt Log | Validation Audit | Risk Review Queue | DIIID Evidence Report | +

Figure C2: Validation Audit screen

GAMEBOARD+: AN INNOVATIVE TEACHING TOOL FOR SUSTAINABLE MATHEMATICS LEARNING

Nurhazirah Mohamad Yunos[1,*], Wan Munirah Wan Mohamad[1], Nor Kamariah Kasmin[1], Nur Syamilah Arifin[1], Nur Idayu Alimon[1]

[1]Fakulti Sains Komputer dan Matermatik, Universiti Teknologi MARA, Cawangan Johor, Kampus Pasir Gudang

[*]Corresponding author: nurhazirah12394@uitm.edu.my

ABSTRACT

Mathematics is an essential discipline that develops logical reasoning, analytical thinking, and problem-solving skills. However, many students perceive mathematics as a challenging subject, resulting in low motivation, limited participation, and difficulties in understanding mathematical concepts. Conventional lecture-based approaches often position students as passive learners and provide limited opportunities for interaction, collaboration, and active knowledge construction. To address this issue, GAMEBOARD+ was developed as an innovative gameboard-based teaching tool to enhance students' engagement, understanding, and achievement in mathematics learning. The objective of this innovation is to provide an interactive, student-centred, and collaborative learning environment by integrating mathematical problem-solving activities with game-based learning strategies. GAMEBOARD+ consists of customised physical board games designed according to specific topics in the Business Mathematics course. Each game incorporates topic-specific question cards, structured game rules, and collaborative activities that encourage students to discuss, solve problems, and apply mathematical concepts. The implementation follows the learning cycle of Play–Discuss–Reflect–Evaluate, allowing students to actively construct knowledge through peer interaction and immediate feedback. The effectiveness of GAMEBOARD+ was evaluated by comparing students' grade distributions before and after its implementation. The findings showed an improvement in students' academic performance, where the percentage of students achieving A+ increased from 0% to 6.00%, while A and A− grades increased from 13.04% to 22.22%. Classroom observations also indicated enhanced student engagement, participation, collaboration, and confidence during learning activities. In conclusion, GAMEBOARD+ provides a practical, reusable, and cost-effective innovation that transforms mathematics learning into an interactive and enjoyable experience. This innovation supports student-centred learning practices and contributes to improving students' mathematical understanding and academic achievement.

Keywords: mathematics, gameboard, student-centred learning, engaging

1.0 INTRODUCTION

Mathematics plays a fundamental role in developing logical reasoning, analytical thinking, and problem-solving skills that are essential for academic success and future careers. However, mathematics is often perceived as a challenging subject, leading to low student engagement, reduced motivation, and unsatisfactory academic performance when taught using traditional lecture-based approaches. Conventional teaching methods frequently position students as passive recipients of knowledge, limiting opportunities for interaction, collaboration, and active participation during the learning process.

To address these challenges, higher education institutions have increasingly adopted Student-Centred Learning (SCL) and active learning approaches. Research has demonstrated that active learning strategies significantly improve students' understanding and academic achievement compared with traditional instruction (Freeman et al., 2014). In addition, game-based learning has emerged as an effective pedagogical approach that enhances motivation, collaboration, critical thinking, and conceptual understanding in mathematics education (Ting et al., 2019). Recent studies further reported that game-based learning creates engaging learning environments that positively influence students' mathematical achievement, participation, and learning motivation (Debrenti, 2024; Hidayat et al., 2024). Furthermore, research shows that gamification and game-based activities improve students' academic performance and overall learning experience in mathematics courses (González et al., 2024).

Therefore, this project introduces GAMEBOARD+, an innovative gameboard-based teaching tool designed to create an engaging, collaborative, and student-centred learning environment. By integrating mathematical problem-solving with structured game-based activities, GAMEBOARD+ aims to enhance students' understanding of mathematical concepts while improving their engagement, participation, and academic achievement.

2.0 OBJECTIVE

The objectives of this project are to:

1. Develop an innovative gameboard-based teaching tool for mathematics learning.
2. Enhance students' understanding of mathematical concepts through active and collaborative learning.
3. Improve students' engagement, participation, confidence, and academic achievement.

3.0 METHODOLOGY

The methodology of this innovation consists of three main phases: development, implementation, and evaluation. These phases were designed to ensure that GAMEBOARD+ was systematically developed, effectively implemented in the classroom, and evaluated based on its impact on students' learning outcomes.

Development Phase

GAMEBOARD+ was designed based on the principles of Student-Centred Learning (SCL) and game-based learning. Different board games were developed and customised to suit specific topics in the Business Mathematics course, including Simple Interest, Bank Discount, Compound Interest, Annuity, Trade and Cash Discounts, Markup and Markdown, Instalment Purchase, and Depreciation. Each game was equipped with topic-specific question cards, game rules, and learning activities to encourage active participation, collaborative discussion, and problem-solving.

Implementation Phase

The gameboard was implemented after the completion of each chapter as a reinforcement activity. Students were divided into small groups and participated in structured game-based learning sessions. During the activities, students discussed mathematical problems, solved questions collaboratively, and received immediate feedback from their lecturer and peers. The learning process followed a structured cycle:

Play → Discuss → Reflect → Evaluate

This approach encouraged students to actively construct their understanding rather than relying solely on traditional lectures.

Evaluation Phase

The effectiveness of GAMEBOARD+ was evaluated by comparing students' academic performance before and after its implementation. Students' grade distributions from the March–August 2023 semester (without GAMEBOARD+) were compared with those from the March–August 2024 semester (with GAMEBOARD+ implementation). The comparison focused on the percentage of students achieving each grade category to determine whether the innovation contributed to improved academic performance. In addition, classroom observations were conducted throughout the implementation to evaluate students' engagement, participation, collaboration, and confidence during learning activities

4.0 RESULT

A survey has been conducted to assess the effectiveness of the implementation. Figure 1 compares the percentage distribution of students' grades in the Business Mathematics course for Diploma in Business Management (Logistics) between the March–August 2023 semester, in which conventional teaching methods were employed, and the March–August 2024 semester, during which GAMEBOARD+ was implemented after completing each chapter.

The comparison demonstrates a noticeable improvement in students' academic performance following the implementation of GAMEBOARD+. The proportion of students obtaining excellent grades increased substantially. Specifically, the percentage of students achieving A+ increased from 0% in 2023 to 6.00% in 2024. Similarly, the percentage of students obtaining A and A− increased from 13.04% to 22.22%, representing an increase of approximately 9 percentage points for each grade category.

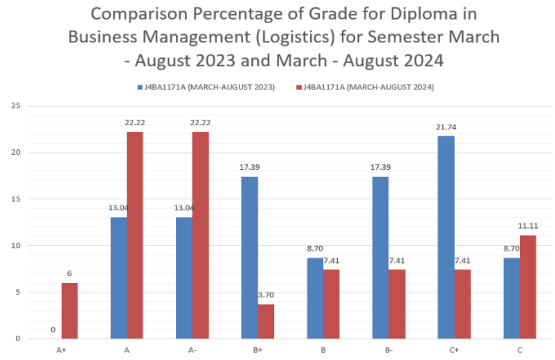


Figure 1: Comparison of students' grade distribution before and after the implementation of GAMEBOARD+ in the Business Mathematics course (March–August 2023 and March–August 2024)

In contrast, the proportion of students receiving middle-range grades decreased considerably. The percentage of B+ grades dropped from 17.39% to 3.70%, while B− decreased from 17.39% to 7.41%, and C+ declined markedly from 21.74% to 7.41%. These reductions indicate that many students who previously achieved average grades were able to improve their performance and move into higher grade categories after experiencing the gameboard-based learning activities.

Although there was a slight increase in the percentage of students obtaining grade C from 8.70% to 11.11%, the overall grade distribution shifted positively towards higher academic achievement. More importantly, the emergence of A+ grades and the substantial increase in A and A− grades suggest that GAMEBOARD+ particularly benefited students with the potential to achieve excellent performance.

The improvement can be attributed to the pedagogical approach adopted in GAMEBOARD+, which promotes active learning, collaborative discussion, and immediate feedback. Through structured game-based activities, students actively participated in solving mathematical problems, discussed alternative solution strategies with their peers, and reinforced their conceptual understanding in an engaging learning environment. This aligns with the principles of Student-Centred Learning (SCL), where students become active participants rather than passive recipients of knowledge (Freeman et al., 2014; Ting et al., 2019).

5.0 CONCLUSION

GAMEBOARD+ demonstrates the potential of game-based learning as an effective approach to enhance mathematics education by creating an interactive, collaborative, and student-centred learning environment. The implementation of GAMEBOARD+ improved students' engagement, participation, confidence, and academic performance, as evidenced by the positive shift in grade distribution after its implementation. By integrating mathematical problem-solving activities with structured gameplay, students were encouraged to actively construct knowledge, collaborate with peers, and develop a more profound understanding of mathematical concepts.

Furthermore, GAMEBOARD+ serves as a practical, reusable, and cost-effective teaching innovation that educators can adapt to different mathematical topics and learning contexts. This innovation provides an alternative approach to traditional teaching methods and supports the implementation of active learning strategies in higher education. Overall, GAMEBOARD+ contributes to transforming mathematics learning into a more meaningful, enjoyable, and effective learning experience for students.

The gameboard is an effective, practical, and reusable teaching innovation that enhances learning outcomes while promoting active participation and collaborative learning. Its simple and low-cost design supports sustainable educational practices and can be readily adopted in mathematics classrooms. This innovation aligns with the theme "Smart Innovations for a Sustainable and Resilient Future" by providing an engaging and sustainable approach to improving mathematics education.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang, for supporting this innovation project. Special thanks are extended to the students who participated in the implementation and evaluation of the gameboard, as well as to colleagues who provided valuable feedback throughout the development process.

REFERENCES

Debrenti, E. (2024). Game-based learning experiences in primary mathematics education. Frontiers in Education, 9, 1331312. https://doi.org/10.3389/feduc.2024.1331312

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

González, J., et al. (2024). Gamification and problem-based learning (PBL): Development of creativity in the teaching-learning process of mathematics in university students. Thinking Skills and Creativity, 53, 101614. https://doi.org/10.1016/j.tsc.2024.101614

Hidayat, R., Qi, T. Y., Ariffin, P. N. B. T., Hadzri, M. H. B. M., Chin, L. M., Ning, J. L. X., & Nasir, N. (2024). Online game-based learning in mathematics education among Generation Z: A systematic review. International Electronic Journal of Mathematics Education, 19(1), em0763. https://doi.org/10.29333/iejme/14024

Ting, F. S. T., Lam, W. H., & Shroff, R. H. (2019). Active learning via problem-based collaborative games in a large mathematics university course in Hong Kong. Education Sciences, 9(3), 172. https://doi.org/10.3390/educsci9030172

CALCMORPH: TRANSFORMING MAT235 THROUGH AI-GENERATED VISUAL NOTEBOOKS AND THE ADAB FRAMEWORK

Nor Kamariah Kasmin@Bajuri[1,*], Nur Idayu Alimon[1], Wan Munirah Wan Mohamad[1], Nur Syamilah Arifin[1], Nurhazirah Mohamad Yunos[1]

[1]Fakulti Sains Komputer dan Matematik, Universiti Teknologi Mara (UiTM) Cawangan Johor Kampus Pasir Gudang

[*]Corresponding author: kamariah0305@uitm.edu.my

ABSTRACT

Engineering students enrolled in MAT235 often experience difficulties in mastering complex topics such as integration, multivariable calculus, and ordinary differential equations due to high cognitive load, fragmented learning resources, and limited opportunities to actively engage with and reflect on mathematical concepts. To address these challenges, CalcMorph is introduced as an AI-powered learning innovation that transforms complex calculus into visual understanding by leveraging NotebookLM to generate interactive visual notebooks and infographics aligned with the ADAB framework. The effectiveness of CalcMorph was evaluated by examining how AI-generated visual learning resources enhanced students' understanding and reflection through structured learning activities embedded within the MAT235 curriculum. The findings demonstrate that the visual notebooks improved students' understanding, knowledge organisation, learning engagement, and confidence in solving complex mathematical problems while encouraging meaningful reflection on their learning process. Overall, CalcMorph offers a smart, sustainable, and scalable educational solution that modernises engineering mathematics education.

Keywords: engineering mathematics, NotebookLM, ADAB framework, mathematics education

1.0 INTRODUCTION

Mathematics anxiety is a widespread issue in modern engineering education that directly impacts student success and retention rates in higher education. Many engineering undergraduates view their core mathematics course, MAT235 (Calculus / Integration), not as a foundational tool but as a major academic burden (Uzun and Hoxha, 2026). This negative perception creates a damaging cycle. The control-value theory of achievement emotions posits that when students perceive low competence in mathematical tasks while valuing academic success highly, it leads to severe emotional distress that impairs performance (Pekrun et al., 2025). Because engineering curricula are heavily cumulative, these poor math results directly damage student performance in core engineering subjects like mechanics, thermodynamics, and electrical circuits.

Concurrently, traditional abstract teaching methods often cause cognitive overload in dense STEM tracks. Recent meta-analyses confirm a moderate but consistent negative correlation between mathematics anxiety and mathematics achievement, particularly inside exam-oriented educational systems (Zhao and Wang, 2026). Students quickly lose interest in the subject matter and find it increasingly difficult to understand complex mathematical rules, integration techniques, and calculus formulas. To address this issue, educators require active learning strategies that address both cognitive and emotional aspects of the learning environment (Taylor and Evans, 2025). Visual learning tools and source-grounded artificial intelligence frameworks have emerged as promising mechanisms to build clearer mental frameworks and foster learner autonomy (Robinson et al., 2026). This paper explores how integrating an advanced AI-powered learning platform, NotebookLM, into the study process can simplify complex information and alleviate mathematics anxiety for engineering students taking MAT235 (Smith and Peterson, 2025).

2.0 OBJECTIVE

The main objectives of this study are as follows:

- To evaluate the impact of combining student self-summarisation with AI-assisted mind mapping on conceptual comprehension in MAT235 (Calculus / Integration).
- To measure the effectiveness of NotebookLM as a pedagogical tool in reducing student cognitive load and mathematics anxiety.
- To analyse student perceptions, engagement levels, and attitudes regarding the adoption of AI-driven visual aids in their study routines.

3.0 METHODOLOGY

This study utilises a structured, four-phase action research methodology mapped across the institutional ADAB learning design framework, which includes seven elements: Situate, Digest, Synthesise, Create, Connect, Reflect, Value and Extend. The intervention is designed to actively engage students in their own learning process while using AI for structural organisation.

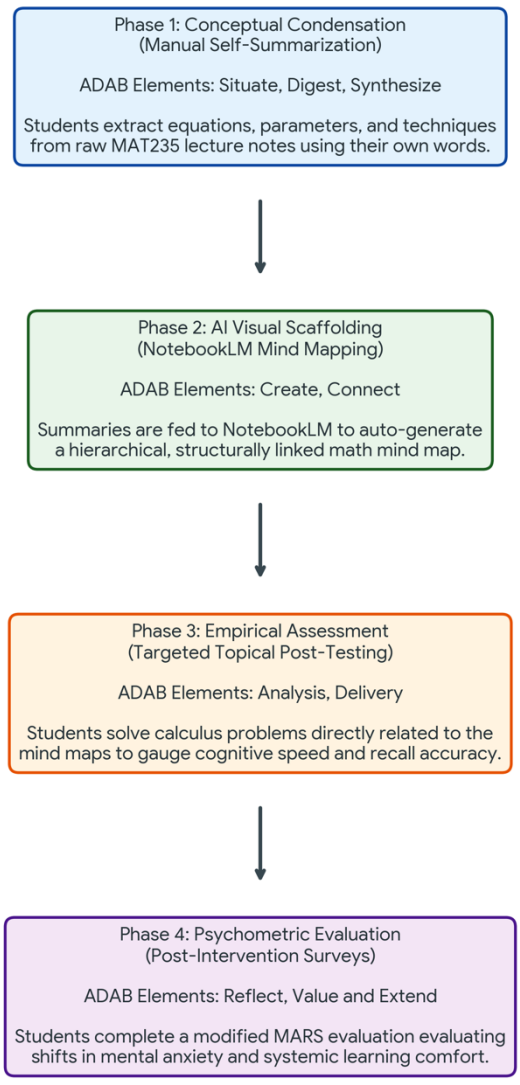


Figure 1: Sequential workflow schema of the human-AI collaborative learning framework for engineering mathematics instruction.

3.1 Conceptual Condensation (Situate, Digest, Synthesize)

The intervention initiated with independent note synthesis, deeply rooted in the Situate and Digest elements of the ADAB model. Students began by analysing their raw lecture notes for specific MAT235 units, such as Methods of Integration (Integration by Parts and Trigonometric Substitutions). Before

interacting with any external technology, participants were required to fulfil the Synthesise element. They manually processed the information and wrote out a concise summary in their own words. This phase forced students to manually work through core calculus theories, integration equations, and operational steps, aligning with self-regulated learning theories to prevent passive reliance on technology (Robinson et al., 2026).

3.2 AI Visual Scaffolding (Create, Connect)

In the second phase, students transitioned to the Create and Connect elements of the framework. The student-generated text summaries from Phase 1 were uploaded as source documents into NotebookLM. Students then prompted the AI platform to organise their notes into structured, hierarchical mind maps (Salinas Frencia, 2025). This step leveraged the software's native visual formatting features to link different integration formulas, trigonometric identities, and boundary conditions. This process created a clear visual architecture of the chapter, helping students bridge the gap between abstract rules and practical application (Smith and Peterson, 2025).

3.3 Empirical Assessment (Analysis, Delivery)

To verify the academic value of the generated mind maps, students entered the Analysis and Delivery stages. Participants were subjected to targeted topical post-tests featuring complex MAT235 problems directly related to the mind-mapped chapters. The testing phase measured whether the visual scaffolds translated into better problem-solving abilities, improved calculation speed, and better factual retention during exam conditions, serving as a primary direct metric for mathematical efficiency (Sobel and Sarmiento, 2025).

3.4 Psychometric Evaluation (Reflect, Value and Extend)

Following the assessments, the study integrated the Reflect and Value and Extend elements. A comprehensive survey was administered to the cohort using Likert-scale questions adapted from the Mathematics Anxiety Rating Scale (MARS) framework. Students were asked to critically reflect on their learning journey, shifts in their math anxiety levels, their perceived ease of revision, and how this workflow transformed their confidence. The phase evaluated how students can extend these AI-assisted habits to benefit their other core engineering courses (Uzun and Hoxha, 2026).

4.0 RESULT

In this section, the data collected from the assessments and surveys provided key insights into the value of this pedagogical approach.

Quantitative Performance Analysis

An analysis of the MAT235 post-test results showed a distinct improvement in student performance. The average test scores of the participating cohort were higher compared to historic student baselines from previous semesters where traditional study methods were used. Students who engaged with the mind-mapping process demonstrated a clearer understanding of when and how to apply specific calculus formulas, demonstrating a clear reduction in the instructional friction linked to cognitive overload (Zhao and Wang, 2026).

Reductions in Student Mathematics Anxiety

The psychometric survey data revealed a significant drop in self-reported math anxiety. A large majority of the students stated that the visual hierarchy of the AI mind maps made complex topics feel manageable, reinforcing how crucial protective indicators like lesson quality and cognitive clarity are to emotional comfort (Taylor and Evans, 2025). By breaking down dense textbook chapters into interconnected visual blocks, the students felt less overwhelmed during test preparation for MAT235, changing their affective state and reducing fear-based performance inhibition (Sobel and Sarmiento, 2025).

Implications for Educational Researchers

For researchers and educators looking to replicate this study, the findings show that NotebookLM functions as a highly reliable cognitive aid in higher education (Salinas Frencia, 2025). Because the AI utilises a source-grounded approach and strictly organises the user's uploaded summaries rather than generating content from the open internet, it avoids the "hallucinations" or factual errors common to standard generative LLMs (Robinson et al., 2026). This design uses retrieval-augmented generation (RAG) to ensure absolute mathematical accuracy while promoting academic integrity and significantly cutting down study time (Smith and Peterson, 2025).

5.0 CONCLUSION

The main conclusions of this study demonstrate that incorporating NotebookLM into MAT235 coursework successfully reduces student anxiety while enhancing topic comprehension. Shifting students from passive note-takers to active creators of AI-structured learning frameworks makes abstract engineering mathematics less intimidating. The combined approach of human summarisation and AI formatting offers a scalable, practical method for educators to support student retention and confidence in demanding technical fields.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Universiti Teknologi MARA Cawangan Johor for the funding.

REFERENCES

Pekrun, R., Stephens, E. J., & Fraser, J. (2025). Impact of math anxiety and general anxiety on academic achievement: An integration of control-value theory and stress models. Journal of Educational Psychology, 117(2), 210–224.

Robinson, T., Shoitan, M., Molina, R., & Medina, A. (2026). Source-grounded AI and learner autonomy in higher education: A NotebookLM case study. Journal of Artificial Intelligence in Education, 14(3), 89–104.

Salinas Frencia, J. (2025). NotebookLM: An LLM with RAG for active learning and collaborative tutoring in STEM. ResearchGate Preprint, doi:10.13140/RG.2.2.39077.2640

Smith, K., & Peterson, L. (2025). Transforming STEM education: A case study on the pedagogical implementation of Google's NotebookLM. International Journal of EdTech Innovation, 8(4), 312–327.

Sobel, M., & Sarmiento, L. (2025). Mathematical anxiety's mediating significance in the relationship between self-efficacy and mathematical efficiency. International Journal of Research and Innovation in Social Science, 9(8), 1142–1155.

Taylor, H., & Evans, M. (2025). Understanding mathematics anxiety: The role of social-emotional skills and perceived lesson quality. Cogent Education, 12(1), 2609386.

Uzun, A., & Hoxha, B. (2026). Latent profiles of perfectionism and mathematics anxiety among university students. Higher Education Research & Development, 45(4), 712–729.

Zhao, Y., & Wang, L. (2026). Mathematics anxiety and its impact on students' learning outcomes: A comprehensive meta-analysis review (2014–2024). Educational Review, 78(1), 45–62.

MUAMALAT EXPLORER KIT: SPECIAL REFERENCE TO MAJALLAH AHKAM JOHOR

Muhammad Azizur Rahman Ramli[1,*], Muhammad Fahmi Md Ramzan [1,] ,Nurfarhana Mohd Daud[1], Mahasin binti Saja @ Mearaj [1],

[1]UiTM Johor Branch (Segamat Campus), Academy of Contemporary Islamic Studies (ACIS)

[*]Corresponding author: azizur@uitm.edu.my

ABSTRACT

Traditional Fiqh teaching methods are less motivating for the digital generation, leading to poor memorisation of terms and terminology in fiqh and legal matters. To bridge this gap, this project introduces the Muamalat Explorer Kit: Special Reference to Majallah Ahkam Johor. This educational innovation consists of two interrelated components: Firstly, a comprehensive booklet detailing Majallah Ahkam Johor covering topics from sale and purchase contract to *khiyar*. Secondly, an interactive Android application (APK) titled Muamalat Explorer. The mobile game is designed with specific pedagogical outcomes, requiring students to master the terms of Islamic contract and *khiyar* (option) by successfully completing five simulated trade transactions. The conceptual foundation of this kit is based on two main frameworks: Kolb's Experiential Learning Cycle to structure the transition from reading to practical application and the Islamic education triad of 'Ilm (Knowledge), 'Amal (Action), and Akhlaq (Ethics). This application, developed using the Agile Framework, translates authentic Islamic law from Majallah al-Ahkam Johor into a dynamic digital environment. Majalah Ahkam Johor is the official Johor state translation of Majallah al-Ahkam al-Adliyyah, an Islamic civil law code (related to Fiqh Muamalat) enacted during the Ottoman Empire. It served as a guide to civil and business law in the early 20th century society in Johor. Initial evaluation involved interviews with six students. Their feedback clearly showed that this dual-item kit was effective in deepening their understanding of Fiqh Muamalat. Students reported that reading the physical booklet first, followed by furthering their experiential learning in a mobile game, strengthened their understanding and bridged the gap between complex Fiqh concepts and modern reality. Ultimately, the Muamalat Explorer Kit provides a future-ready pedagogy that aligns the traditional Fiqh syllabus with the interactive needs of today's digital generation.

Keywords: RPG, games, majalah ahkam johor, muamalat, innovation

1.0 INTRODUCTION

Islamic finance differs from conventional economics in that it must comply with the Sharia and transaction contracts prescribed by Allah and His Messenger. Islam prohibits the activities of taking *Riba, Gharar* and Gambling. Meanwhile, teaching Islamic banking activities presents unique challenges to students because its core terms and concepts, such as *murābaḥah* (cost-plus financing), *mushārakah* (partnership), *muḍārabah* (profit sharing), and *ijarah* (rent) are difficult for students to understand. Ethical principles, spiritual and moral values also need to be learned. Furthermore, classroom delivery tends to remain focused on contractual structures rather than practical and ethical applications. As a result, students may struggle to understand and connect the religious, legal and sales operations holistically.

This results in a critical gap in educational practices, highlighting the need for interactive pedagogical approaches such as real-world Islamic transactions and ethical decision-making scenarios. Although students grasp these concepts theoretically, their practical application often falls short. Ethical reasoning, particularly when confronting real or simulated dilemmas, demands practice, self-reflection, and moral sensitivity (Basalma, 2024; Wahyuni & Soumena, 2025). Integrating ethical frameworks into the classroom is therefore crucial so that future practitioners can go beyond mere compliance with Shariah law to truly internalise its moral principles. Furthermore, since text-based learning alone is insufficient, critical thinking must be nurtured through hands-on, contextual experiences. Exposing students to the realities of the industry enables them to weigh financial goals alongside spiritual values, fostering a grounded, Islamically aligned ethical awareness.

The definition of gamification or game-based learning is to create situations that have a “game-like feel” among players (Wiggins, 2018), where the scenario will directly engage them in a specific way that the game creator intends to achieve (Dicheva et al., 2015). Game-based learning has emerged as an approach that can enhance the understanding of complex theoretical concepts and go beyond classroom teaching methods alone. By incorporating interactive and engaging game elements, students can actively participate in the learning process and foster a deeper understanding of the subject.

This is in line with Kolb's (1984) Experiential Learning Theory, which emphasises learning through experience, reflection, conceptualisation, and experimentation. Sungkawaningrum et al. (2025) found that in most classrooms, Islamic banking subjects are still taught using traditional methods. This often leaves students feeling passive and disconnected. As a result, students may have difficulty connecting theory with practice. Similarly, according to Fitria (2023b), higher education has shifted from teacher-centred learning to student-centred learning. Traditional lecture-based teaching, although effective in transferring theoretical knowledge, often fails to maintain student interest or promote deep understanding. According to her, this is in contrast to game-based learning which encourages students to learn through exploration, experimentation, and reflection. This is reinforced by Piaget's (1977) Constructivist Learning Theory, where this method involves students in a learning cycle of concrete experiences, reflective observation, abstract conceptualisation, and active experimentation. However, there is a difference between game-based learning and simulation-based learning. Games are artificial and pedagogical tools; they involve conflict, rules and predetermined goals, while simulations are dynamic tools, representing reality, demanding accuracy and validation (Sauve, 2007).

Several teaching and learning innovations, such as AqdiLab. have the potential to bridge the knowledge gap between classical fiqh and contemporary financial realities. It uses gamification elements, such as cards and digital quizzes, to be played in groups, with each group completing simulations with clue-based tasks and reflective feedback sessions. This leads to increased student attendance to class and good student performance (Meerangani et al., 2025). Findings show that 82% of students understand more clearly about the various types of Islamic contracts. Findings also show that 88% of students find the simulation method more interesting than traditional lectures. Similarly, 75% of students stated that interactive challenges help them relate theoretical concepts to real-life applications. In fact, 80% of students are more confident in explaining contract structures based on classical sources (Meerangani et al., 2025).

With the same concept, the innovative Muamalat Playing Card game was developed to foster greater interest and improve subject knowledge. This game method is adapted from the “Happy Family” card game. Muamalat Playing Card game has 40 cards representing 12 families or categories. Each card contains the definition of each Muamalat Playing Card contract. This Muamalat card game will start with a card game involving four players (A, B, C and D). Each player will be given cards equally and will start placing cards and asking anyone who has a card from the same muamalat term. After each turn is over, whoever can collect the same term will win this game. The winner will be determined by the player who finishes the cards in his hand (Rahim, H., Kamarudin, et al., 2023).

However, in accordance with the passage of time, digital and more interactive games need to be developed. Scaffolding techniques need to exist in the game so that students understand the purpose of playing. Scaffolding is used as an illustration where the teacher provides temporary assistance to students to help them complete tasks or develop new understanding, which then enables students to work on the game tasks without help from anyone (Hammond & Gibbons, 2005). For example, the geofarmer game uses the concept of Role Play Game (RPG), which combines storyline, characters and non-game characters (NPC) as guides. The findings show that learning outcomes with various guidelines can be achieved in stages. However, there are students who are unable to complete the challenges that have been set, especially when the challenges given are based on higher-level thinking (Oprean et al., 2023). Therefore, the muamalat fiqh game is based on RPG games and the use of local muamalat fiqh references has been identified. The Muamalat explorer game contains two parts, namely the Johor Majallah Ahkam Code Guide Item as a guide to learn the Islamic Contract and Khiyar (option). Majalah Ahkam Johor was chosen because it was used as a reference for the kadi in the State of Johor before independence. Majalah Ahkam Johor is a translation of the Majallah Ahkam Al-Adliyyah. The Majallah al-Aḥkām al-‘Adliyyah was implemented in 1893, which is the principle of Civil law belonging to the Ottoman Empire based on the Hanafi School, giving a strong influence on the Civil law of the Johor Empire in the 19th century, known as the Majalah Ahkam Johor. Due to Johor's position as a state that is in the process of implementing Islamic law, the relationship with the Ottoman Empire was further strengthened. The Book of Majallah al-Aḥkām al-‘Adliyyah is the law related to buying and selling (Buyu‘), renting and leasing (Ījārah), liability (Kafālah), transferring debts and receivables (Hiwālah), mortgage (Rahnu), reconciliation (Sulh) and so on. (Othman, M. H., Rozali, et al., 2021).

2.0 OBJECTIVE

1. Analyze students' cognitive understanding of basic muamalat concepts such as Ijab Qabul and Khiyar through the Muamalat Explorer Kit based on Role-Play Game (RPG) with local fiqh references (Majalah Ahkam Johor)

3.0 METHODOLOGY

AI-Generated Applications in Education AI tools such as Google AI Studio create new possibilities for teachers to develop educational applications without programming skills. This reflects the emerging notion of the teacher as a developer, where educators take an active role in designing, customising, and refining AI-generated interactive and gamified content that aligns with the national curriculum. However, research on the effectiveness of AI-generated learning applications, particularly in Malaysia, remains limited (Rahman, 2026). Therefore, the game was tested on 6 students of the muamalat program. Their responses were analysed based on qualitative methods. This qualitative method was also used in evaluating RPG games as done by Oprean et al. (2023). Students were gathered and they played with the Android program. Then, an interview session was held for the purpose of analysing their understanding and learning experience in this game. The Muamalat Explorer Android application was generated by using Google AI Studio application. According to Rahman (2026), it can create new applications for teachers to develop educational applications without programming skills. At the same time, it makes teachers as application developers, where teachers play an active role in designing, adapting and refining interactive content aligned with the curriculum of an institution. The source code for this Android application can be accessed via [https://github.com/azizursyuhada/muamalat-explorer].

3.1 GAME DESCRIPTION

The game features three structured interface panels designed to guide students through the content cited in Item 1 specifically, Majallah Ahkam Johor, Sections 167–185 (Jual-Beli / Buying and Selling) and Sections 300–309 (Khiyar / Options). The Player Status Panel is important as a metric for measuring knowledge of how many dinars (currency), Fiqh Knowledge (knowledge) has been accumulated, how much reputation and the status of transactions that need to be done. The Control Panel provides easy navigation and interaction instructions. On the right, the Main Mission Panel outlines the learning objectives progressively, which is instructing players to acquire basic knowledge in the mosque with Ustaz Ali before applying these theories through practical and Sharia-compliant transactions in the market. The core narrative and victory conditions of the game emphasise ethical compliance and holistic learning over simple profit. Players progress by mastering Islamic legal concepts such as Khiyār (choice) and Majlis (session), moving from theoretical lessons to real-world market applications. To win, players must successfully complete five valid transactions while maintaining a balance across all of their status indicators. This ensures that success is only achieved through a demonstrated understanding of Islamic commercial law, informed decision-making, and strict adherence to ethical Shariah principles. The interface of Muamalat Explorer on Android can be seen below.

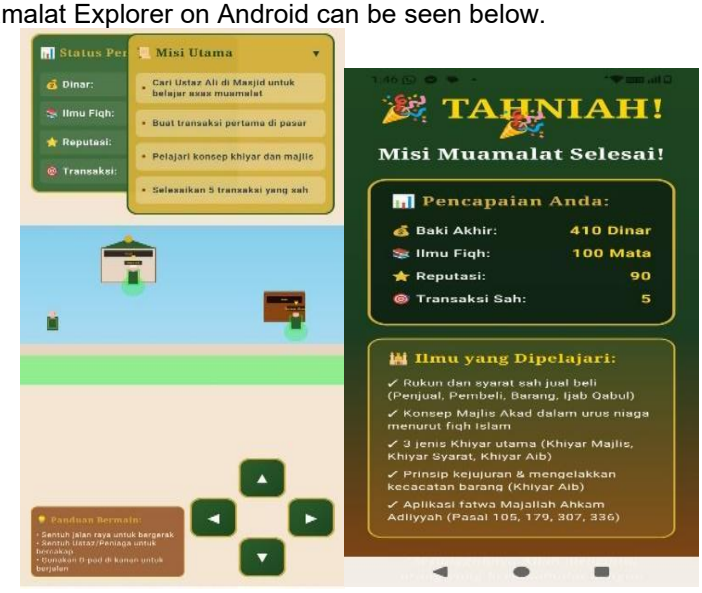


Figure 1: Status Panel and Control Panel

4.0 RESULT

The interview found that there were three new themes *"Easy to Learn", "Visual Learning"* and *"Need Guidance"*

Table 1: Theme Analysis

	Experience	Learning Style	Challenge	Uniqueness of the game
1	Attractive medium	Visual	Difficult menu	
2	Easy to learn	Visual		More specific to Muamalat Subject
3	Suitable for new students	Playing while learning	Needs teacher instructions	
4	Interactive			Like a roblox game
5	Structured game	Exploration	Needs a user manual	
6	Easy compared to books	Added value	Character needs to be realistic	
	Easy to learn	**Visual Based Learning Style**	**Needs guidance**	

The primary novelty of these findings lies in demonstrating that complex, classical Islamic legal texts such as Majallah Ahkam Johor can be effectively demystified through gamified visual learning without compromising subject integrity. Unlike traditional text-heavy instruction, this game introduces a novel dual-value approach: it caters to visual and exploratory learning styles ('Easy to Learn', 'Visual Learning'), while highlighting a critical pedagogical requirement for digital Muamalat tools and the necessity of guided exploration ('Need Guidance'). Rather than replacing traditional instruction, the game emerges as a unique, highly engaging supplementary tool that transforms abstract legal principles into interactive, accessible experiences.

5.0 CONCLUSION

In conclusion, the Muamalat Explorer innovation kit, which combines the Majallah Ahkam Johor guidebook and the Role-Playing Game (RPG)-based Android application, has successfully proven its effectiveness in improving students' cognitive understanding and practical application capabilities of Muamalat Fiqh. The application, developed using Google AI Studio, allows students to master complex concepts, such as Islamic contract and khiyar, in an interactive, ethical, and effective manner. Qualitative findings confirm that this virtual experiential learning method is not only more engaging than traditional teaching but is also able to bridge the gap between classical fiqh theory and today's digital financial reality.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the students of IC210 (Bachelor of Muamalat), UiTM Johor Branch, for their valuable participation and support in this study.

REFERENCES

Basalma, E. O. (2024). The SDG-Islamic banking nexus: Insights from the OIC top economies. Share: Jurnal Ekonomi dan Keuangan Islam, 13(1), 347–368

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. Journal of Educational Technology & Society, 18(3), 75–88.

Fitria, T. N. (2023b). Integrating English Language Teaching (ELT) Into Islamic Boarding Schools: A Review of Strategy and Challenges. Journal of English Language and Pedagogy (JELPA), 1(2), 64–78.

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Prentice-Hall.

Othman, M. H., Rozali, E. A., & Ismail, N. K. (2021). Majalah Ahkam Johor: Sumbangannya dalam Perkembangan Islam di Johor pada Akhir Abad ke 19: Majalah Ahkam Johor: Its Contribution on Islamic Development in Johor in the Late 19th Century. Journal of Al-Tamaddun, 16(2), 1-19..

Sauve, L., Renaud, L., Kaufman, D., & Marquis, J. S. (2007). Distinguishing between games and simulation: A systematic review. Education Technology & Society, 10(3), 247–256.
Sungkawaningrum, F., Irawati, Y., Ayuningsih, S. D., & Faizudin, M. (2025). Islamic Banking Learning Through Educational Games: Building Islamic Financial Awareness in Children. Al-Mashrof (Journal Islamic Banking And Finance), 1(2), 110–118.
Wahyuni, W., & Soumena, F. Y. (2025). Transparansi Dan Akuntabilitas Dalam Pelaporan Keuangan Syariah; Studi Pada Lembaga Keuangan Islam Di Indonesia. Manajemen Keuangan Syariah, 5(1), 1–17.
Wiggins, B. E. (2018). An overview and study on the use of games, simulations, and gamification in higher education. Gamification in education: Breakthroughs in research and practice, 191–204.
Rahman, S. A. A. (2026). XTif GMath: A Gamified, Interactive, AI-Generated Application for Learning Form 1 KSSM Mathematics. Malaysia Journal of Invention and Innovation, 5(1), 18-24.
Meerangani, K. A., Abdul Hamid, M. F., Ahad, N., & Rosele, M. I. (2025). AqdiLab: interactive simulation of Muamalat contracts. The International Competition on Sustainable Education 2025 E-Proceeding, 35-39.
Rahim, H., Kamarudin, M. K., Mohamad Norzilan, N. I., Hasbullah, N. N., & Karimon, N. A. (2023). Muamalat playing card: inovasi dalam pengajaran dan pembelajaran di era pascanormal.
Oprean, D., Brown, D., McGorry, N., Pieper, B., Rankin, N., & Larsen, S. (2023, October). Exploring In-Game Scaffolds for Higher-Order Learning in a Case-Based RPG Learning Game. In Proceedings of the 17th European Conference on Games Based Learning (Vol. 17, pp. 467-471).

MYANAK DIGITAL: AI-POWERED ELECTRONIC CHILD HEALTH RECORD AND EARLY DEVELOPMENT INTELLIGENCE SYSTEM IN MALAYSIA

Norhidayah Azman[1,*], Siti Maryam Md Nor[1], Mughaneswari Sahadevan[1]
Ahmad Shazeer Bin Mohamed Thaheer [2]

[1]Faculty of Business Management and Professional Studies, Department of Business Studies, Management and Science University (MSU), Shah Alam, Selangor
[2]Universiti Teknologi MARA, Cawangan Selangor, Kampus Puncak Alam, Malaysia

[*]Corresponding author: norhidayah_azman@msu.edu.my

ABSTRACT

The *Buku Rekod Kesihatan Bayi dan Kanak-Kanak* (Blue Book) plays an essential role in documenting children's health information in Malaysia, including immunisation records, growth monitoring, developmental milestones, and medical history. However, the current paper-based system is vulnerable to loss, damage, incomplete documentation, and limited accessibility across healthcare facilities. These challenges may affect continuity of care, timely interventions, and efficient healthcare management. As Malaysia advances toward digital health transformation, there is a growing need for an intelligent and integrated platform that supports real-time child health monitoring and predictive healthcare services.
This innovation introduces **MyAnak Digital**, an AI-powered electronic child health record system, designed to replace the conventional Blue Book with a secure, cloud-based digital ecosystem. The system centralises child health information, including birth records, vaccination history, growth measurements, medical conditions, allergies, and developmental assessments. Through a mobile application and web-based platform, parents, healthcare professionals, childcare providers, and authorised agencies can securely access and update records anytime and anywhere. The key innovation of MyAnak Digital lies in its integration of artificial intelligence technologies. The system utilises AI-driven analytics to monitor child growth patterns, assess developmental milestones, identify potential risks of malnutrition or developmental delays, and generate personalised health recommendations. Automated vaccination reminders, health alerts, and a multilingual digital health assistant further enhance parental engagement and preventive healthcare practices. Additionally, a population health dashboard provides aggregated insights for healthcare authorities to support evidence-based planning and resource allocation. In conclusion, MyAnak Digital offers a sustainable and scalable solution for modernising child healthcare records in Malaysia. The integration of AI-powered monitoring, cloud technology, and digital health services has the potential to improve healthcare efficiency, strengthen preventive care, and ensure that every child receives timely and appropriate health interventions.

Keywords: digital health, artificial intelligence, child healthcare, electronic health records, vaccination management, early childhood development, smart healthcare, sustainable innovation

1.0 INTRODUCTION

The health and well-being of children during the early years of life are critical determinants of future physical, cognitive, and social development, establishing the foundation for lifelong health outcomes (Black et al., 2017). In Malaysia, the *Buku Rekod Kesihatan Bayi dan Kanak-Kanak* serves as an official health document issued by the Ministry of Health (MOH) to record birth information, immunisation history, growth monitoring, developmental assessments, and healthcare visits from birth until six years of age. The record book plays an essential role in supporting child health surveillance, facilitating communication between healthcare professionals and parents, and ensuring adherence to the National Immunisation Programme (MOH, 2026).

Despite its importance, the current paper-based record system faces several operational challenges that compromise healthcare delivery. Physical records can be misplaced, damaged, forgotten during clinic visits, or become inaccessible when families relocate or seek treatment at different healthcare facilities (Lim & Hashim, 2025). Furthermore, the manual nature of documentation limits real-time

information sharing, data integration, health analytics, and continuity of care across healthcare providers. As Malaysia continues to advance its healthcare digitalisation agenda, the need for a secure, accessible, and intelligent electronic child health record system has become increasingly evident. Research highlights that nationwide digital health records are essential for improving healthcare efficiency, quality of care, and continuity of medical services across the healthcare ecosystem (Gong et al., 2024; Naim et al., 2025). The urgency for strengthening child health monitoring is further supported by recent national statistics. According to the Department of Statistics Malaysia, approximately 9.03 million children under the age of 18 were living in Malaysia in 2025, including 2.31 million children under five years old, representing a substantial population requiring continuous health surveillance and preventive healthcare services. The same report indicated a decline in infant immunisation coverage across multiple vaccine categories in 2024, highlighting the critical need for more effective monitoring and reminder systems to support vaccination compliance (Department of Statistics Malaysia, 2025). [dosm.gov.my]

In addition, Malaysia's National Immunisation Programme provides free vaccinations from birth until childhood to protect against thirteen vaccine-preventable diseases. However, maintaining complete immunisation records remains essential because vaccination information is required for healthcare management and school registration processes. The Ministry of Health also encourages parents to safeguard children's health records due to their significance as a lifelong health reference (MOH, 2026).

Concurrently, Malaysia has accelerated its digital health transformation through platforms such as **MySejahtera**, which has evolved into a comprehensive health application that already supports selected health records and children's vaccination certificates. The Ministry of Health's Digital Strategic Plan 2026–2030 further signals the government's commitment to developing integrated digital healthcare services and strengthening health information systems nationwide (MOH, 2026).

Globally, digital health interventions have proven their potential in enhancing maternal and child health outcomes. Research indicates that electronic health records not only improve data accuracy and clinical decision-making but also aid in better coordination of care (WHO, 2023; Ahmad et al., 2026). The incorporation of artificial intelligence within paediatric healthcare has shown itself to be a transformative strategy in early detection of developmental delays, malnutrition risk assessment, and individualised health recommendations (Smith et al., 2024; Zhang et al., 2025).

To address these challenges, this project proposes **MyAnak Digital: An AI-Powered Electronic Child Health Record and Early Development Intelligence System**, an innovative platform designed to replace the conventional *Buku Rekod Kesihatan Bayi dan Kanak-Kanak*. The system integrates electronic health records, artificial intelligence analytics, vaccination tracking, growth monitoring, developmental screening, and predictive healthcare alerts within a secure cloud-based ecosystem. By transforming traditional paper-based records into an intelligent digital platform, MyAnak Digital supports proactive, preventive, and data-driven child healthcare management while contributing to Sustainable Development Goals (SDG) 3 (Good Health and Well-Being), SDG 9 (Industry, Innovation and Infrastructure), and SDG 10 (Reduced Inequalities). This innovation aligns with Malaysia's vision for a smart, sustainable, and resilient digital healthcare future.

2.0 OBJECTIVE

The development of MyAnak Digital is guided by the following specific objectives:

1. To develop a secure and integrated digital child health record system that replaces the conventional *Buku Rekod Kesihatan Bayi dan Kanak-Kanak* by centralising immunisation records, growth monitoring data, development assessment, medical history, and healthcare information in a cloud-based platform accessible by authorised users.
2. To incorporate Artificial Intelligence (AI) technologies for real-time monitoring, predictive risk assessment, and early detection of child health and developmental issues, enabling timely intervention and improved healthcare outcomes for children from birth to six years of age.
3. To enhance child healthcare management and preventive healthcare by automated vaccination reminders, personalised health recommendations, digital health analytics, decision-support tools for parents, healthcare professionals, and public health authorities to improve immunisation compliance, reduce missed appointments, and aid evidence-based healthcare planning.
4. To improve equitable access to child healthcare services using a multilingual, user-friendly, accessible digital platform in various socioeconomic settings and geographical locations,

minimising health disparities and ensuring every child gets continuous, comprehensive healthcare monitoring, irrespective of their family history or location of residence.

5. To support national health policy and public health surveillance using population-level health analyses and data-driven decision-support dashboards for healthcare authorities to identify patterns, optimally direct resources, and implement specific interventions for enhancing child health outcomes at the community, district, and national level.

3.0 METHODOLOGY

This study adopts a system development and integration approach to design and implement an AI-enabled smart child healthcare system that digitises the traditional hardcopy blue book into a centralised e-clinical record within the MySejahtera platform. The methodology focuses on developing a functional digital solution that supports child healthcare monitoring, predictive analysis, and data accessibility. The system is developed through three phases: (i) system design and data integration, (ii) AI model development, and (iii) user interface and platform implementation.

In the first phase, maternal health data, including antenatal records, clinical history, and patient reported inputs, are structured into a standardised digital format to ensure interoperability across healthcare providers. This addresses the fragmentation associated with manual and paper-based record systems (Lim & Hashim, 2025). In the second phase, artificial intelligence techniques are embedded into the system to enable predictive analytics. Machine learning models are trained to analyse maternal health indicators and identify early signs of high-risk pregnancy conditions, supporting proactive intervention and clinical decision-making, consistent with evidence that AI-based predictive healthcare systems can improve early risk detection and maternal health outcomes (Ahmad et al., 2026). In the final phase, a user-friendly mobile interface is integrated within the MySejahtera platform, enabling real-time access to maternal health records, automated alerts, and personalised recommendations. Together, these phases are intended to improve usability, accessibility, and patient engagement, particularly for expectant mothers in different socio-economic settings. The system is designed to be practical and scalable and to align with national digital health infrastructure, supporting feasibility for large-scale implementation (World Health Organization, 2026).

3.1 System Feature and Functionality

The development of MyAnak Digital: AI-Powered Electronic Child Health Record and Early Development Intelligence System follows a five-phase methodology: needs assessment, system design, system development, artificial intelligence integration, and system validation.

Phase 1: Needs Assessment and Requirement Analysis

A needs assessment is conducted to identify the limitations of the current Buku Rekod Kesihatan Bayi dan Kanak-Kanak and to gather requirements from key stakeholders, including parents, healthcare professionals, clinic administrators, and childcare providers. Existing child health monitoring processes, immunisation tracking practices, and developmental screening procedures are reviewed to determine the system's core functions. These findings are then used to establish system requirements, security specifications, and user interface expectations.

Phase 2: System Design

Based on the requirements identified in Phase 1, a cloud-based digital health architecture is designed. The system consists of four main modules: (1) Digital Child Health Record Module, (2) Vaccination Management Module, (3) AI Growth and Development Monitoring Module, and (4) Health Analytics and Reporting Dashboard. Wireframes, database structures, and user interfaces are developed with the aim of creating an intuitive experience for parents and healthcare providers. Data protection mechanisms, user authentication protocols, and role-based access controls are also incorporated to maintain confidentiality and comply with healthcare data governance standards.

Phase 3: System Development

Building on this design, the MyAnak Digital platform is developed as a web-based and mobile application using cloud computing technologies. The system digitises all information currently stored in the physical health record book, including birth information, child identification details, immunisation records, growth measurements, developmental milestones, medical history, allergy records, and nutritional assessments. A centralised database is established to support real-time data synchronisation and secure information sharing among authorised healthcare facilities and users.

Phase 4: Artificial Intelligence Integration

Artificial intelligence algorithms are then incorporated to support preventive healthcare and clinical decision-making. The AI engine performs growth trend analysis based on weight, height, BMI, and head

circumference; early identification of potential malnutrition and stunting risks; developmental milestone assessment and delay detection; predictive health risk modelling; and personalised healthcare recommendations. In addition, the system generates automated notifications for upcoming vaccinations, missed appointments, abnormal growth patterns, and developmental concerns. A multilingual AI-powered virtual health assistant further provides guidance and educational information to parents on child healthcare and development.

Phase 5: System Testing and Validation

Finally, the completed system undergoes functional testing, usability testing, and security testing to assess its reliability and performance. A pilot implementation is conducted with selected parents and healthcare practitioners, and user feedback is collected through satisfaction surveys and structured evaluations covering ease of use, usefulness, accessibility, and effectiveness. System performance is assessed using the following indicators: accuracy of child health record management, vaccination reminder effectiveness, accuracy of AI-generated alerts and recommendations, user satisfaction level, and reduction in manual record-keeping processes.

4.0 RESULT

The development of MyAnak Digital: AI-Powered Electronic Child Health Record and Early Development Intelligence System is expected to change how child healthcare records are managed by replacing the conventional paper-based *Buku Rekod Kesihatan Bayi dan Kanak-Kanak* with a digital platform. The system is intended to offer advantages for parents, healthcare providers, and policymakers, in line with Malaysia's ongoing digital healthcare transformation agenda.

The primary result of the system is the digitisation of child health records into a centralised cloud-based platform. Essential information, including birth records, immunisation history, growth measurements, medical history, developmental assessments, allergies, and nutritional status, can be securely stored and accessed through mobile and web-based platforms. This reduces the risk of lost, damaged, or incomplete records and supports continuity of healthcare services across multiple facilities.

A further outcome is the implementation of an AI monitoring engine capable of analyzing growth patterns and developmental milestones in real time. The AI system evaluates children's height, weight, BMI, head circumference, and developmental progress against established pediatric health standards. Abnormal trends or potential developmental concerns are flagged, enabling healthcare professionals and parents to initiate early intervention. This predictive capability represents an improvement over the current manual monitoring approach.

The system also supports immunisation management through automated vaccination scheduling and reminder notifications. Parents receive timely alerts for upcoming vaccinations, which is expected to reduce missed appointments and improve compliance with the National Immunisation Programme. In addition, the system generates real-time vaccination status reports for healthcare providers and identifies children who may be at risk of incomplete immunisation coverage.

At the policy level, MyAnak Digital provides a data-driven dashboard that enables healthcare authorities to monitor child health trends at community, district, state, and national levels. Aggregated health analytics can help policymakers identify areas with higher risks of stunting, malnutrition, delayed development, or low vaccination coverage, thereby supporting healthcare planning, resource allocation, and preventive intervention strategies.

5.0 CONCLUSION

MyAnak Digital: AI-Powered Electronic Child Health Record and Early Development Intelligence System offers a sustainable approach to modernising the management of child healthcare records in Malaysia. By replacing the conventional *Buku Rekod Kesihatan Bayi dan Kanak-Kanak* with a cloud-based digital platform, the system addresses long-standing challenges associated with paper-based records, including data loss, limited accessibility, fragmented information management, and the lack of real-time health monitoring.

The integration of artificial intelligence extends the system beyond simple record digitisation by enabling predictive growth analysis, developmental milestone monitoring, automated vaccination reminders, and early health risk detection. These capabilities support a more proactive and preventive approach to healthcare, allowing parents and healthcare professionals to identify potential health concerns earlier and respond with timely interventions. In addition, the centralised platform facilitates

information sharing among authorised users, which is expected to improve healthcare efficiency, continuity of care, and clinical decision-making.

The system also has potential public health value through population-level health analytics that can support evidence-based policymaking, resource allocation, and national child health surveillance. By improving digital healthcare accessibility and child health outcomes, MyAnak Digital aligns with Sustainable Development Goal (SDG): SDG 3 (Good Health and Well-Being), SDG 9 (Industry, Innovation and Infrastructure), and SDG 10 (Reduced Inequalities).

In conclusion, MyAnak Digital represents a shift from paper-based documentation toward a data-driven, AI-enabled approach to child healthcare management. The proposed system has potential for national implementation, scalability, and future integration with Malaysia's digital health infrastructure, with the broader aim of ensuring that every child has access to continuous, accessible, and high-quality healthcare throughout their early developmental years.

REFERENCES

Department of Statistics Malaysia. (2025). Children statistics, Malaysia, 2025. Department of Statistics Malaysia. https://www.dosm.gov.my [dosm.gov.my]

Gong, R., Mukhriz, I., & Tan, J.-E. (2024). Digital health records in Malaysia: The journey and the way forward. Khazanah Research Institute. https://www.krinstitute.org/publications/digital-health-records-in-malaysia-the-journey-and-the-way-forward [krinstitute.org]

Ministry of Health Malaysia. (2026). Child health record book. MyGovernment Malaysia. https://www.malaysia.gov.my/en/categories/health/babies-and-children/child-health-record-book [malaysia.gov.my]

Ministry of Health Malaysia. (2026). Child immunisation programme. MyGovernment Malaysia. https://www.malaysia.gov.my/en/categories/kesihatan/kesihatan-bayi-dan-kanak-kanak/program-imunisasi-bayi-dan-kanak-kanak [malaysia.gov.my]

Ministry of Health Malaysia. (2026). MySejahtera application. MyGovernment Malaysia. https://www.malaysia.gov.my/en/categories/kesihatan/fasiliti-dan-kemudahan-kesihatan/aplikasi-mysejahtera [malaysia.gov.my]

Ministry of Health Malaysia. (2026). Digital strategic plan Ministry of Health Malaysia 2026–2030. Ministry of Health Malaysia. https://www.moh.gov.my/en/publications-and-reports/policies-act-policies-guide-lines/strategic-plan/list-of-strategic-plans [moh.gov.my]

Naim, N., Kuroda, Y., Yamada, S., Mori, Y., Liu, C., Espinoza, R., Yamamoto, G., & Kuroda, T. (2025). The evolution of healthcare digitalisation policies in Malaysia: A four-decade narrative review (1985–2025). Digital Health, 11, 1–12. https://doi.org/10.1177/20552076251353279

SCROLL, CLICK, BOOM! MASTER THE POWER OF FACEBOOK, INSTAGRAM & TIKTOK

Muruga Chinniah[1,*], Palaniappan Shamala[2], Mazida Ismail[1], Mazlina Ismail[1], Nur Adilah Hj Saud[1]

[1] Fakulti Pengurusan dan Perniagaan, Universiti Teknologi MARA (UiTM), Cawangan Johor, Kampus Segamat, 85000 Segamat, Johor, Malaysia
[2] Fakulti Sains Komputer dan Matematik, Universiti Teknologi MARA (UiTM), Cawangan Johor, Kampus Segamat, 85000 Segamat, Johor, Malaysia

[*]Corresponding author: murug480@uitm.edu.my

ABSTRACT

Digital marketing has become essential for the growth and sustainability of Small and Medium Enterprises (SMEs). It enables businesses to reach wider markets, engage customers more effectively, and improve competitiveness at a lower cost. However, many SMEs still struggle with limited digital knowledge, lack of marketing skills, and low confidence in using digital platforms for business growth. These challenges highlight the need for practical digital marketing training. 3S: Swipe, Share & Sell – The New Face of Marketing was developed to address these challenges by equipping SME entrepreneurs with practical digital marketing skills. The project's main innovation is the *Scroll, Click, Boom! Master the Power of Facebook, Instagram & TikTok* training module. Unlike traditional entrepreneurship programmes that focus mainly on theories, this module provides step-by-step, hands-on guidance that participants can immediately apply in their businesses. It covers content creation, social media strategies, business account management, paid advertising, and mobile marketing, helping SMEs strengthen their online presence and business performance. The project was implemented through a collaboration between Universiti Teknologi MARA (UiTM), the Labis District Council (MDL), local SMEs, and students from the Faculty of Business and Management. This partnership combines academic expertise, government support, and community participation to promote knowledge sharing and sustainable digital transformation. The Scroll, Click, Boom! module is practical, user-friendly, and easily adaptable by universities, government agencies, entrepreneurship development organisations, and SME support centres. It serves as both a training guide and a long-term reference for entrepreneurs. With the increasing demand for digital skills, the module has strong market potential and can be delivered through workshops or online learning platforms. By improving SMEs' digital capabilities, this innovation contributes to business competitiveness, sustainable growth, and the development of a stronger digital entrepreneurial ecosystem in Malaysia.

Keywords: digital marketing training, SME digital transformation, social media marketing, community engagement & entrepreneurship development

1.0 INTRODUCTION

"Scroll, Click, Boom! Master the Power of Facebook, Instagram & TikTok" is a pioneering-edge digital marketing training module developed as an extension from the community-engagement project "3S: Swipe, Share & Sell – The New Face of Marketing". This module is designed by students from Universiti Teknologi MARA (UiTM) Johor Branch as a part of their SULAM MKT571: Digital Content, Social Media and Mobile Marketing course. It aims to deliver Small and Medium Enterprises (SMEs) an experience and skills to utilise Facebook, Instagram, and TikTok for marketing effectively. Unlike conventional training materials that mainly focus on theories, this module adopts a hands-on and experiential learning approach by providing step-by-step guidance on content creation, business account management, social media marketing strategies, paid advertising, and performance analytics. This approach is consistent with recent studies showing that practical digital marketing training significantly enhances SME competitiveness, customer engagement, and business performance (Malik et al., 2024; Salleh et al., 2025; Elkhoudary et al., 2026).

2.0 PROBLEM STATEMENT

The rapidity in the growth of digital technology has brought a shift in consumer purchasing practices. Undeniably, social media has become a key channel for marketing SMEs. But still, many SME entrepreneurs, particularly those in rural areas, are still holding onto traditional practices when it comes to purchasing, primarily due to the lack of digital knowledge. Common challenges are (1) creating engaging digital content, (2) managing business social media accounts, (3) understanding platform algorithms, (4) selecting appropriate posting schedules, and (5) interpreting marketing performance indicators such as reach, engagement, and audience insights. These findings are in line with the results of recent research which indicated that lacking digital literacy and marketing knowledge continues to be one of the most significant obstacles for SMEs in their journey of digital transformation (Azman et al., 2026; Landjohou & Christopher, 2026; Elkhoudary et al., 2026). Similar challenges were identified during interviews and discussions conducted under the previous 3S: Swipe, Share & Sell project, with seven participating SMEs in Labis. The findings underscored the need for a structured, practical, and user-friendly digital marketing module.

3.0 MOTIVATION FOR DEVELOPING THE MODULE

The Scroll, Click, Boom! Master the Power of Facebook, Instagram & TikTok module was developed to bridge the digital skills gap among SME entrepreneurs and improve their confidence in using social media for business growth. The module was designed by integrating the Course Learning Outcomes (CLOs) of MKT571, feedback from SME entrepreneurs, and the SULAM approach, which combines academic learning with community engagement. This enables students to apply classroom knowledge to solve real business challenges while developing communication, leadership, teamwork, and digital marketing competencies. Research has shown that experiential learning, university–community collaboration, and industry-based training significantly improve students' employability while supporting SME innovation and digital capability development (Salleh et al., 2025; Elkhoudary et al., 2026). Furthermore, the module supports Malaysia's digital transformation agenda and contributes to Sustainable Development Goal (SDG) 8: Decent Work and Economic Growth and SDG 11: Sustainable Cities and Communities by strengthening SME competitiveness, promoting digital inclusion, and encouraging sustainable community development. Its practical design, flexibility, and scalability make it suitable for adoption by universities, government agencies, entrepreneurship development organisations, and SME support centres throughout Malaysia (Landjohou & Christopher, 2026; Azman et al., 2026).

4.0 OBJECTIVE

1. Enhance the Digital Skills of SME Entrepreneurs
   Equip SME entrepreneurs with practical competencies in digital content creation, social media marketing, mobile marketing, and business account management using Facebook, Instagram, and TikTok.
2. Support Sustainable Development Goal (SDG) 8: Decent Work and Economic Growth
   Improve SMEs' competitiveness, increase customer reach, and create sustainable income opportunities through effective digital marketing strategies that contribute to local economic growth.
3. Support Sustainable Development Goal (SDG) 11: Sustainable Cities and Communities
   Strengthen the digital capacity of rural and local entrepreneurs, promoting inclusive economic participation and building more resilient and sustainable communities through digital transformation.
4. Achieve the Learning Outcomes of the SULAM MKT571 Course
   Provide students with authentic service-learning experiences by applying digital marketing knowledge to solve real business challenges faced by SMEs, while fostering collaboration between the university, local government, and the community.

5.0 METHODOLOGY

The development of the Scroll, Click, Boom! Master the Power of Facebook, Instagram & TikTok module adopted the Design and Development Research (DDR) approach integrated with Service-Learning Malaysia – University for Society (SULAM). DDR provides a systematic framework for designing, developing, evaluating, and refining educational products to ensure they are evidence-based and meet users' needs. The integration of SULAM further strengthens experiential learning by allowing students to apply academic knowledge to solve authentic community problems while generating

meaningful social impact (Richey & Klein, 2020; Aluwi et al., 2025). Recent studies also emphasise that community-based learning enhances students' professional competencies while improving SMEs' digital capabilities through collaborative knowledge transfer.

The needs assessment, involving seven SME entrepreneurs, identified limited digital literacy, weak social media management skills, and low confidence in using digital marketing. These findings are consistent with recent systematic reviews that show SMEs continue to face barriers in digital marketing adoption due to the inadequate digital knowledge, limited strategic capabilities and technology-related challenges (Malik et al., 2024; Osman et al., 2026; Elkhoudary et al., 2026).

5.1 Module Development Framework

The module was developed by integrating the MKT571 curriculum, the SULAM pedagogical approach, and continuous feedback from SME entrepreneurs. This learner-centred approach ensured that the module addressed both academic requirements and real industry challenges. Research indicates that combining curriculum-based learning with experiential and community-based learning improves students' critical thinking, communication, leadership, and problem-solving skills while producing practical solutions for SMEs (Aluwi et al., 2025; Ahern, 2026).

The module content covers Digital Content Marketing, Social Media Marketing, Mobile Marketing, Digital Advertising, Social Media Analytics, and Business Account Management. These competencies are recognised as essential digital marketing capabilities that improve SME innovation, customer engagement, competitiveness, and long-term business performance (Salleh et al., 2025; Elkhoudary et al., 2026; Akel et al., 2026).

Continuous feedback collected from SME entrepreneurs throughout the programme was used to refine the learning activities. User-centred and iterative module development has been shown to increase the usability, relevance, and effectiveness of training resources, particularly for adult learners and SME capacity-building programmes (Elkhoudary et al., 2026; Osman et al., 2026).

5.2 Module Implementation

The module was implemented over four months using a structured four-phase learning framework comprising Phase 1: Digital Awareness & Business Diagnosis, Phase 2: Business Account Development & Content Creation, Phase 3: Campaign Implementation, and Phase 4: Performance Evaluation & Continuous Improvement. This progressive approach reflects experiential learning principles, where learners gradually build knowledge through practical application, reflection, and continuous improvement. Such approaches have been found to increase digital competency and confidence among SME entrepreneurs (Ahern, 2026; Arisandra et al., 2026).

The practical training included business account creation, content development, campaign management, paid advertising, and social media analytics. Current research consistently demonstrates that hands-on digital marketing training enables SMEs to improve customer engagement, online visibility, innovation capability, and business performance more effectively than theory-based learning alone (Salleh et al., 2025; Elkhoudary et al., 2026; Akel et al., 2026).

The final evaluation using pre- and post-tests, social media analytics, business observations, and participant feedback aligns with current recommendations that digital marketing programmes should measure both learning outcomes and business impact. Evidence suggests that continuous mentoring, performance monitoring, and analytics-based decision-making significantly improve SMEs' digital transformation and long-term sustainability (Osman et al., 2026; Elkhoudary et al., 2026). Table 1 summarises the key features of the "Scroll, Click, Boom!" module.

Table 1: Key Features of the "Scroll, Click, Boom!" Module

Aspect	Description
Innovation Features	An innovative digital marketing module integrating the MKT571 curriculum, SULAM approach, and real SME applications. It provides practical guidance on social media marketing, advertising, analytics, and performance evaluation.
Functionality	A practical toolkit that guides entrepreneurs in creating business accounts, developing content, managing campaigns, using advertisements, and analysing digital marketing performance.
Usefulness	Helps SME entrepreneurs improve branding, customer engagement, and online visibility while developing students' communication, teamwork, and problem-solving skills. Suitable for adoption by universities and entrepreneurship organisations.

Practicality	A user-friendly module with step-by-step guides and practical examples. It uses affordable tools such as smartphones and free social media platforms, suitable for flexible learning delivery.

6.0 RESULT

The Scroll, Click, Boom! Master the Power of Facebook, Instagram & TikTok programme was successfully implemented over a four-month period using the SULAM approach, involving 21 MKT571 students, seven SME entrepreneurs, and the Labis District Council (MDL). The project produced the Scroll, Click, Boom! training module as a practical digital marketing guide for SMEs. Participants' average scores improved from 2.17 (pre-test) to 4.69 (post-test), achieving an overall programme effectiveness of 93%. The programme successfully enhanced SMEs' digital marketing competencies, strengthened students' experiential learning, and fostered sustainable collaboration between the university, industry, and the local community. Participants' satisfaction with the facilitators and overall program satisfaction are summarised in Table 2.

Table 2: Participants' Satisfaction with the Facilitators and Overall Program

Evaluation	Participants' Feedback	Analysis / Interpretation
Facilitators' Knowledge	100% of participants agreed that facilitators demonstrated strong digital marketing knowledge.	Facilitators effectively delivered knowledge and improved participants' understanding.
Quality of Delivery	100% of participants were satisfied with clear explanations, professionalism, and interactive teaching.	The engaging delivery approach maintained participant involvement and understanding.
Learning Experience	Participants found the training enjoyable, practical, and easy to follow.	Hands-on activities and real business cases created an effective learning experience.
Knowledge and Skills Gained	Participants gained confidence in using Facebook, Instagram, and TikTok for business marketing.	The program improved digital marketing skills and readiness for business application.
Overall Program Satisfaction	Participants showed high satisfaction and recommended similar training in the future.	Positive feedback highlights the effectiveness of the SULAM-based training and the *Scroll, Click, Boom!* module.

The 3S: Swipe, Share & Sell programme significantly enhanced the digital marketing capabilities of participating SME entrepreneurs through a structured four-phase training approach. Across all phases, participants demonstrated substantial improvements in knowledge, confidence, and practical skills, as reflected in the pre- and post-test results in Table 3.

Table 3: Summary of program performance by Phases

Phase	Pre	Post	Improvement	Key Outcome	Analysis
Phase 1	2.64	4.29	+1.65 (62.5%)	Improved understanding of digital marketing and platforms	Strong foundation established for later phases.
Phase 2	2.26	4.43	+2.17 (96.0%)	Professional business accounts and branding skills	Hands-on coaching greatly improved practical skills.
Phase 3	2.29	4.49	+2.20 (96.1%)	Content planning and camping management	Highest adoption of practical content marketing.
Phase 4	2.17	4.69	+2.52 (116.1%)	Analytics and performance evaluation	Greatest improvement; data-driven decision making developed.
Overall	2.34	4.48	+2.14 (91.5%)	Higher knowledge, confidence and competency	Module and SULAM approach proved highly effective.

Figure 1 shows Innovation Outcome of the 3S Project: *Swipe, Share & Sell – The New Face of Marketing* – Development of the "Scroll, Click, Boom! Master the Power of Facebook, TikTok & Instagram" Training Module.



Fig 1: 3S Project: *Swipe, Share & Sell* Training Module

7.0 CONCLUSION

The “Scroll, Click, Boom! Master the Power of Facebook, Instagram & TikTok” module is an innovative digital marketing resource developed under the 3S: Swipe, Share & Sell – The New Face of Marketing project to enhance SME digital capabilities. Integrating the MKT571 curriculum with the SULAM approach, the module supports students in applying academic knowledge while helping SMEs overcome real-world digital marketing challenges. Based on SME needs, it follows four phases: Digital Awareness, Business Account Development, Campaign Implementation, and Performance Evaluation.

The module provides practical guidance on social media marketing, content creation, campaign management, and performance analysis. Its effectiveness is demonstrated by the improvement of participants’ average scores from 2.17 (pre-test) to 4.69 (post-test), achieving 93% programme effectiveness. The project also strengthens students’ experiential learning while providing a sustainable solution for SME digital transformation and university–community engagement.

ACKNOWLEDGEMENT

The authors would like to express sincere gratitude to everyone who contributed, both directly and indirectly, to the completion of this study.

REFERENCES

Akel, G., Armağan, E., Acayıp, E., & Sezen, G. (2026). Digital Marketing in SMEs: Capabilities,Strategies, and Future Directions. Yönetim ve Ekonomi Araştırmaları Dergisi, 24(1). Journal URL: https://dergipark.org.tr/tr/pub/yead/article/1531950

Azman, N. O., Basiruddin, R., & Ibrahim, I. S. A. (2026). Digital marketing adoption and continuance challenges in Malaysian MSMEs: A systematic review. International Journal of Entrepreneurship and Management Practices.

Elkhoudary, A., Yadav, J. K., & Alam, M. M. D. (2026). Digital marketing capabilities as drivers of SME innovation and performance: A systematic literature review and research agenda for emerging economies. Humanities and Social Sciences Communications, 13, Article 605. DOI: https://doi.org/10.1057/s41599-026-07126-x

Kolb, D. A. (2021). Experiential Learning: Experience as the Source of Learning and Development (2nd ed.). Pearson Education.https://doi.org/10.31674/ijrtbt.2026.v010i01.001

Malik, S. A., Zakaria, N., & Othman, S. (2024). The impact of digital marketing technology for transformation on SMEs: A systematic review. INSIGHT Journal. https://doi.org/10.24191/ij.v11i2.2403

Ministry of Higher Education Malaysia. (2020). Service Learning Malaysia – University for Society (SULAM): A Guide to Course Implementation. Official guide: https://sulam.mohe.gov.my/

Osman, N., Basiruddin, R., & Ibrahim, I. S. A. (2026). Digital Marketing Adoption and Continuance Challenges in Malaysian MSMEs: A Systematic Review. International Journal of Entrepreneurship and Management Practices, 9(34), 227–251. DOI: https://doi.org/10.35631/IJEMP.934014

Unveiling Barriers and Drivers of AI Adoption for Digital Marketing in Malaysian SMEs. (2025). Journal of Open Innovation: Technology, Market, and Complexity, 11(2), 100519. DOI: https://doi.org/10.1016/j.joitmc.2025.100519

Richey, R. C., & Klein, J. D. (2020). Design and Development Research: Methods, Strategies, and Issues (2nd ed.). Routledge. DOI: https://doi.org/10.4324/9780203826034

Salleh, N. F., Ramlee, N. A. Z., Ghazali, N., Asnawi, N. H., & Abd Rahim, L. N. (2025). *Exploring the role of digital marketing in small business growth: A literature review using the Technology Acceptance Model (TAM)*. *Advances in Business Research International Journal*

CATEGORY B1

TERTIARY LEVEL

SCIENCE & TECHNOLOGY

EXPERIMENTAL INVESTIGATION OF DENSITY AND CALORIFIC VALUES OF BINARY BLENDS OF ALGAE-DIESEL BIOFUEL

Faridzul Iqbal Muthar[1], Hazim Sharudin[1], Sharzali Che Mat[2], Hasannuddin Abd Kadir[1*]

[1]Faculty of Mechanical Engineering, Universiti Teknologi MARA, Cawangan Johor, Pasir Gudang Campus 81750 Masai, Johor, Malaysia
[2]Faculty of Mechanical Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Permatang Pauh, Pulau Pinang, Malaysia

[*] Corresponding author: hasannuddin@uitm.edu.my

ABSTRACT

Growing global energy demand has intensified concerns over Greenhouse gas emissions (GHG). As a result, Straight vegetable oil (SVO) has been explored as a potential substitute for petroleum diesel because its fuel properties are broadly comparable to those of conventional diesel. In this study, algae oil was selected as the main feedstock for producing an algae–diesel biofuel blend. An experimental investigation was carried out to statistically evaluate the physicochemical properties of algae oil–diesel mixtures and to formulate a suitable alternative fuel using the mixture design approach. Eight experimental runs involving binary blends at different compositions, including D25A75, A100, D50A50, D100, and D75A25, were generated. The developed predictive models for density, viscosity, and calorific value (CV) produced coefficients of determination (R^2) of 0.9859, 0.9997, and 0.9621, respectively. Optimization results identified the D82A18 algae–diesel blend as the most favourable formulation, with predicted properties complying with ASTM International ASTM D6751.

Keywords: Alternative biofuel, binary blend, mixture design method, straight vegetable oil

1.0 INTRODUCTION

The development of Rudolf Diesel's early engines, which could operate on pure peanut oil, marked the origin of straight vegetable oil (SVO) as a renewable fuel source (Song, 2020). However, the direct use of biofuels in diesel engines is constrained by several drawbacks, including high viscosity, lower calorific value (CV), and poor oxidation stability. These limitations can adversely affect fuel atomization, reduce the heat release rate during combustion, and promote fuel degradation through lipid oxidation (Gaur, 2022) and (Das, 2022).

In recent years, increasing attention has been directed toward producing biofuels from algal biomass. Algae-derived fuels have been reported to improve thermal efficiency (TE) while reducing emissions such as unburned hydrocarbons (UHC) and carbon monoxide (CO) (Lodi, 2023). In this study, raw algae oil was blended directly with petroleum diesel to formulate a binary algae–diesel fuel. This approach is expected to lower CO and UHC emissions while preserving fuel properties that remain comparable to those of conventional diesel fuel.

2.0 OBJECTIVES

To investigate the physicochemical properties of binary blends of algae-diesel biofuel.
To formulate a new algae-diesel biofuel blends using the mixture design method.
To optimize the algae-diesel biofuel blends using the mixture design method.

3.0 METHODOLOGY

3.1 MATERIAL

The reference diesel fuel was procured from a local gasoline station, while the algae oil was sourced from a private supplier. A preliminary visual assessment indicated that the algae oil exhibited a clear, light-yellow appearance, accompanied by a mild, neutral odour and a subtle taste.

3.2 CHARACTERIZATION OF ALGAE OIL AND DIESEL BIOFUEL BLENDS

Fuel property measurements were conducted using procedures based on ASTM international standards and established in-house methods. The density (kg/m³) of each sample was determined at ambient temperature using a 25 mL Gay-Lussac pycnometer in accordance with DIN ISO 3507. Kinematic viscosity (mm²/s) was measured with a Cannon-Fenske viscometer following ASTM D445. The calorific value (CV) was evaluated using an IKA C200 oxygen bomb calorimeter in accordance with ASTM D240.

3.3 BIOFUEL FORMULATION AND PREPARATION USING THE MIXTURE DESIGN METHOD

Statistical models were developed from the experimental data to enable the analysis and optimization of algae–diesel fuel blends using the mixture design methodology. Following the experimental design stage, eight experimental runs were generated, as presented in Table 1.

Table 1: Proposed experimental runs

Run	Blend Composition (vol. %)		Nomenclature
	Algae Oil	Diesel	
1	75	25	D25A75
2	100	0	A100
3	50	50	D50A50
4	100	0	A100
5	50	50	D50A50
6	0	100	D100
7	25	75	D75A25
8	0	100	D100

3.4 THE OVERVIEW OF ANALYSIS OF VARIANCE (ANOVA)

Analysis of variance (ANOVA) is employed to evaluate the variability arising from the differences among grouped datasets. In this study, ANOVA was applied through Design Expert 13 to examine the effects of independent variables (fuel blend ratios) on the dependent variables (fuel properties). Overall, ANOVA provides a reliable statistical approach for optimization by assessing the significance and maximisation of the response parameters (Sharudin, 2025).

4.0 RESULT

4.1 THE PHYSICOCHEMICAL PROPERTIES OF ALGAE-DIESEL BIOFUEL

The physicochemical properties of algae oil and diesel fuel are summarised in Table 2. The results indicate that the kinematic viscosity of the algae oil, as well as fuel formulations containing cerium oxide nanoparticles, exceeds the limits specified in ASTM D6751. This limitation can be mitigated by blending with diesel fuel, whose lower-viscosity hydrocarbon components dilute the more viscous fuels and reduce the overall fuel viscosity.

Table 2: Physicochemical properties of algae-diesel biofuel.

Property	Unit	Algae Oil	Diesel	ASTM D6751
Viscosity	mm^2/s	45.84	3.1	1.9-6.0
Calorific Value	MJ/kg	40.52	44.8	-
Density	kg/m^3	957.10	832.6	870-900

4.2 THE EFFECTS OF VARIED COMPOSITIONS OF ALGAE-DIESEL BIOFUEL BLENDS ON DENSITY

Design Expert software was utilised to establish a mathematical relationship between biofuel composition and density. Figure 1 illustrates the interaction between varying proportions of algae oil and diesel fuel, showing that density decreases linearly as the proportion of algae oil is reduced. This relationship can be quantitatively described using Eq. (1). Collectively, Figure 1 and Eq. (1) provide a predictive framework for estimating the density of fuel blends within the limits specified by ASTM standards.

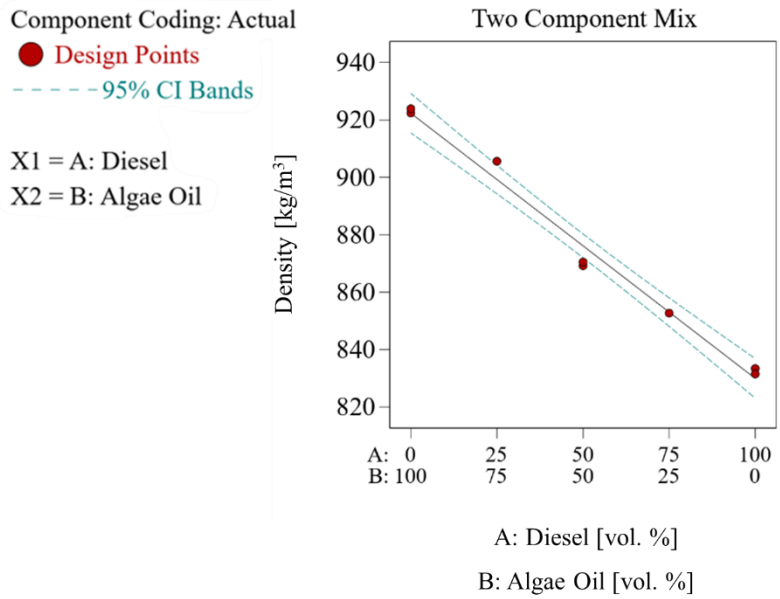


Figure 1: The effect of algae-diesel biofuel blends on density.

$$\rho = 9.22\ x\ AO + 8.30\ x\ D \quad (1)$$

4.3 THE EFFECTS OF VARIED COMPOSITIONS OF ALGAE-DIESEL BIOFUEL BLENDS ON CALORIFIC VALUE

Calorific value (CV) represents the amount of heat energy released when a unit mass of fuel is fully combusted, and it is commonly used as an indicator of fuel energy content and fuel consumption. Figure 2 shows that fuel blends with a higher proportion of diesel exhibit greater calorific values. The results indicate that CV reaches its peak when the algae oil fraction is the lowest, demonstrating an approximately linear relationship between the two components. Eq. (2) provides a mathematical model that accurately predicts the calorific value of the fuel blends.

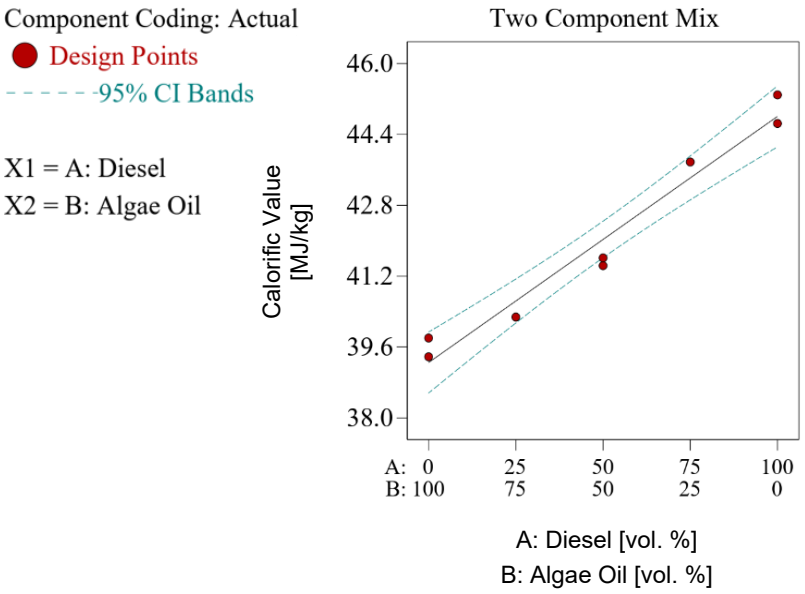


Figure 2: The effect of algae-diesel biofuel blends on the calorific value.

$$CV = 0.39\ x\ AO + 0.45\ x\ D \quad (2)$$

4.4 ANALYSIS OF VARIANCE (ANOVA)

The response variables were analysed statistically using Design Expert 13. The results showed that both density and calorific value (CV) could be effectively modelled using linear regression, with coefficients of determination (R^2) of 0.9859 and 0.9621, respectively. In contrast, viscosity (not shown) exhibited a non-linear behaviour with a higher R^2 value of 0.9997, indicating a strong model fit and accurate representation of the experimental data.

5.0 CONCLUSION

This study concludes that the developed biofuel blends have potential as alternative fuels for diesel engine applications, as their physicochemical properties are shown to be comparable to those of petroleum diesel. Furthermore, the regression analysis demonstrated strong predictive capability for estimating blend properties. Therefore, the objectives of this work have been successfully achieved.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to the Ministry of Higher Education Malaysia for the financial support through Fundamental Research Grant Scheme (FRGS /1/2024/ TK02/ UITM/03/2).

REFERENCES/RUJUKAN

Das, A. K., Sahu, S. K., & Panda, A. K. (2022). Current status and prospects of alternate liquid transportation fuels in compression ignition engines: A critical review. *Renewable and Sustainable Energy Reviews*, *161*, 112358. https://doi.org/10.1016/j.rser.2022.112358

Gaur, A., Dwivedi, G., Baredar, P., & Jain, S. (2022). Influence of blending additives in biodiesel on physiochemical properties, engine performance, and emission characteristics. *Fuel*, *321*, 124072. https://doi.org/10.1016/j.fuel.2022.124072

Lodi, F., Zare, A., Arora, P., Stevanovic, S., Ristovski, Z., Brown, R. J., & Bodisco, T. (2023). Engine performance characteristics using microalgae derived dioctyl phthalate biofuel during cold, preheated and hot engine operation. *Fuel*, *344*, 128162. https://doi.org/10.1016/j.fuel.2023.128162

Sharudin, H., Che Mat, S., Nazri, N. I., Ab Hamid Pahmi, M. A., Husin, A., Ismail, N. I., Mahamad Basri, M. H., & Othman, R. (2025). Experimental investigation on density, kinematic viscosity and calorific value of sunflower oil - pentanol binary biofuel blend. *ESTEEM Academic Journal*, *21*(September), 81–91. https://doi.org/10.24191/esteem.v21iseptember.4680.g5013

Song, C. (2020, August 8). *Introduction to chemistry of diesel fuels: 1 : Chemistry of diesel fu*. Taylor & Francis. https://www.taylorfrancis.com/chapters/edit/10.1201/9781003075455-1/introduction-chemistry-diesel-fuels-chunshan-song

STUDYSYNC: AN ANDROID-BASED COLLABORATIVE STUDY MANAGEMENT APPLICATION FOR DIPLOMA STUDENTS

Nik Muhd Zulkarnaiem Bin Nik Kob[1], Umi Kalsum Hassan[1]

[1]Kolej Poli Teknik Mara Batu Pahat

Corresponding author: bpj241210184@kptm.edu.my,umi_kalsum@kptm.edu.my

ABSTRACT

StudySync is an Android-based collaborative study management application prototype developed to improve communication, organisation, and teamwork among diploma students engaged in academic group projects. With the increasing use of digital learning, students frequently rely on multiple applications for messaging, assignment management, file sharing, and deadline tracking. This fragmented approach often leads to poor coordination, missed deadlines, duplicated information, disorganised learning resources, and reduced productivity during collaborative learning activities. Therefore, there is a need for a centralised platform that integrates these essential academic functions into a single mobile application.

The objective of this project is to develop a user-friendly and efficient study management application that enhances collaboration, simplifies group project management, and improves students' overall learning experience. StudySync provides a comprehensive set of features, including secure user authentication, study group creation and management, task assignment and deadline monitoring, real-time group chat, file sharing, notifications, and profile management. The application also implements role-based access control through Leader and Member roles to ensure effective study group management and collaboration. Developed using Kotlin in Android Studio, StudySync utilises Firebase Authentication for secure user access, Cloud Firestore for real-time database management, and Firebase Storage for managing shared learning materials.

The integration of these features into a single platform minimises students' dependence on multiple applications while promoting better communication, efficient task coordination, organised resource sharing, and timely completion of academic activities. Furthermore, the use of cloud-based technologies ensures secure, scalable, and real-time synchronisation of information among group members. In conclusion, StudySync provides an innovative and practical solution for collaborative learning by centralising essential academic management functions into one mobile application, thereby improving productivity, teamwork, and academic efficiency among students.

Keywords: collaborative learning, study management, android application, firebase, mobile learning

1.0 INTRODUCTION

Collaborative learning has become an essential component of higher education, particularly in diploma programmes where students are required to work together to complete assignments, projects, and other academic activities. Effective collaboration depends on efficient communication, proper task coordination, timely sharing of learning resources, and continuous monitoring of project progress. Research has shown that collaborative learning improves students' academic performance, problem-solving abilities, and teamwork skills when supported by effective communication and coordination among group members (Johnson & Johnson, 2019).

The rapid adoption of smartphones and mobile technologies has transformed the way students access educational resources and collaborate with their peers. Mobile learning applications provide flexibility by enabling students to communicate, access learning materials, and participate in academic activities regardless of time and location. Previous studies have demonstrated that mobile learning technologies enhance student engagement, accessibility, and collaborative learning experiences in higher education (Crompton & Burke, 2018). Furthermore, cloud-based mobile applications support real-time information sharing and improve communication efficiency among users, making them suitable platforms for collaborative academic environments (Al-Emran et al., 2020).

Despite these technological advancements, many students still depend on multiple applications such as WhatsApp, Telegram, Google Drive, and personal reminder applications to manage different aspects of group projects. Switching between multiple platforms often leads to fragmented communication,

disorganised learning materials, poor task coordination, and missed assignment deadlines, ultimately reducing the efficiency of collaborative learning activities.

To address these challenges, the StudySync prototype was developed as an Android-based collaborative study management application that integrates study group management, task organisation, real-time communication, file sharing, notifications, and profile management within a single platform. By centralising these academic collaboration functions, the prototype aims to improve teamwork, enhance productivity, and provide a more organised and efficient learning experience for diploma students.

2.0 OBJECTIVE

The objectives of StudySync are:

To develop an Android-based application that centralises academic collaboration for diploma students.

To improve communication and coordination among study group members through integrated messaging and notifications.

To assist students in managing assignments, deadlines, and shared learning materials efficiently.

3.0 METHODOLOGY

StudySync was developed using the Agile Software Development Life Cycle (SDLC), an iterative software development methodology that emphasises continuous planning, development, testing, and improvement based on user feedback (Pressman & Maxim, 2020). Agile was selected because it provides flexibility in accommodating changing user requirements while ensuring that the application remains functional and user-centred throughout the development process. The application was implemented using Android Studio with Kotlin as the primary programming language following Google's recommended Android application development practices (Android Developers, 2024). Firebase Authentication, Cloud Firestore, and Firebase Storage were integrated to provide secure authentication, real-time database management, and cloud-based file storage, respectively (Firebase, 2024). The methodology consists of several functional modules that work together to provide a centralised collaborative learning platform.

3.1 REQUIREMENT ANALYSIS

This phase focuses on identifying the functional and non-functional requirements of StudySync through literature review, analysis of collaborative learning practices, and requirement gathering involving diploma students. The requirement analysis identified several common issues including fragmented communication, poor task coordination, missed deadlines, and inefficient sharing of academic resources. Based on these findings, the application was designed to integrate communication, task management, file sharing, notifications, and study group management into a centralised mobile platform.

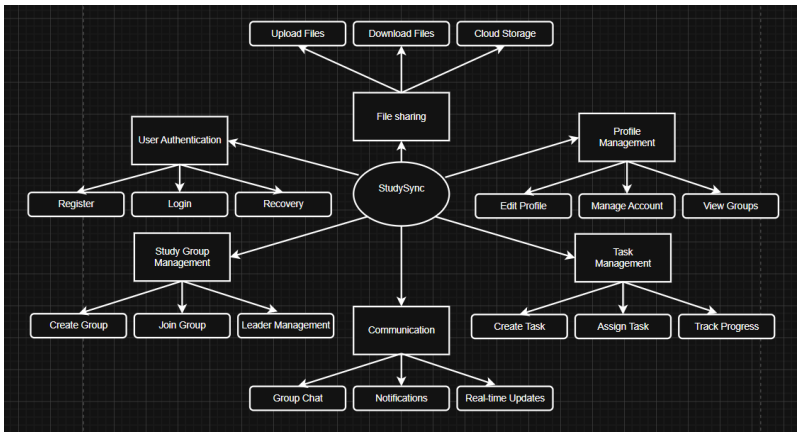


Figure 1: Functional requirements identified for the StudySync application prototype.

3.2 SYSTEM DESIGN

The StudySync application is designed using an object-oriented software architecture to provide a scalable, secure, and maintainable collaborative learning platform. An object-oriented architecture promotes modularity, maintainability, and scalability, making it suitable for mobile application development (Sommerville, 2016). The system architecture consists of an Android mobile application developed using Kotlin, which communicates with Firebase cloud services to manage user authentication, real-time data synchronisation, and file storage. The application integrates the following main components:

- Android mobile application developed using Kotlin
- Firebase Authentication for secure user registration and login
- Cloud Firestore for storing user, group, task, and notification data
- Firebase Storage for storing study materials such as lecture notes, PDF documents, presentation slides, and images

In addition, the user interface was designed based on Material Design 3 principles to ensure consistency, responsiveness, and an intuitive user experience (Google, 2023). The overall system architecture of StudySync is illustrated in Figure 2.

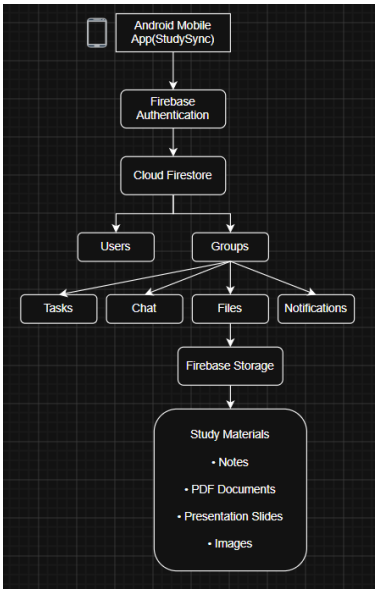


Figure 2: The overall system achitechture of StudySync.

3.3 PROTOTYPE DEVELOPMENT

The StudySync prototype was developed using Android Studio with Kotlin as the primary programming language. The development process followed the Agile Software Development Methodology, where the application was implemented through iterative sprints. Each sprint focused on designing, developing, testing, and refining individual modules based on the defined functional requirements and continuous evaluation. This iterative approach enabled incremental improvements while ensuring that the application remained aligned with user requirements.

The prototype consists of several integrated modules that support collaborative learning among students, including:

- User Authentication Module
- Study Group Management Module
- Task Management Module
- Group Chat Module
- Shared File Module
- Notification Module
- Profile Management Module

Firebase services were integrated throughout the development process to provide secure user authentication, real-time database synchronisation, and cloud-based file storage. Firebase Authentication manages user registration and login, Cloud Firestore stores application data such as user information, study groups, tasks, and notifications, while Firebase Storage manages uploaded

learning materials including lecture notes, PDF documents, presentation slides, and images. The completed prototype demonstrates how cloud-based mobile technologies can be integrated to provide a centralised and efficient collaborative learning environment for diploma students.

3.4 PROTOTYPE TESTING

The StudySync prototype was tested to verify that all implemented modules functioned correctly and fulfilled the specified functional requirements. The testing process was conducted throughout the Agile development lifecycle to identify defects, validate system performance, and improve overall application reliability. Several testing approaches were performed to ensure the quality of the prototype, including:

- Unit Testing was conducted to verify that individual modules such as User Authentication, Study Group Management, Task Management, Group Chat, Shared File Management, Notifications, and Profile Management operated according to their intended functions.

- Integration Testing was performed to ensure proper communication between the Android application and Firebase services, including Firebase Authentication, Cloud Firestore, and Firebase Storage. This testing verified that user data, group information, tasks, notifications, and uploaded learning materials were synchronised correctly across the application.

- Functional Testing was carried out to validate the core functionalities of the prototype, including user registration and login, study group creation and joining, task assignment, file uploading, real-time messaging, notification delivery, and profile management.

- Usability Testing was conducted with selected diploma students to evaluate the application's user interface, navigation, accessibility, and overall user experience. Feedback obtained from the participants was used to refine the interface and improve the usability of the application.

The results of the testing process indicated that the prototype functioned as intended and successfully supported collaborative learning activities by integrating communication, task management, file sharing, and study group organisation into a centralised mobile platform.

4.0 RESULT

The developed StudySync prototype demonstrates the feasibility of using a centralised mobile application to improve collaborative learning among diploma students. By integrating communication, study group management, task organization, file sharing, and notifications into a single platform, the application reduces students' dependence on multiple third-party applications for managing academic activities. This centralised approach improves accessibility to learning resources and enhances coordination among study group members.

The implementation of StudySync contributes positively to academic collaboration by providing a structured environment where students can organise assignments, monitor deadlines, and communicate efficiently within their respective study groups. The real-time synchronisation provided by Cloud Firestore ensures that newly created tasks, uploaded learning materials, notifications, and group messages are immediately accessible to authorised members. This minimises communication delays and helps students remain informed about ongoing project activities. Previous studies have shown that centralised collaborative learning environments and mobile learning technologies can improve student engagement, communication, and academic productivity (Crompton & Burke, 2018; Al-Emran et al., 2020).

The integration of Firebase Authentication and Firebase Storage further enhances the reliability and security of the application by providing secure user authentication and cloud-based storage for shared academic resources. Students can upload and retrieve lecture notes, PDF documents, presentation slides, and images from a centralised repository, reducing the risk of misplaced learning materials while supporting collaborative knowledge sharing.

Overall, the StudySync prototype demonstrates the potential of cloud-based mobile technologies to improve teamwork, task coordination, and academic organisation among diploma students. The application provides a practical foundation for future enhancements, including integration with institutional learning management systems, cross-platform support, and intelligent study planning features to further strengthen collaborative learning experiences.

5.0 CONCLUSION

In conclusion, the StudySync mobile application addresses common challenges encountered by diploma students in managing academic group projects, including fragmented communication, poor task coordination, disorganised learning materials, and missed assignment deadlines. By integrating study group management, task scheduling, real-time communication, file sharing, and notifications into a single Android application, StudySync provides a centralised platform that enhances collaboration and improves the overall efficiency of academic teamwork.

The implementation of cloud-based technologies, including Firebase Authentication, Cloud Firestore, and Firebase Storage, enables secure user authentication, real-time data synchronisation, and reliable storage of shared learning resources. These technologies contribute to a responsive and scalable application that supports students in managing collaborative learning activities more effectively.

Overall, StudySync demonstrates the potential of mobile and cloud computing technologies to improve academic collaboration by providing a practical, user-friendly, and organised study management solution. The prototype establishes a strong foundation for future enhancements, such as integration with institutional Learning Management Systems (LMS), cross-platform compatibility, intelligent task prioritisation, and AI-assisted study planning, enabling the application to better support students' evolving learning needs.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to **Kolej Poly-Tech MARA Batu Pahat** for providing the facilities and academic support throughout the development of this project. The authors also wish to thank the project supervisor for the valuable guidance, constructive feedback, and continuous encouragement provided during the planning, development, and completion of the StudySync application. Appreciation is also extended to all lecturers, classmates, and individuals who contributed directly or indirectly to the successful completion of this project.

REFERENCES/RUJUKAN

Al-Emran, M., Mezhuyev, V., & Kamaludin, A. (2020). Technology acceptance model in mobile learning: A systematic review. *Education and Information Technologies, 25*(5), 3891–3907.

Android Developers. (2024). *Android Developers documentation*. https://developer.android.com

Crompton, H., & Burke, D. (2018). The use of mobile learning in higher education: A systematic review. *Computers & Education, 123*, 53–64.

Firebase. (2024). *Firebase documentation*. https://firebase.google.com/docs

Google. (2023). *Material Design 3*. https://m3.material.io

Johnson, D. W., & Johnson, R. T. (2019). *Joining together: Group theory and group skills* (12th ed.). Pearson.

Pressman, R. S., & Maxim, B. R. (2020). *Software engineering: A practitioner's approach* (9th ed.). McGraw-Hill.

Sommerville, I. (2016). *Software engineering* (10th ed.). Pearson.

P.A.S.A.R: PORTABLE ANAEROBIC SYSTEM FOR ALTERNATIVE RESOURCES

Muhammad Muadz As Sabiq Bin Sidik Al Amini[1,*], Muhammad Aiman Bin Lokman Hayazi[1], Nisa Aadila Binti Muhammad Beheshti[1], Nur Zulfa Imani Binti Khairul Ikram[1] Nur Aa'in Mazura Binti Che Mahtar[1]

[1]Jalan Aminuddin Baki, Seremban, 70100 Seremban, Negeri Sembilan, Malaysia.

[*]Corresponding author: muadz.assabiq@gmail.com

ABSTRACT

Last year, SWCorp recorded that Malaysia generated approximately 17,000 tonnes of food waste daily. This amount increases by about 11.6% during festive seasons such as Ramadan bazaars. Most of this food waste is sent to landfills, where it breaks down anaerobically and releases methane, a greenhouse gas that is 28 times more potent than carbon dioxide. Despite this issue, small-scale systems that convert food waste into usable energy at the community level remain uncommon, and many people remain unaware of the impact of methane emissions. To address this issue, the Portable Anaerobic System for Alternative Resources (P.A.S.A.R), a 3-in-1 smart anaerobic digestion system with a continuous feeding design, was developed. Unlike batch systems, our model enables the daily addition of food waste. A 25 L airtight container was first filled with a 1:1 mixture of cow dung and water and left for 14 days to allow bacterial growth. After this period, 0.5 kg of food waste was added daily. Gas production was monitored using an MQ-4 methane sensor and a pressure sensor. The biogas produced was passed through steel wool, activated carbon, and a moisture trap to purify the biogas before being stored in a PVC biogas bag. Under the stable conditions, the system generated 9-12 litres of biogas daily, containing 55–60% methane. Given that, this amount has supported a cooking flame for 10–15 minutes. Concurrently, this system produces an equivalent daily volume of nutrient-rich liquid effluent, which is then harvested for use as an organic fertiliser. Ultimately, this scalable digester can be utilised as a tool to combat Malaysia's 17,000-tonne food waste crisis. P.A.S.A.R system transforms food waste into a renewable LPG alternative and sustainable bio-fertiliser, demonstrating a scalable circular economy solution. Furthermore, this system diverts waste from landfills and captures potent greenhouse gases.

Keywords: P.A.S.A.R , methane emissions, continuous feeding design, fertiliser, bio-fertiliser

1.0 INTRODUCTION

1.1 PROBLEM STATEMENT

Malaysia produces approximately 17,000 tonnes of food waste daily, with food waste generation increasing by around 11.6% during festive seasons such as Ramadan bazaars. A large portion of this waste is disposed of in landfills, where anaerobic decomposition releases methane, a greenhouse gas approximately 28 times more potent than carbon dioxide over a 100-year period, contributing significantly to climate change.

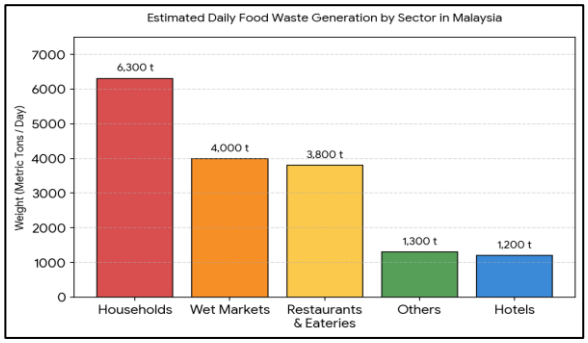


Figure 1: Estimated Daily Food Waste Generation by Sector in Malaysia. Source: SWCorp Malaysia.

1.2 EXISTING SOLUTIONS

Previous studies have demonstrated that anaerobic digestion effectively converts food waste into biogas and nutrient-rich digestate (Meegoda et al., 2025). Meanwhile, Santamaria et al. (2025) highlighted the importance of sustainable food waste management through improved waste segregation and reuse practices. However, many existing systems remain large-scale and operate using batch feeding.

1.3 THE P.A.S.A.R CONCEPT

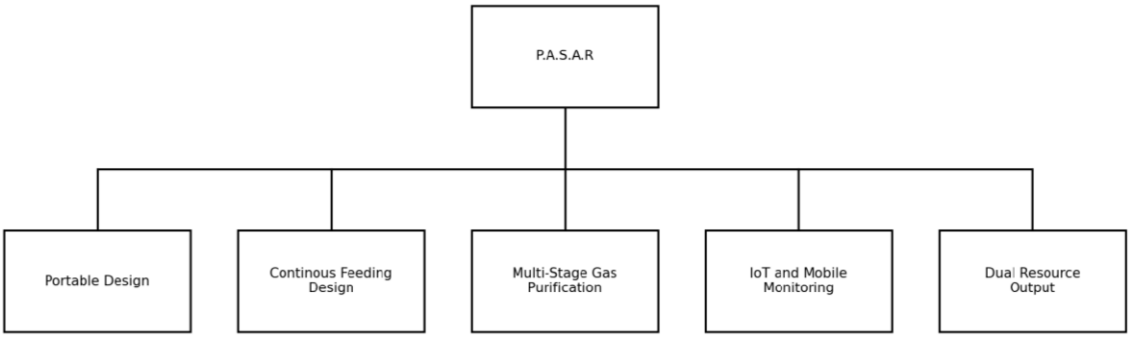


Diagram 1: The Core Concept of P.A.S.A.R.

The tree diagram above illustrates the core concept of P.A.S.A.R. The system combines a portable design, continuous feeding mechanism, IoT and mobile monitoring, multi-stage gas purification, and dual resource recovery into a single integrated platform. These features enable efficient food waste treatment while producing renewable biogas and organic fertilizer for sustainable community use.

1.4 COMPARISON TABLE

Table 1: Comparison between Conventional Biodigesters and P.A.S.A.R.

Feature	**Conventional Biodigestor**	**P.A.S.A.R.**
Portable Design	X	✓
Continous Feeding	Batch Feeding	Continuous Feeding
Gas Purification	Limited or None	Multi-Stage Filtration
System Monitoring	Manual	IoT + Mobile App
Resource Recovery	Biogas Only	Biogas + Organic Fertilizer
Storage Monitoring	None	Pressure and Temperature Monitoring

As shown in Table 1, P.A.S.A.R integrates several features that are typically unavailable together in conventional small-scale biodigesters, improving usability, monitoring, and resource recovery.

2.0 OBJECTIVE

1. To design and develop a portable continuous-feed anaerobic digestion system (P.A.S.A.R) for converting food waste into renewable biogas and organic fertilizer.
2. To integrate IoT-based monitoring using pressure, temperature, and methane sensors with a mobile application for real-time system monitoring.
3. To evaluate the performance of P.A.S.A.R in producing methane and promoting sustainable food waste management.

3.0 METHODOLOGY

3.1 COMPONENTS OF P.A.S.A.R



Figure 2: Components of P.A.S.A.R

Figure 2 illustrates the main components of P.A.S.A.R. The digester tank provides an anaerobic environment for food waste decomposition, while the filtration unit removes unwanted impurities before the purified biogas is stored in the storage tank. The sensor module continuously monitors operating conditions, and the digestate outlet enables the collection of nutrient-rich organic fertilizer.

3.2 ANAEROBIC DIGESTION PROCESS

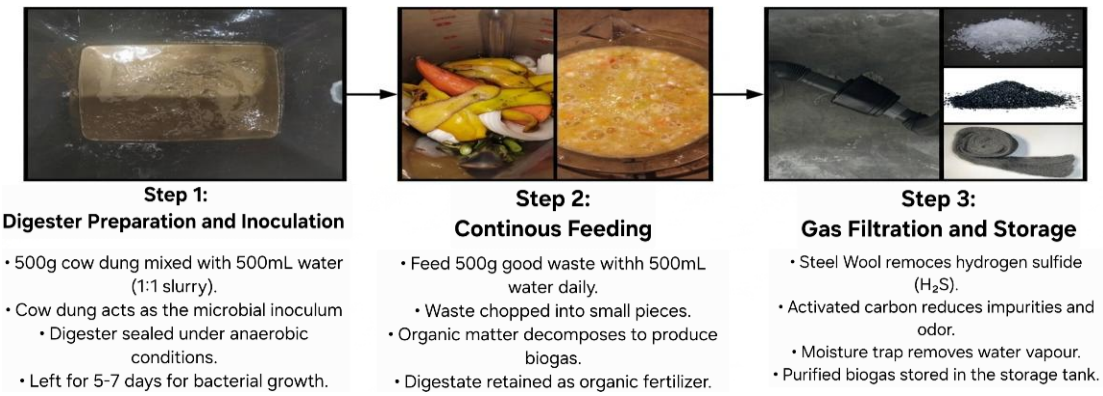


Diagram 2: Anaerobic Digestion Process of P.A.S.A.R.

The anaerobic digestion process converts organic food waste into methane-rich biogas through four biological stages: hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Cow dung serves as the microbial inoculum during start-up, while continuous feeding supplies fresh organic matter for bacterial activity. The produced biogas is purified using steel wool, activated carbon, and a moisture trap before being stored, while the remaining digestate is recovered as an organic fertilizer.

3.3 IOT-BASED MONITORING SYSTEM

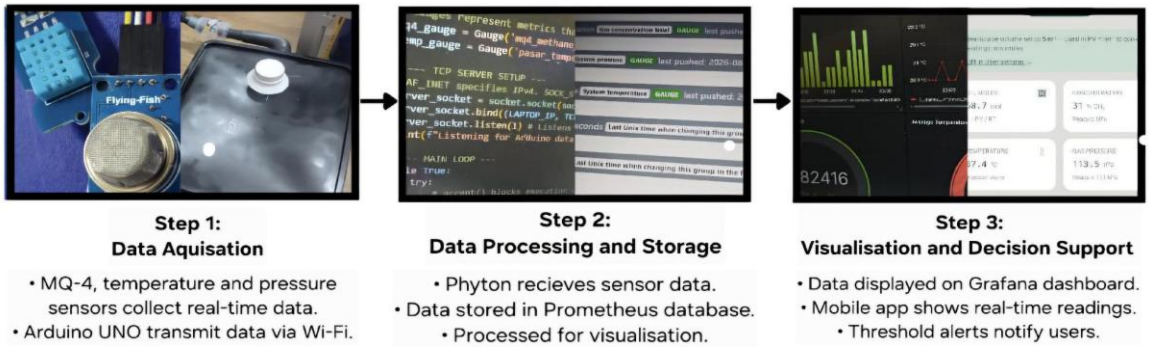


Diagram 3: IoT architecture and PASAR mobile application for real-time monitoring of methane concentration, storage pressure, temperature, methane quantity, and threshold-based notifications.

The IoT-based monitoring system enables continuous remote observation of biodigester performance without interrupting anaerobic digestion. Sensor data from the methane, temperature, and pressure sensors are transmitted to a Prometheus database and visualized through the Grafana dashboard and PASAR mobile application. The system provides real-time monitoring, historical trends, methane inventory estimation, and threshold-based notifications to support safe and efficient operation.

3.4 DATA PROCESSING AND PERFORMANCE EVALUATION

Equations

Equation (1): Van Der Waals

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Equation (2): Methane moles

$$nCH4 = xCH4 \times n$$

Equation (3): Equivalent Methane Volume

$$VCH4 = nCH4 \times 25L$$

Table 2: Value of parameters from equations used.

Parameter Reference Table

Parametres	Values
P: Storage Pressure	Measured by Pressure Sensor / kPa
V: Storage Tank Voleume	25L
n: Number of Moles of Gas	Obtained from Equation 1
R: Methane Gas Constant	0.08206 L·atm·mol⁻¹·K⁻¹
T: Temperature of Storage Tank	Measured by Temperature Sensor / K
nCH_4: Estimated Methane Fraction	Measured by MQ-4 Sensor / $\%CH_4$
a: Methane Molecular Attraction	2.253 L²·atm·mol⁻²
b: Methane Molecular Dimension	0.0428 L·mol⁻¹

Sensor readings of pressure and temperature were combined with the fixed storage tank volume to estimate the amount of methane stored using the Van der Waals equation. The calculated methane inventory was subsequently converted into an estimated methane volume for user interpretation. These processed data were displayed in the PASAR mobile application together with methane concentration, storage pressure, temperature, storage capacity, and historical performance trends.

4.0 RESULT

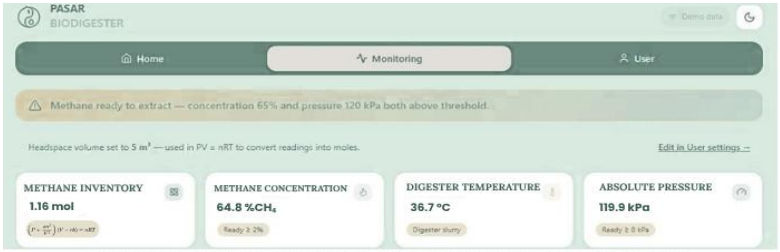


Figure 4: PASAR mobile application displaying real-time biodigester monitoring parameters.

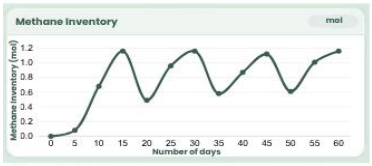


Figure 5: Methane inventory (mol) during continuous biodigester operation.

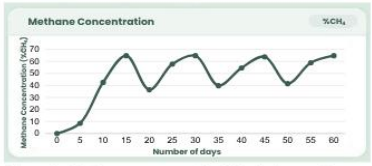


Figure 6: Methane concentration (%) during continuous biodigester operation.

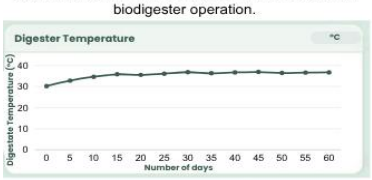


Figure 7: Digester temperature profile during anaerobic digestion.

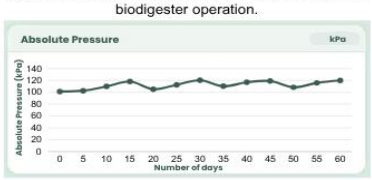


Figure 8: Absolute pressure variation inside the biogas storage tank.



Figure 9: Combustion of purified biogas produced by PASAR.



Figure 10. Plant growth after application of PASAR digestate as organic fertilizer.

The monitoring data demonstrated that PASAR successfully converted food waste into methane-rich biogas under continuous operation. Methane concentration gradually increased during the start-up period before stabilising at approximately 64.8%, indicating successful establishment of methanogenic activity. The calculated methane inventory also increased with time and reached 1.16 mol under stable operating conditions.

The pressure profile followed the increase in methane inventory, while the digester temperature remained relatively constant between 35°C and 37°C, providing favourable conditions for anaerobic digestion. Periodic reductions in methane inventory and pressure corresponded to gas extraction events, after which methane production resumed through continuous feeding. These trends demonstrate the capability of PASAR to provide stable and repeatable biogas products.

Compared with conventional household biodigesters, PASAR integrates continuous feeding, multi-stage gas purification, IoT-based monitoring, and a mobile application into a compact portable system. These features allow users to monitor biodigester performance in real time while improving operational safety and user accessibility.

5.0 CONCLUSION

PASAR demonstrates a practical approach for converting food waste into renewable energy through anaerobic digestion while supporting sustainable waste management. The integration of IoT monitoring, gas purification, and a portable continuous-feeding design improve system usability compared with conventional small-scale biodigesters. The monitoring platform enables real-time observation of methane concentration, storage pressure, temperature, and methane inventory, allowing safer operation and informed gas extraction. Future work includes improving methane purification efficiency, increasing storage capacity, and validating long-term performance under different operating conditions. Overall, PASAR offers a promising solution for reducing food waste while producing renewable cooking fuel and organic fertiliser.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our advisor, Puan Nur Aa'in Mazura Binti Che Mahtar, for her invaluable guidance, encouragement, and continuous support throughout the development of this project. Her advice and constructive feedback greatly contributed to the successful completion of P.A.S.A.R. We also extend our appreciation to Kolej MARA Seremban for providing the facilities, resources, and opportunities that enabled us to carry out this research and prototype development. Our heartfelt thanks go to our parents and families for their unwavering encouragement, patience, and moral support throughout this project. Not to forget, we would like to thank everyone who

directly or indirectly contributed to the completion of this project. Their support and assistance are sincerely appreciated.

Above all, we also express our heartfelt gratitude to Allah SWT, The Almighty God, who has given us strength, knowledge and guidance to accomplish this research.

REFERENCES/RUJUKAN

Angelidaki, I., Alves, M., Bolzonella, D., Borzacconi, L., Campos, J. L., Guwy, A. J., Kalyuzhnyi, S., Jenicek, P., & van Lier, J. B. (2011). Defining the biomethane potential (BMP) of solid organic wastes and energy crops: A proposed protocol for batch assays. Water Science and Technology, 59(5), 927-934.

Ryckebosch, E., Drouillon, M., & Vervaeren, H. (2011). Techniques for transformation of biogas to biomethane. Biomass and Bioenergy, 35(5), 1633-1645.

Madigan, M. T., Brock Biology of Microorganisms.Ryckebosch, E., Drouillon, M., & Vervaeren, H. (2011). Techniques for transformation of biogas to biomethane. Biomass and Bioenergy, 35(5), 1633-1645.

Mao, C., Feng, Y., Wang, X., & Ren, G. (2015). Review on research achievements of biogas from anaerobic digestion. Renewable and Sustainable Energy Reviews, 45, 540-555.

Interg Solid Waste Management and Public Cleansing Corporation (SWCorp Malaysia). Food Waste Management. Retrieved from https://www.swcorp.gov.my

Governmental Panel on Climate Change (IPCC). (2023). Climate Change 2023: Synthesis Report. Retrieved from https://www.ipcc.ch

United Nations. Sustainable Development Goals. https://sdgs.un.org/goals

ECOSERVE 3-IN-1 COLLECTION TROLLEY

Jacky Yap[1], Mahmod Abd Hakim Mohamad[2], Mohd Shahir Yahya[2], Mohd Najib Janon[2]

[1]Department of Mechanical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, Pagoh, 84600, Malaysia
[2]Sustainable Product Development (S-Proud), Department of Mechanical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Pagoh, Johor, MALAYSIA

Corresponding author: jackyivan88@gmail.com

ABSTRACT

The escalating volume of food waste in institutional dining facilities challenges operational efficiency, hygiene, and environmental sustainability. To build resilient and future-ready food service infrastructures, innovative approaches to daily waste and resource management are essential. This study presents a smart physical innovation: the design and development of an integrated, portable 3-in-1 collection trolley aimed at optimising plate handling and food waste management in university cafés. The proposed system utilises an intelligent mechanical layout, seamlessly combining a spring-loaded plate stacking mechanism, a dedicated utensil compartment, and an enclosed waste bin within a single mobile unit. Driven by a systematic engineering approach, the development process incorporated user-centred design principles, morphological analysis, and rigorous mechanical performance evaluation. Experimental validation confirms the system's operational resilience; the trolley safely supports up to 80 plates while maintaining optimal stability and ergonomic accessibility. Furthermore, the enclosed waste compartment actively advances environmental hygiene by significantly reducing odour emissions and pest attraction compared to conventional open-air systems. User feedback indicates marked improvements in workflow efficiency, staff ergonomics, and overall workplace sanitation. By intelligently consolidating these functions, this research delivers a cost-effective, sustainable, and resilient solution for modernising institutional food service operations, demonstrating broad adaptability for diverse commercial environments.

Keywords: multipurpose trolley, plate waste trolley, multi-compartment collection trolley, food waste management, engineering design

1.0 INTRODUCTION

Food waste has emerged as a critical global issue, contributing significantly to environmental degradation and operational challenges in food service systems (Filimonau & De Coteau, 2019; Mutanda & Nhamo, 2026). Within the paradigm of Smart Innovations for a Sustainable and Resilient Future, addressing these challenges requires not only technological advancement but also practical, human-centred engineering solutions that bridge the gap between sustainability goals and operational feasibility. In institutional settings such as Universiti Tun Hussein Onn Malaysia (UTHM) cafés, inefficient waste handling practices often result in poor hygiene conditions, increased labour requirements, and reduced service quality, making sustainable and resilient interventions in university cafeterias increasingly urgent (Turker, 2025).

Although automated solutions like conveyor-based systems have been developed, their high capital cost and spatial requirements limit their applicability in small-scale environments (Gu et al., 2007). Therefore, this study aims to address these challenges through the design and development of a cost-effective, portable 3-in-1 collection trolley.

2.0 OBJECTIVE

1. To design a portable collection trolley that integrates dedicated compartments for plates, utensils and food waste into a single mobile unit.
2. To improve the operational efficiency and ergonomics of plate and food waste collection in university cafés by reducing handling time and physical strain on workers.
3. To evaluate the performance of the prototype in terms of load capacity, mobility, stability and odour containment.

3.0 METHODOLOGY

The design and development of the 3-in-1 Collection Trolley followed a systematic engineering design process aligned with the principles of Smart Innovations for a Sustainable and Resilient Future, ensuring functionality, durability, and user-friendliness. The process included problem identification, concept generation, embodiment design, prototype fabrication, and performance evaluation. During concept generation, a morphological chart was used to systematically explore combinations of design parameters and structure the complex design problem effectively (Ritchey, 2011). The selected concept features a mild steel frame for structural strength, plywood panels for cost efficiency, 4-inch heavy-duty swivel caster wheels with brakes for manoeuvrability, and an enclosed 77 L high-density polyethylene (HDPE) bin for food waste odour control.

3.1 ENGINEERING ANALYSIS

The plate compartment is equipped with a spring mechanism mounted beneath the base plate to maintain plates at an accessible height. The spring constant (k) was determined using Hooke's Law, as shown in Eq. (1), where F is the maximum load from stacked plates (approximately 20 kg) and x is the maximum compression distance (0.15 m) (Papargyropoulou et al., 2014). Furthermore, ensuring appropriate workstation parameters and incorporating ergonomic design in manual handling tools significantly mitigate repetitive strain and lower rapid entire body assessment (REBA) risk scores among operators (Iqbal et al., 2020; Abu-Kasim & Mohd-Taib, 2022).

$$F = kx \tag{1}$$

This ensures smooth compression without sudden drops, protecting the plates from damage and reducing ergonomic strain for users, as improperly designed handling systems are a primary contributor to musculoskeletal disorders (Kurnianingtyas, 2022).

3.2 MECHANISMS AND FUNCTIONALITY

The conceptual and detailed designs were translated into 3D CAD models to visualise the arrangement of components. Figure 1 illustrates the isometric view of the trolley, highlighting the external structure and accessibility. Figure 2 presents the side view, detailing the internal layout, including the spoon and fork sliding mechanism, plate compartment, and the centralised trash bin container.

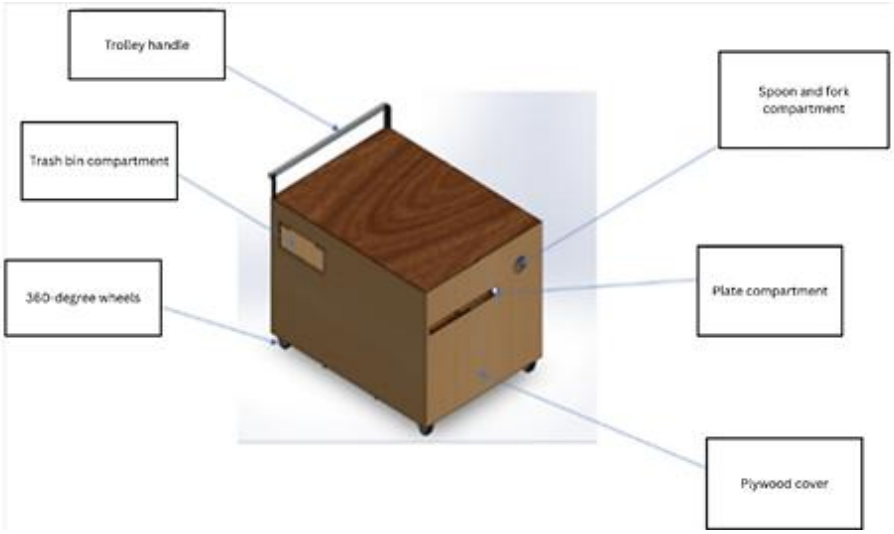


Figure 1: Isometric dimensioned drawing of the 3-in-1 Collection Trolley.

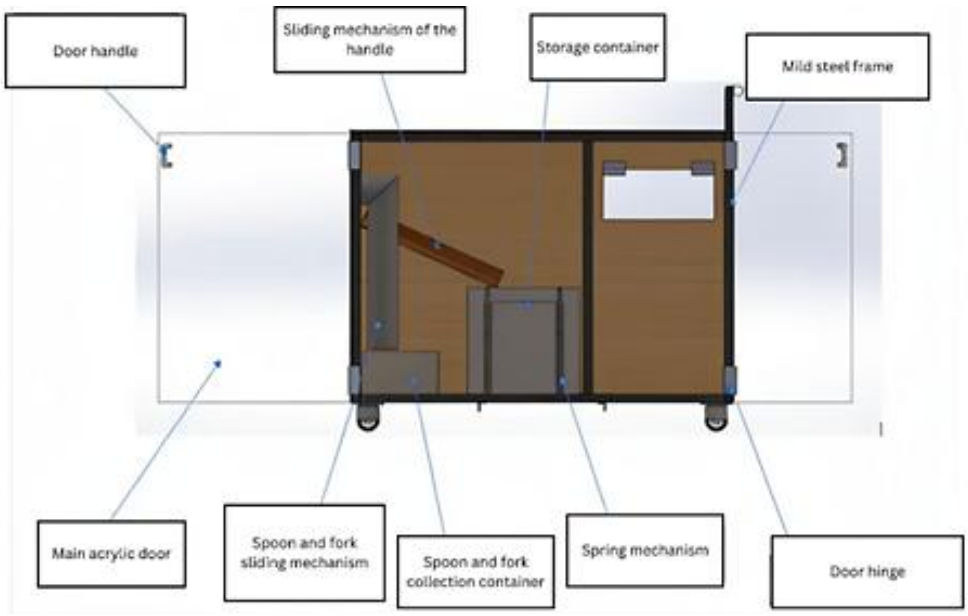


Figure 2: Side view showing the internal layout and compartments.

4.0 RESULT

The fabricated prototype was subjected to a series of tests to verify its functionality, structural stability, and user acceptance.

Operational Capacity: Testing demonstrated the trolley's exceptional operational capacity in a real-world environment. Performance trials conducted at the UTHM campus café from 8:00 AM to 2:00 PM recorded a total collection of 286 plates. As illustrated in Figure 3, the collection efficiency peaked during the lunch hour (12:00 PM to 1:00 PM), where the trolley successfully accommodated 80 plates systematically stacked within the dual compartments.

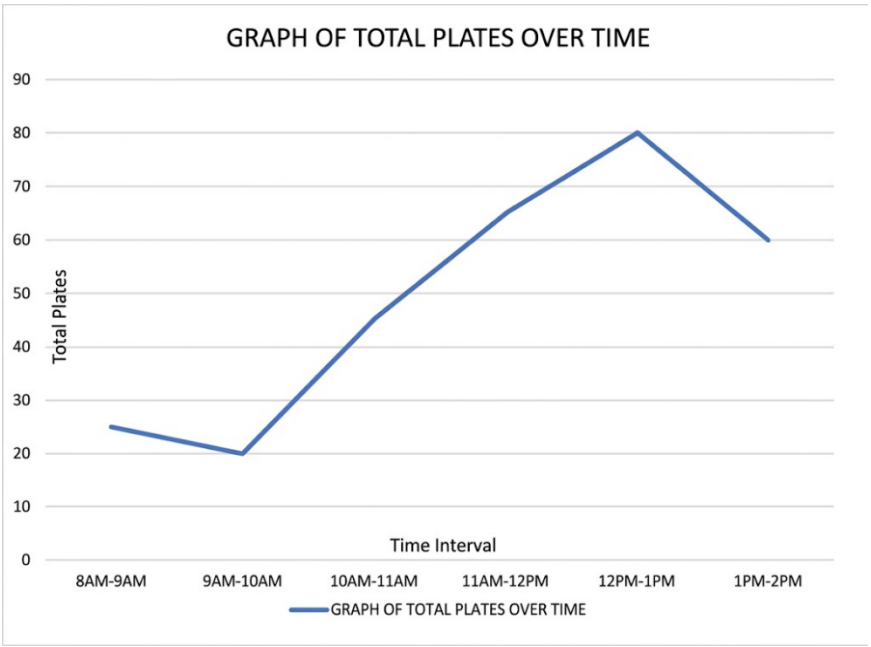


Figure 3: Total number of plates collected over time during café operating hours.

Mobility and Stability: The 4-inch dual-locking swivel caster wheels provided smooth mobility across both flat and uneven café surfaces while securely holding the trolley in place during stationary loading.

Food Waste Containment: The enclosed 77 L HDPE waste bin effectively trapped odours. Observations confirmed that odour leakage and pest attraction were significantly reduced compared to traditional open-bin systems.

User Feedback: A survey among café staff and student users highlighted positive usability, noting easier collection processes, reduced odours, and an overall more efficient cleaning workflow. Recommendations for future improvements included integrating bin-level sensors and utilising lightweight composite materials.

5.0 CONCLUSION

This study successfully designed, developed, and validated the EcoServe 3-in-1 Collection Trolley to improve efficiency, ergonomics, and hygiene in institutional café operations. The innovation integrates a spring-loaded plate stacking mechanism, utensil collection compartment, and enclosed food waste bin into a single portable unit, providing a practical and cost-effective solution to existing waste handling challenges. Experimental results confirmed the system's structural stability, mobility, load-carrying capability, and effectiveness in reducing odour emissions. The proposed design aligns with sustainable product design principles and offers a viable alternative to expensive automated material handling systems, with potential applications in various institutional and commercial food service environments.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to Universiti Tun Hussein Onn Malaysia for providing the necessary resources and support throughout the course of this research. Special appreciation is extended to colleagues and peers who contributed valuable insights and constructive feedback.

REFERENCES/RUJUKAN

Abu-Kasim, M.Z.H. & M.F. Mohd-Taib. 2022. Ergonomics evaluation for turning machinists in oil and gas industry. International Journal of Integrated Engineering, 14 (2): 55-61. DOI: 10.30880/ijie.2022.14.02.008

Filimonau, V., & De Coteau, D. 2019. Food waste management in hospitality operations: A critical review. Tourism Management, 71: 234-245. DOI: 10.1016/j.tourman.2018.10.009.

Gu, J., M. Goetschalckx & L.F. McGinnis. 2007. Research on warehouse operation: A comprehensive review. European Journal of Operational Research, 177 (1): 1-21. DOI: 10.1016/j.ejor.2006.02.025.

Iqbal, M., I. Hasanuddin, A. Hassan, M.S. Mohd Soufi & F. Erwan. 2020. The study on ergonomic performances based on workstation design parameters using virtual manufacturing tool. International Journal of Integrated Engineering, 12 (5): 124-129. DOI: 10.30880/ijie.2020.12.05.015.

Kurnianingtyas, C.D. 2022. Analysis of work posture and manual handling on the material transport activities of Indonesian traditional market worker. International Journal of Industrial Engineering and Engineering Management, 4 (2): 65-74. DOI: 10.24002/ijieem.v4i2.5921

Painter, K., E. Thondhlana & H. Kua. 2016. Food waste generation and potential interventions at Rhodes University, South Africa. Waste Management, 56: 491-497. DOI: 10.1016/j.wasman.2016.07.013.

Papargyropoulou, E., R. Lozano, J.K. Steinberger, N. Wright & Z. Ujang. 2014. The food waste hierarchy. Journal of Cleaner Production, 76: 106-115. DOI: 10.1016/j.jclepro.2014.04.020.

Ritchey, T. 2011. Wicked Problems/Social Messes: Decision Support Modelling with Morphological Analysis. Springer, Berlin. ISBN: 9783642196522.

Turker, G.F. 2025. Reducing food waste in campus dining: A data-driven approach to demand prediction and sustainability. Sustainability, 17 (2): 379. DOI: 10.3390/su17020379.

MAID4U: WEB-BASED HOME CLEANING SERVICE BOOKING AND MANAGEMENT SYSTEM

Norsuhana binti Idris[1], Nuraina Nafisya binti Syamsularifin[1], Nor Al Haney Hidayanah[1]

[1]Kolej Poly-Tech MARA Batu Pahat

Corresponding author: norsuhana.idris@kptm.edu.my

ABSTRACT

The home cleaning service industry has experienced significant growth due to increasing urbanisation, changing lifestyles, and the rising number of dual-income households seeking professional cleaning solutions. Despite this demand, many small and medium-sized home cleaning service providers continue to rely on conventional booking methods such as phone calls, social media platforms, and instant messaging applications. These fragmented approaches often result in scheduling conflicts, inefficient workforce allocation, inconsistent customer records, and limited-service transparency. This paper presents MAID4U, a web-based Home Cleaning Service Booking and Management System, developed to digitalise and streamline the operational workflow of home cleaning service providers. The system integrates customer booking, cleaner management, appointment scheduling, workforce coordination, and administrative reporting into a single centralised platform. MAID4U provides dedicated portals for customers, cleaners, management personnel, and administrators, enabling seamless communication and efficient service management. Customers can browse cleaning packages, schedule appointments, monitor booking progress, and access service history, while management staff can assign cleaners, monitor workforce availability, generate reports, and oversee daily operations through an integrated dashboard. Developed using PHP, MySQL, HTML5, CSS3, JavaScript, and Bootstrap based on the Agile Software Development methodology, the system offers a scalable and cost-effective digital solution for small and medium-sized enterprises (SMEs). The innovation enhances operational efficiency, reduces administrative workload, improves booking accuracy, and promotes service transparency. By supporting digital transformation within the home cleaning industry, MAID4U demonstrates strong practical applicability and commercialisation potential, contributing towards smarter and more sustainable service management.

Keywords: home cleaning service, web-based booking system, service management, digital transformation, workforce management

1.0 INTRODUCTION

The rapid advancement of digital technologies has transformed how service-based businesses interact with customers and manage their operations. Customers increasingly expect convenient online booking, real-time service updates, and efficient communication, making digital transformation essential for improving operational efficiency, customer satisfaction, and business competitiveness.

The home cleaning service industry continues to grow due to urbanisation, changing lifestyles, and increasing demand for professional cleaning services. However, many small and medium-sized enterprises (SMEs) still rely on manual booking methods such as phone calls, WhatsApp, and spreadsheet-based scheduling, resulting in duplicate bookings, scheduling conflicts, fragmented information, and inefficient workforce coordination. Although online booking platforms are available, many focus only on appointment scheduling and lack integrated features for workforce management and operational monitoring.

To address these challenges, MAID4U was developed as a web-based Home Cleaning Service Booking and Management System that integrates customer booking, cleaner assignment, appointment scheduling, workforce coordination, and operational monitoring within a centralised platform. By providing dedicated portals for customers, cleaners, management staff, and administrators, MAID4U enhances service efficiency, operational transparency, and customer experience while supporting the digital transformation of home cleaning service providers.

2.0 OBJECTIVE

The objectives of this innovation are:

To develop MAID4U, a web-based Home Cleaning Service Booking and Management System that digitalises customer booking, cleaner management, and operational processes for home cleaning service providers.

To improve operational efficiency by integrating customer management, appointment scheduling, cleaner allocation, and administrative reporting into a centralised digital platform.

To enhance customer experience and support the digital transformation of small and medium-sized home cleaning service providers by offering an accessible, user-friendly, and efficient online service management solution.

3.0 METHODOLOGY

The development of MAID4U adopted the Agile Software Development (ASD) methodology, which emphasises iterative development, continuous stakeholder collaboration, and incremental software delivery. Agile enables developers to respond effectively to changing user requirements while maintaining software quality and development efficiency (Beck et al., 2001). Pressman and Maxim (2020) further explained that Agile promotes continuous testing and user feedback throughout the software development lifecycle, resulting in a software that better satisfies user expectations.

The methodology adopted in this study consists of five major components: development methodology, system architecture, system workflow, functional modules, and system validation. Each component contributes to ensuring that MAID4U addresses the operational challenges faced by home cleaning service providers while delivering an efficient and user-friendly digital solution.

3.1 DEVELOPMENT METHODOLOGY

MAID4U was developed using the Agile Software Development methodology to support iterative development and continuous improvement. The development process consisted of five phases: requirement analysis, system design, system development, system testing, and deployment, as illustrated in Figure 1. Agile enables continuous refinement based on stakeholder feedback, ensuring that the system meets both user and operational requirements (Dennis et al., 2020; Beck et al., 2001).

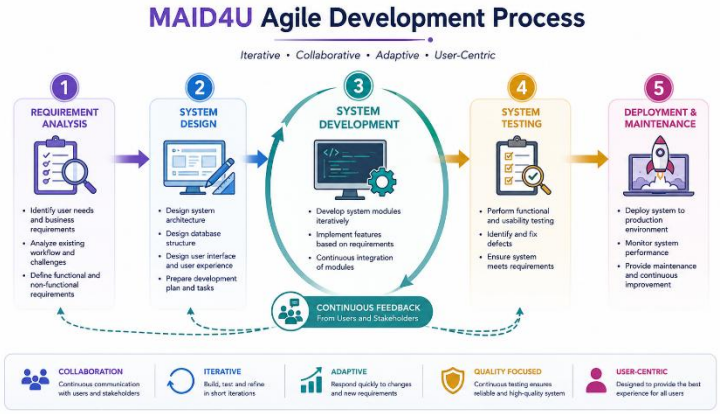


Figure 1: Agile software development process of MAID4U

3.2 SYSTEM ARCHITECTURE

MAID4U adopts a centralised web-based client-server architecture that enables customers, cleaners, management staff, and administrators to access the system through a web browser, with all operational data stored in a MySQL database (Figure 2). Developed using PHP, MySQL, HTML5, CSS3, Bootstrap, and JavaScript, the system provides a scalable and cost-effective solution for SMEs (Sommerville, 2020; Welling & Thomson, 2017).

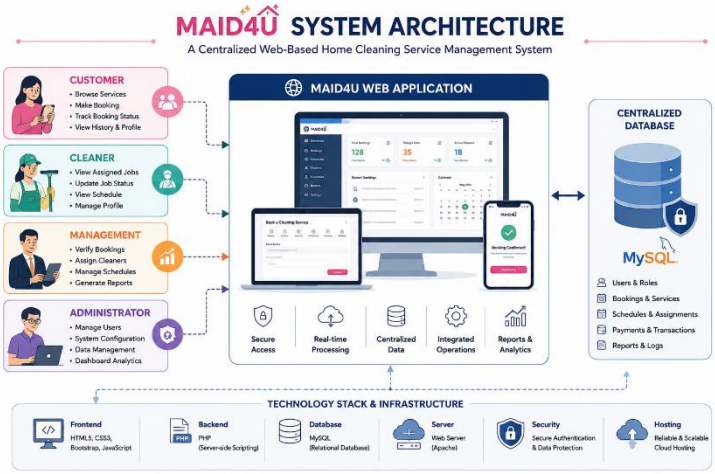


Figure 2: Overall system architecture of MAID4U.

3.3 SYSTEM WORKFLOW

The MAID4U workflow begins with customers submitting online booking requests, followed by management verification and cleaner assignment based on availability. After service completion, cleaners update the job status, enabling customers to track service progress while management monitors operations and generates reports (Figure 3). This workflow improves operational efficiency, reduces scheduling conflicts, and enhances service transparency.

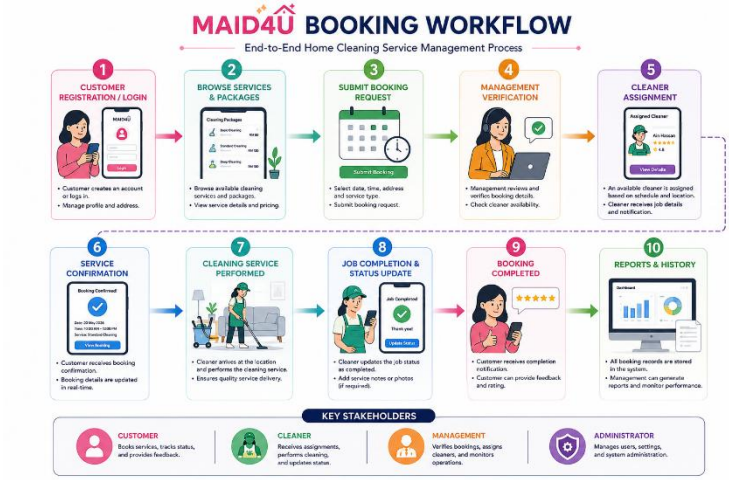


Figure 3: MAID4U home cleaning service booking workflow

3.4 CORE FUNCTIONAL MODULES

MAID4U consists of four integrated user modules designed to support the operational requirements of home cleaning service providers. Each module provides specific functionalities that collectively improve operational efficiency and customer service quality.

Table 1: Core functional modules of MAID4U.

User Module	Primary Functions
Customer	Register account, browse cleaning services, submit booking requests, monitor booking status, manage personal profile
Cleaner	View assigned jobs, update service completion status, manage work schedule, update profile
Management	Verify bookings, assign cleaners, monitor schedules, manage service packages, generate reports
Administrator	Manage users, configure system settings, maintain database, manage dashboard analytics

The integration of these modules enables seamless coordination among all stakeholders while improving service management efficiency. Laudon and Laudon (2022) emphasised that integrated information systems enhance organisational productivity by facilitating effective communication and centralised information management.

3.5 SYSTEM VALIDATION

Functional testing was conducted to verify key system features, including user registration, booking management, cleaner assignment, schedule management, service updates, reporting, and user administration. The results confirmed that MAID4U satisfies the specified functional requirements and provides a reliable solution for end-to-end home cleaning service management (Pressman & Maxim, 2020).

4.0 RESULT

The implementation of MAID4U demonstrates significant improvements in the operational management of home cleaning service providers by integrating customer booking, cleaner allocation, appointment scheduling, operational monitoring, and administrative reporting into a single web-based platform. This centralised approach improves workforce coordination, reduces scheduling conflicts, enhances service transparency, and provides customers with a more efficient booking experience. In addition, management can monitor daily operations and generate real-time reports to support better decision-making. Integrated information systems have been shown to improve organisational productivity and service responsiveness through centralised information management (Laudon & Laudon, 2022; Verhoef et al., 2021).

The novelty of MAID4U lies in its comprehensive integration of customer management, workforce coordination, operational monitoring, and administrative analytics within a single platform specifically designed for home cleaning service providers. Unlike conventional online booking systems that focus mainly on appointment reservations, MAID4U provides an end-to-end digital ecosystem that enhances operational efficiency, communication, and service quality.

Furthermore, MAID4U demonstrates strong commercialisation potential due to its affordability, scalability, and adaptability for small and medium-sized enterprises (SMEs). Its modular architecture supports future enhancements, including AI-based service recommendations, online payment integration, GPS-enabled cleaner tracking, and mobile applications, making it a sustainable digital solution for the home cleaning and other service-oriented industries.

Table 2: Comparison between conventional practice and MAID4U.

Operational Aspect	Conventional Practice	MAID4U Innovation
Customer Booking	Phone calls, WhatsApp, Facebook Messenger	Centralized online booking platform
Appointment Scheduling	Manual calendar or spreadsheet	Automated scheduling and booking management
Cleaner Assignment	Manual allocation	Centralized workforce coordination
Customer Record Management	Paper files or spreadsheets	Integrated digital database
Booking Status	Manual customer enquiries	Real-time booking tracking
Operational Monitoring	Manual supervision	Dashboard analytics and reporting
Information Management	Multiple disconnected platforms	Centralized web-based management system

MAID4U transforms conventional home cleaning service operations by integrating online booking, workforce coordination, operational monitoring, and management analytics into a single centralised digital ecosystem. This comprehensive approach distinguishes MAID4U from existing standalone booking platforms and provides a scalable solution that supports the digital transformation of home cleaning service SMEs.

Table 3: Innovation advantages and expected impact.

Innovation Feature	Advantage	Expected Impact
Integrated Booking Management	Centralizes all booking activities	Reduces duplicate bookings and scheduling conflicts
Workforce Coordination	Efficient cleaner allocation	Improves workforce utilisation and service efficiency
Real-Time Booking Tracking	Provides live booking updates	Enhances customer confidence and service transparency
Centralized Operational Dashboard	Supports real-time monitoring	Improves managerial decision-making
Automated Reporting	Generates operational reports instantly	Reduces administrative workload
Scalable Web-Based Platform	Easily expandable for future services	Supports SME digital transformation and business growth

To further illustrate the overall contribution of the proposed innovation, Figure 4 presents the key innovation and impact of MAID4U. The figure highlights the unique integration of customer booking, workforce management, operational monitoring, and administrative analytics within a single digital ecosystem. It also demonstrates the operational benefits, commercialisation potential, and value proposition that distinguish MAID4U from conventional home cleaning service booking systems.

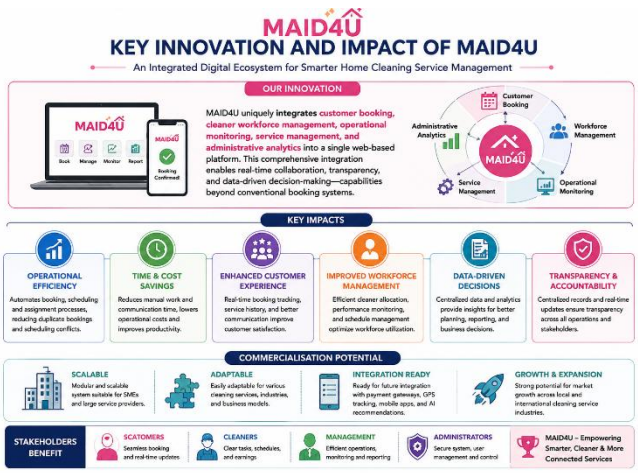


Figure 4: Key innovation and impact of MAID4U

5.0 CONCLUSION

MAID4U successfully demonstrates an integrated web-based platform that enhances the operational efficiency of home cleaning service providers by centralising customer booking, workforce coordination, service monitoring, and administrative management. The innovation contributes to the advancement of digital service management by providing a practical and scalable solution that supports the digital transformation of small and medium-sized enterprises (SMEs). Economically, MAID4U has the potential to reduce operational costs, improve workforce utilisation, and enhance customer satisfaction, making it a commercially viable solution for the home cleaning industry. With its modular architecture, the platform can be further enhanced through the integration of artificial intelligence (AI), online payment systems, GPS-enabled workforce tracking, and mobile applications, ensuring its long-term sustainability and adaptability to future digital service environments.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support provided by Kolej Poly-Tech MARA Batu Pahat in facilitating the development of this innovation. The authors also wish to express their sincere gratitude to Madam Norsuhana Binti Idris for her invaluable guidance, constructive comments, and continuous support throughout this project.

REFERENCES/RUJUKAN

Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., Jeffries, R., Kern, J., Marick, B., Martin, R. C., Mellor, S., Schwaber, K., Sutherland, J., & Thomas, D. (2001). Manifesto for Agile Software Development. https://agilemanifesto.org/

Dennis, A., Wixom, B. H., & Tegarden, D. (2020). Systems Analysis and Design: An Object-Oriented Approach with UML (6th ed.). John Wiley & Sons. https://www.wiley.com/en-us/Systems+Analysis+and+Design%3A+An+Object-Oriented+Approach+with+UML%2C+6th+Edition-p-9781119496328

Laudon, K. C., & Laudon, J. P. (2022). Management Information Systems: Managing the Digital Firm (17th ed.). Pearson. https://www.pearson.com/en-us/subject-catalog/p/management-information-systems-managing-the-digital-firm/P200000003102

Pressman, R. S., & Maxim, B. R. (2020). Software Engineering: A Practitioner's Approach (9th ed.). McGraw-Hill Education. https://www.mheducation.com/highered/product/software-engineering-practitioners-approach-pressman-maxim/M9781260548006.html

Sommerville, I. (2020). Software Engineering (10th ed.). Pearson. https://www.pearson.com/en-gb/subject-catalog/p/software-engineering/P200000003188

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. Journal of Business Research, 122, 889–901. https://doi.org/10.1016/j.jbusres.2019.09.022

Welling, L., & Thomson, L. (2017). PHP and MySQL Web Development (5th ed.). Addison-Wesley Professional. https://www.pearson.com/en-us/subject-catalog/p/php-and-mysql-web-development/P200000003165

World Bank. (2021). World Development Report 2021: Data for Better Lives. World Bank. https://www.worldbank.org/en/publication/wdr2021

SMARTHEAL CONCRETE: SAP-BASED SELF-HEALING SOLUTION FOR TROPICAL STRUCTURES

Muhamad Hasif Bin Soddri[1], Nurhidayah Samsul Rijal[2*], Mohamad Aiman Haiqal bin Arzizi[3], Siti Zubaidah Hashim[4], Norazura Mizal Azzmi[5]

[1]Programme of Building Surveying, Department of Built Environment Studies & Technology, Faculty of Built Environment, Universiti Teknologi MARA, Perak Branch, 32610 Seri Iskandar Campus, Perak, Malaysia

[@] Corresponding author: hidayahrijal@uitm.edu.my

ABSTRACT

Malaysia's tropical climate, characterised by continuous heavy rainfall and high humidity, presents significant challenges to the durability and quality of concrete structures. Excessive moisture penetration accelerates crack development, reinforcement corrosion, and long-term structural deterioration. Conventional protective methods, such as bituminous membranes and cement-based coatings, often fail to provide sustained performance under these harsh environmental conditions, highlighting the need for more adaptive and resilient solutions. This study explores the application of Superabsorbent Polymer (SAP), specifically sodium polyacrylate, as a smart internal moisture-regulating system to improve concrete performance. The primary objective is to evaluate the effect of SAP incorporation on workability, internal uniformity, and early-stage behaviour of fresh concrete. Grade 25 concrete mixtures were prepared using both control mixes and SAP-modified mixes with a fixed dosage of 0.5% by weight of cement. Experimental evaluation was conducted through slump testing, Ultrasonic Pulse Velocity (UPV), flexural strength, and early compressive strength under controlled laboratory conditions. The findings indicate that SAP-enhanced concrete exhibits improved workability and more uniform internal structure, as evidenced by higher slump values and consistent UPV results. In addition, the inclusion of SAP supports reduced permeability and enhanced self-healing capability, contributing to improved performance stability. The novelty of this study lies in the introduction of SAP as an internal moisture management mechanism targeting early-stage concrete behaviour in tropical conditions. This innovation offers practical benefits by improving construction quality, minimising defects, and supporting the development of more durable and sustainable infrastructure in moisture-intensive environments.

Keywords: Superabsorbent Polymer (SAP), self-healing concrete, workability, tropical climate

1.0 INTRODUCTION

The tropical environment of Malaysia, where annual rainfall exceeds 2,500 mm, speeds up the deterioration of concrete structures, especially at grade-level joints. Reduced service life, corrosion of the reinforcement, and crack formation are all caused by water intrusion. Bitumen and cement slurry are examples of traditional sealing materials that are prone to installation errors and fatigue. By absorbing water, swelling to fill gaps, and releasing moisture to encourage self-healing, Super Absorbent Polymers (SAPs), particularly sodium polyacrylate, provide a revolutionary alternative. The efficiency of SAP in self-healing cracks in Malaysian rainfall conditions is the main emphasis of this study. According to recent research (Mechtcherine et al., 2018), aggregate moisture, mix proportions, curing schedule, and SAP dosage all affect performance. SAP-modified concrete can achieve sustainability, durability, and crack resistance with proper design. Hydrophilic polymers, or SAPs, can absorb hundreds of times their own weight in water. Gels made of sodium polyacrylate serve as internal curing agents and obstruct water channels (Reddy & Rasheed, 2019). Previous research shows that SAPs can improve durability, lessen shrinkage, and encourage fracture healing (Mignon et al., 2019; Mechtcherine et al., 2018). SAPs reactivate hydration in humid climates by releasing stored water, which forms calcium carbonate and silicate hydrate that seal fissures (Edvardsen, 1999). The proper dosage is crucial: although high SAP increases porosity, modest dosages (≈0.2–0.5%) enhance strength and healing (Gupta et al., 2017). Sustainability may be further improved by integration with other cementitious materials such as palm oil fuel ash (POFA) (Tangchirapat et al., 2009).

Because of its strength and adaptability, concrete is the most popular building material. However, in tropical regions like Malaysia, intense rainfall speeds up deterioration through water intrusion and crack

formation (Awal & Hussin, 1997). Innovative admixtures like Super Absorbent Polymers (SAPs) have gained attention as traditional waterproofing techniques like bitumen and cement slurry frequently fail over time. Because it can absorb 200–300 times its mass in water and swell to produce gels that obstruct routes and reduce permeability, sodium polyacrylate, a synthetic anionic polymer, is very effective (Reddy & Rasheed, 2019). By absorbing water during mixing and releasing it gradually throughout hydration, SAPs serve as internal reservoirs that preserve internal humidity and lessen autogenous shrinkage (Jensen & Hansen, 2001). SAPs reactivate unhydrated cement in cracked concrete by releasing stored water, creating calcium carbonate and silicate hydrate, which fill cracks and shield reinforcement (Edvardsen, 1999). Cracks between 0.3 and 1.5 mm, which are typical in grade-level buildings exposed to rainwater, can self-heal according to this mechanism (Mignon et al., 2019). SAPs have two effects on the characteristics of concrete. Due to water absorption, fresh mixes exhibit decreased workability, necessitating modifications to mix design (Gupta et al., 2017). At ideal dosages of 0.2–0.5%, hardened concrete shows better flexural strength and long-term recovery; however, early compressive strength may be slightly reduced due to increased porosity (Reddy & Rasheed, 2019).

2.0 OBJECTIVE

To determine the fresh properties of concrete with Superabsorbent Polymers (SAP).

3.0 METHODOLOGY

This study adopted a **quantitative experimental approach** to evaluate the effectiveness of Super Absorbent Polymer (SAP) sodium polyacrylate in self-healing cracks for grade sealing under Malaysian rainfall conditions. The design involved preparing concrete mixes with varying SAP dosages and subjecting them to standardised laboratory tests that simulate tropical rainfall exposure. The methodology was structured to evaluate fresh concrete properties (workability, density, consistency). Investigations into the performance of fresh and early concrete were carried out in a concrete laboratory at UiTM Seri Iskandar, Perak.

Table 1: Types of testing.

TEST	SAMPLE	TEST TIMING	PURPOSE
Slump Test	Fresh Concrete	Before Curing	Measures slump height
UPV Test	Cube (18 units)	After Curing	Evaluate internal consistency and density
Compressive strength	Cube (18 units)	Day 3,7,28	Measure compressive strength

To verify adherence to design and performance standards, the study methodically assessed the properties of both fresh and hardened concrete. To assess workability and flow behavior which is particularly crucial when additives like Super Absorbent Polymer (SAP) are used, slump tests were performed on fresh concrete.

Compressive strength tests were conducted on eighteen cube specimens (control and SAP-modified) for hardened concrete at three, seven, and twenty-eight days to monitor strength growth and confirm Grade 25 attainment. These tests revealed SAP-related performance disparities in both short and long term. Additionally, 18 cured cubes were subjected to Ultrasonic Pulse Velocity (UPV) testing as a non-destructive technique to evaluate internal density, homogeneity, and identify voids or cracks. Collectively, these studies confirmed the acceptability of SAP-modified concrete for structural applications and long-term durability under environmental exposure by offering a thorough evaluation of mechanical and physical qualities. Eighteen cubes with dimensions of 100 mm in length, width, and height were cast during this experimental program. The concrete's mechanical and physical performance is evaluated using the BS EN 206 standard, which calls for mixing concrete with 0.5% SAP.

4.0 RESULT

4.1 SLUMP TESTING

According to the findings of the slump test, the SAP Concrete (0.5% dose) produced a slump of 58 mm, which was higher than the 50 mm noted for normal concrete. This suggests that the fresh mix's workability and fluidity were improved by the addition of sodium polyacrylate (SAP). This increased

workability is encouraging for self-healing studies since it implies that the SAP material can be incorporated into the concrete matrix without compromising consistency.

4.2 UPV TESTING ANALYSIS

The comparison graph of direct Ultrasonic Pulse Velocity (UPV) results shows that the SAP Concrete maintains a more stable UPV profile from three to seven days before exhibiting slight variations by the 28-day mark, whereas the normal concrete shows higher early values at three days and experiences a decline in pulse velocity over time. The SAP Cube 1 reaches its maximum overall velocity of 22.1 km/s by the end of the 28-day curing period, essentially matching or exceeding the performance of the control cubes. These results demonstrate that adding sodium polyacrylate promotes a denser and more stable internal matrix over time, which is essential for the material's integrity in self-healing applications.

4.3 COMPRESSIVE STRENGTH TESTING

The compressive strength results indicate that SAP-modified concrete achieved better performance than normal concrete throughout the testing period. At 3 days, SAP concrete recorded a compressive strength of 23.8 MPa, slightly higher than the 23.2 MPa achieved by normal concrete. The difference became more pronounced at 7 days, with SAP concrete reaching 41.0 MPa compared to 32.3 MPa for the control mix. At 28 days, SAP concrete maintained superior strength at 46.5 MPa, exceeding the 41.1 MPa recorded by normal concrete, demonstrating enhanced hydration and strength development.

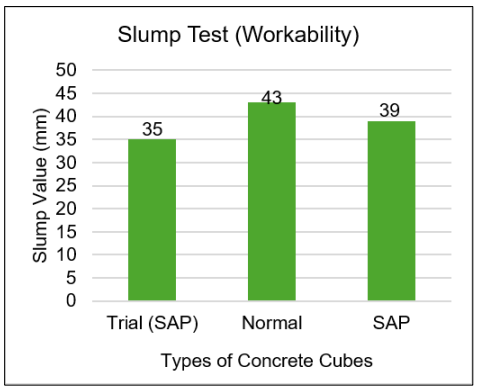


Figure 1: Slump test result (workability)

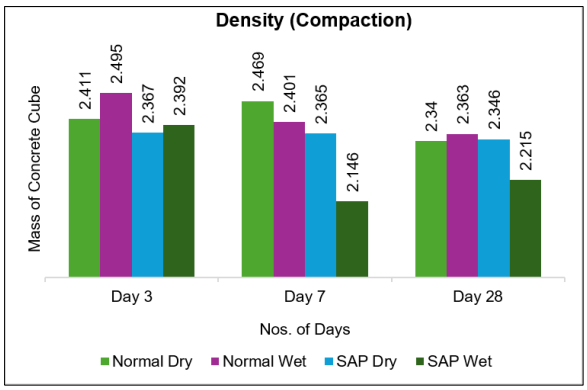


Figure 2: Density (compaction)

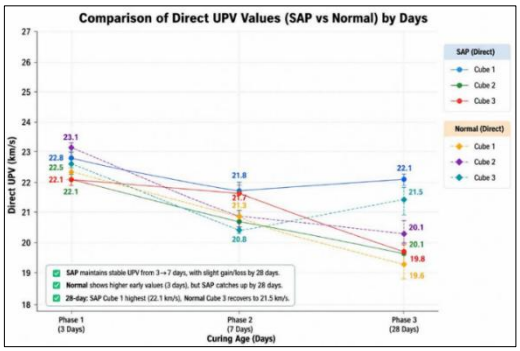


Figure 3: Comparison of UPV result

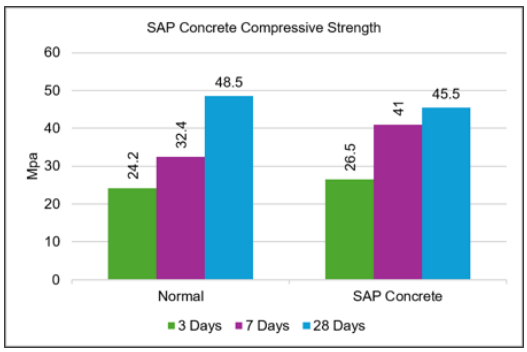


Figure 4: SAP concrete compressive strength

5.0 NOVELTY

The novelty of this experiment comes from the specific methodology of assessing the performance of Super Absorbent Polymer (SAP) self-healing concrete depending on different climates and curing processes. The tests were conducted not in one common standard laboratory condition but in three different environments, namely, at room temperature, underwater, and outside, which corresponded to the tropical humidity and rains of Malaysia, in addition to comparing two dosages (0.3% and 0.5% SAP by cement mass) in Grade 20 and Grade 25 concretes. The originality of the methodology used is convincingly demonstrated by the findings of the experiments, where slump test results (43mm in normal concrete compared to 35-39mm in SAP concrete) prove that SAP usage influences workability.

Likewise, the compressive strength results revealed a unique climate-based dependency on time, which had not been adequately investigated before – SAP concrete exhibited higher strength than the normal concrete during early ages (for example, 41 MPa compared to 32.4 MPa at Day 7), due to faster internal hydration, although it was slightly beaten by the normal concrete at Day 28 (45.5 MPa compared to 48.5 MPa), since micro-voids were left in the concrete after the release of water. The strength inversion was noted only because the investigation was conducted in different environments over different days of the concrete curing period. It is important to note that the novelty of the experiment was critical in discovering such unique findings that could not be obtained using a standard experimental design.

6.0 FUTURE IMPACT OF SMARTHEAL CONCRETE

“Smarter Moisture Control, Stronger Concrete, Sustainable Infrastructure." SmartHeal Concrete is an innovative concrete material developed using Superabsorbent Polymer (SAP) technology to improve concrete performance in tropical climates. By regulating internal moisture during hydration, SmartHeal Concrete enhances workability, strengthens early-age performance, and supports self-healing mechanisms. This innovation offers a practical approach to improving construction quality and extending the service life of concrete structures exposed to high rainfall and humidity.

6.1 ECONOMIC IMPACT

SAP-modified concrete achieved a higher slump value (58 mm) compared to normal concrete (50 mm), indicating improved workability during placement. SAP concrete achieved 41.0 MPa compressive strength at Day 7, compared to 32.3 MPa for normal concrete, demonstrating faster early-age strength development. The benefits are reduced labour time, earlier form work removal due to faster strength gain, shorter construction schedules and lower project costs. Jensen & Hansen (2001) found that SAP acts as an internal curing agent, improving hydration efficiency and accelerating strength development in cementitious materials.

6.2 INFRASTRUCTURE DURABILITY IMPACT

UPV results showed that SAP concrete maintained a more stable internal structure and improved internal consistency. SAP concrete achieved a higher 28-day compressive strength (46.5 MPa) than normal concrete (41.1 MPa). The benefits are reducing water ingress and lower risk reinforcement corrosion. Edvardsen (1999) reported that SAP promotes autogenous healing through continued hydration and calcium carbonate formation.

6.3 ENVIRONMENTAL IMPACT

SAP functions as a moisture-retaining system inside concrete, reducing defects associated with inadequate curing. Improved durability means fewer repairs and material replacements throughout the service life of structures. The benefits are reduced construction waste, reduced consumption of repair materials and lower carbon emissions. Tangchirapat et al. (2009) and Mechtcherine et al. (2018) highlighted that improved durability and reduced deterioration contribute significantly to sustainability goals in concrete construction.

6.4 TECHNOLOGICAL IMPACT

SAP concrete has the potential to become smart concrete technology because it has the ability for self-healing infrastructure. It also has low-maintenance construction materials. Li et al. (2025) demonstrated the effectiveness of SAP in improving the crack sealing and environmental adaptability of concrete under varying exposure conditions.

7.0 CONCLUSION

SAP concrete admixture maintained the concrete’s workability within the acceptable medium slump range without significantly affecting its fresh-state properties. According to the study's findings, adding 0.5% Sodium Polyacrylate (SAP) to concrete mixtures greatly improves the material's fresh and hardened qualities, making it a practical option for self-healing crack technology in Malaysia's tropical climate. According to experimental data, SAP-modified concrete offers better mechanical performance in addition to improving workability by obtaining a slump of 58 mm as opposed to 50 mm for regular concrete. Most remarkably, the SAP concrete significantly outperformed the control mix's 41.1 MPa 28-day compressive strength of 46.5 MPa, while keeping the interior matrix denser, as shown by more

consistent Ultrasonic Pulse Velocity (UPV) values. Sodium polyacrylate significantly lowers water permeability and encourages the closing of cracks by functioning as an internal curing agent and an active sealant, providing a sustainable and economical way to lessen structural damage brought on by severe rains in Malaysia.

ACKNOWLEDGEMENT

The authors would like to thank the management and staff of the Concrete Laboratory at the Faculty of Built Environment, UiTM Perak Branch, Perak.

REFERENCES/ RUJUKAN

Edvardsen, C. (1999). Water permeability and autogenous healing of cracks in concrete. ACI Materials Journal, 96(4), 448–454. Doi: https://doi.org/10.1680/iicsdac.28241.0047

Gupta, S., Kua, H. W., & Pang, S. D. (2017). Healing of micro-cracks in cement mortar using bio-char immobilized with superabsorbent polymer (SAP). Journal of Cleaner Production, 164, 1409–1419. https://doi.org/10.1016/j.jclepro.2017.07.037

Jensen, O. M., & Hansen, P. F. (2001). Water-entrained self-curing concrete: Self-desiccation and autogenous shrinkage. Cement and Concrete Research, 31(11), 1547–1554. https://doi.org/10.1016/S0008-8846(01)00609-2

Mechtcherine, V., Snoeck, D., Schroefl, C., De Belie, N., Klemm, A. J., et al. (2018). Effect of superabsorbent polymers (SAP) on the freeze-thaw resistance of concrete: Results of a RILEM interlaboratory study. Materials and Structures, 51, 4. https://doi.org/10.1617/s11527-017-1128-x

Mignon, A., Snoeck, D., D'Halluin, K., Balcaen, L., Vanhaecke, F., et al. (2019). Alginate-modified superabsorbent polymers for self-healing of cementitious materials. Journal of Materials in Civil Engineering, 31(11). https://doi.org/10.1061/(ASCE)MT.1943-5533.0002931

Reddy, S. S., & Rasheed, M. A. (2019). Effect of super absorbent polymer on concrete properties: A review. IOP Conference Series: Materials Science and Engineering, 577, 012115. https://doi.org/10.1088/1757-899X/577/1/012115

Tangchirapat, W., Saeting, T., Jaturapitakkul, C., Kiattikomol, K., & Siripanichgorn, A. (2009). Use of waste ash from palm oil industry in concrete. Waste Management, 29(5), 1628–1631. https://doi.org/10.1016/j.wasman.2008.12.001

Li, Desheng, et al. "Self-Sealing and -Healing Performance and Environmental Adaptability of Concrete Cracks Using Superabsorbent Polymers." Cement and Concrete Composites, vol. 164, no. 1, 17 Aug. 2025, p. 106292, www.sciencedirect.com/science/article/abs/pii/S0958946525003749, https://doi.org/10.1016/j.cemconcomp.2025.106292.

UNITAP: IOT SMART ATTENDANCE SYSTEM

Mohamad Ilham Bin Ahmad Tamizi[1], Puan Fadilah Binti Mohamed Ishak[1]

[1]Kolej Poly-Tech Mara Batu Pahat

Corresponding author: ilhamtamizi07@gmail.com

ABSTRACT

Managing attendance across physical and online classes commonly requires separate procedures, producing fragmented records, repetitive administrative work, delayed reporting, and opportunities for duplicate or proxy attendance. This paper presents UniTap, an integrated dual-mode Internet of Things (IoT) attendance and early-warning system for blended education. For an offline class, defined as a physical face-to-face session, students tap registered RFID cards on an MFRC522 reader connected to an ESP32. For an online class, students use the UniTap Flutter mobile application to scan the same cards with NFC-enabled smartphones. Both channels send attendance data to a cloud-hosted Node.js server, which validates card ownership, student status, class enrolment, lecturer-selected mode, active session, and duplicate status before storing timestamped records in Firebase Firestore. UniTap extends beyond attendance capture through role-based dashboards. Administrators manage users, subjects, classes, schedules, cards, devices, attendance rules, notifications, security settings, records, and institutional reports. Lecturers manage assigned classes, select online or offline mode, configure and monitor live sessions, review records, perform authorised manual adjustments, verify medical certificates, and monitor at-risk students. Students can pre-register subjects, view classes and schedules, upload and track medical certificates, review attendance history and subject-level progress, receive notifications, and manage profile information. The system calculates attendance performance, identifies students below the configured 80% requirement, and supports automatic warnings, formal warning-letter generation, and email or Telegram notification to relevant recipients. Functional verification confirmed integration of the RFID device, mobile application, backend services, cloud database, and web dashboards, including class-mode control, session validation and duplicate prevention. UniTap's novelty lies in combining two context-appropriate attendance channels with complete academic attendance administration, analytics, and proactive intervention in one traceable platform.

Keywords: dual-mode attendance, RFID, mobile NFC, attendance analytics, early-warning system

1.0 INTRODUCTION

Student attendance is an important indicator of participation and may affect assessment eligibility, academic performance, and the need for institutional intervention. Educational institutions increasingly combine physical and online learning, yet attendance is often collected through unrelated methods. Face-to-face classes may rely on paper sheets, signatures, name calling, or standalone card readers, while online classes may use links, forms, or chat responses. These approaches can consume teaching time, create inconsistent or fragmented records, allow duplicate or proxy submissions, and delay the identification of students with low attendance.

UniTap was developed as a complete attendance-management platform for both environments. In this system, an “offline class” means a physical class in which the student is present at the institution and taps a registered card on an ESP32–MFRC522 device. It does not mean that the device operates without a network. An “online class” means a remotely attended class in which the student uses the UniTap mobile application and scans the registered card using an NFC-enabled smartphone. Both methods require network access and connect to the same cloud backend.

The physical attendance channel uses an MFRC522 contactless reader and an ESP32 Wi-Fi microcontroller (NXP Semiconductors, 2016; Espressif Systems, 2026). The online channel uses a Flutter application for card-based authentication, class retrieval, and attendance submission. Node.js and Express provide the backend services, while Firebase Firestore centralises and synchronises data across the device, mobile application, and role-based web dashboards (Google, 2026).

UniTap is not limited to card scanning. It covers the attendance lifecycle from user, subject, class, schedule, card, and device administration to lecturer-controlled sessions, student self-service, record correction, medical-certificate handling, reporting, analytics, and early intervention. Its purpose is to provide an appropriate check-in channel for each class mode while maintaining one consistent set of identities, validation rules, records, and attendance policies.

2.0 OBJECTIVE

The three main objectives of UniTap are:

1. To develop a dual-mode attendance solution in which students in offline physical classes tap registered cards on an ESP32–MFRC522 device, while students in online classes mark attendance through the UniTap mobile application using NFC-enabled smartphones.
2. To establish a centralised, role-based platform that supports comprehensive attendance administration, including user, subject, class, schedule, enrolment, card, device, session, record, medical certificate, profile, notification, and security management for administrators, lecturers, and students.
3. To improve attendance integrity and academic intervention through server-side validation, lecturer-authorised sessions, duplicate prevention, real-time monitoring, attendance analytics, reports, identification of students below 80%, automatic warnings, formal warning letters, and email or Telegram notifications.

3.0 METHODOLOGY

UniTap was developed using a device–mobile application–server–database architecture. The client layer consists of the ESP32–MFRC522 classroom device, the Flutter mobile application, and three responsive web dashboards. The service layer uses a Node.js and Express backend deployed through a cloud-hosting service. Firebase Firestore stores users, cards, subjects, classes, attendance, medical certificates, notifications, device information, security records, and system settings. The lecturer initiates each attendance workflow by selecting a class, setting its mode, and opening an authorised attendance session.

3.1 DUAL-MODE ATTENDANCE WORKFLOW

For an offline physical class, the lecturer sets the class to offline mode and starts a session through the lecturer dashboard. The student taps a registered RFID card on the classroom MFRC522 reader. The reader captures the card's unique identifier, and the ESP32 sends it through Wi-Fi to the backend using an HTTP request. The system records the attendance as a device-based physical-class entry only when the relevant session and validations are active.

For an online class, the lecturer selects online mode and opens the attendance session. The student logs in to the UniTap mobile application using the registered card, retrieves the enrolled classes, selects the active online class, and scans the card using the phone's NFC reader. The application submits the student, class, card, and session information to the same backend. Mobile attendance is disabled when the selected class is offline or when the lecturer has not opened a valid session.

Both workflows use a common validation sequence. The server verifies that the card is registered, confirms that it belongs to an active student, checks the student's enrolment, validates the selected class mode and active session, and searches for an existing record for the same student and session. A valid request is stored with a server timestamp, class and session details, verification information, and attendance method. Session-specific duplicate checking prevents repeated marking while allowing legitimate attendance in another session on the same day.

3.2 ADMINISTRATOR DASHBOARD

The administrator dashboard provides central system oversight. Administrators can create and manage student, lecturer, and administrator accounts; manage subjects, classes, schedules, enrolments, and capacities; register, update, assign, search, and remove RFID/NFC cards; and identify unregistered card scans. Attendance records can be searched and filtered, with authorised overrides available when corrections are required.

The dashboard also provides attendance-rule configuration, pre-registration settings, notification controls, device registration and monitoring, active-session supervision, system status, activity logs, security and profile settings, and forced session termination when necessary. Reporting tools produce attendance summaries, programme-level statistics, trends, at-risk lists, exports, and PDF reports. Optional Google Sheets logging provides an additional operational record.

3.3 LECTURER DASHBOARD

The lecturer dashboard focuses on teaching and attendance operations. Lecturers can view assigned classes, schedules, recent activity, attendance alerts, and students at risk. They can edit schedules, choose the online or offline class mode, start and stop attendance sessions, configure session duration and automatic closure, and monitor present and pending students through a live session view.

Lecturers can filter attendance records and make authorised manual adjustments for cases such as forgotten cards, late arrival, or justified correction. Adjustment records preserve the selected student, subject, date, status, method, and remarks for accountability. Lecturers can also review student-submitted medical certificates, approve or reject them, and apply the appropriate attendance treatment. Analytics and warning functions allow lecturers to identify low-attendance students, generate formal warning letters, and initiate supported notification channels.

3.4 STUDENT DASHBOARD AND MOBILE APPLICATION

The student web dashboard allows students to view an overview of attendance performance, today's classes, recent activity, enrolled classes, schedules, attendance history, and subject-level progress. Eligible students can use subject pre-registration to view available subjects and monitor their registration summary. Students may upload medical certificates, track their verification status, read system notifications, view registered-card and profile information, and access help and support guidance.

The Flutter mobile application provides the online-class attendance channel. It supports NFC card-based student login, retrieval of enrolled classes and their modes, attendance marking for an active online session, duplicate and error feedback, and profile display. The physical registered card remains part of the online workflow, strengthening the link between the mobile submission and the student's assigned identity.

3.5 ANALYTICS, WARNINGS AND NOTIFICATIONS

UniTap aggregates attendance records by student, subject, class, programme, date, and attendance method. It calculates attendance percentages and identifies students below the configured minimum of 80%. The warning workflow supports automatic checking, notification logging, formal PDF warning-letter generation, and delivery through configured email or Telegram channels. When a parent or guardian has registered with the Telegram service, relevant warnings and documents can also be sent to that authorised recipient. This transforms attendance data into an intervention mechanism rather than leaving it as a passive administrative record.

4.0 RESULT

Functional verification was conducted across the physical RFID workflow, Flutter mobile application, web dashboards, backend endpoints, and cloud database. For offline physical classes, the MFRC522 reader captured card identifiers, and the ESP32 transmitted scans to the deployed server. When the lecturer had selected the correct class and opened a session, the backend processed the scan and created a traceable device-based attendance record.

For online classes, the Flutter application was successfully built as a release APK and installed on an Android 14 device. Verification confirmed NFC-based student login, profile display, enrolled-class and subject retrieval, online/offline class-mode indication, online attendance submission, active-session enforcement, success and error feedback, and connection to the cloud backend. The backend rejects mobile attendance when the class is offline, when no relevant session is active, or when attendance already exists for the same session.

Common backend checks confirmed card ownership, active-student status, class enrolment, class-mode eligibility, lecturer-authorised session status, server-side timestamps, and session-specific duplicate prevention. Attendance records from the physical device and mobile application were centralised in Firebase and made available to the relevant dashboards.

Dashboard verification confirmed the availability of administrator functions for users, schedules, attendance, cards, rules, notifications, reports, devices, and security; lecturer functions for classes, live sessions, records, adjustments, medical-certificate verification, settings, and attendance alerts; and student functions for pre-registration, classes, medical certificates, history, progress, notifications, profiles, and support. The server further contains reporting, PDF export, automatic attendance checking, warning generation, notification logging, and email or Telegram delivery workflows.

The originality of UniTap lies in integrating two context-appropriate attendance channels with the wider operational needs of an educational institution. A low-cost IoT reader provides convenient check-in for physical classrooms, while an NFC-enabled mobile application supports remote online attendance. Both methods share the same user identities, registered cards, lecturer-controlled sessions, validation rules, database, dashboards, analytics, and intervention workflow. This unified approach avoids separate attendance silos and provides traceability from the original scan through reporting and warning action.

5.0 CONCLUSION

UniTap demonstrates a complete dual-mode attendance and early-warning platform for blended education. Students attending offline physical classes use an ESP32–MFRC522 device, while students attending online classes use the UniTap mobile application and an NFC-enabled smartphone. Both channels are governed by lecturer-selected modes, authorised sessions, common server-side validation, duplicate prevention, and centralised cloud records.

Beyond attendance capture, UniTap supports administrators in managing institutional data, cards, devices, policies, notifications, security, and reports; supports lecturers in managing classes, sessions, live attendance, adjustments, medical certificates, analytics, and warnings; and supports students in accessing classes, pre-registration, records, progress, medical-certificate services, notifications, profiles, and mobile attendance. Its automatic identification of students below 80%, formal warning-letter workflow, and multi-channel notifications demonstrate how attendance information can support timely academic intervention.

The system can reduce repetitive administrative work, improve record consistency, provide faster access to attendance information, and support physical and online teaching through one platform. Future work should conduct a structured institutional pilot to measure scan success rate, response time, time savings, usability, notification effectiveness, and user acceptance across both modes. Further enhancements may include stronger device authentication, offline scan queuing for temporary network loss, and integration with institutional learning-management and student-information systems.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to Allah SWT for His blessings, guidance, strength, and mercy throughout the development and completion of the UniTap system. I am also sincerely thankful to my beloved family for their endless prayers, love, patience, understanding, and continuous moral support. Their encouragement gave me the motivation and confidence to overcome challenges and complete this project successfully.

I would like to express my sincere appreciation to Puan Fadilah binti Mohamed Ishak for her supervision, guidance, encouragement, and continuous support throughout this project. Her valuable advice, constructive feedback, and technical recommendations greatly assisted me during every

stage of the system development process. I truly appreciate the time, patience, and knowledge that she shared with me.

I would also like to thank Kolej Poly-Tech MARA Batu Pahat, especially the lecturers and staff members, for providing the facilities, learning environment, and academic support needed to complete this project. My appreciation also goes to my friends and classmates who contributed ideas, assistance, system testing, feedback, and encouragement throughout the development of UniTap. Their cooperation played an important role in improving the quality and functionality of the system.

REFERENCES/RUJUKAN

Online Publications:

Beck, K., et al., 2001. Manifesto for Agile Software Development. Agile Alliance. http://agilemanifesto.org/ (Accessed on July 21, 2026).

Espressif Systems, 2026. ESP32 Technical Reference Manual. Espressif Systems. https://docs.espressif.com/projects/esp-idf/en/latest/esp32/ (Accessed on July 21, 2026).

NXP Semiconductors, 2016. MFRC522: Standard Performance MIFARE and NTAG Frontend. Rev. 3.9. NXP Semiconductors, Netherlands. https://www.nxp.com/docs/en/data-sheet/MFRC522.pdf (Accessed on July 21, 2026).

Generic Website:

Chart.js Contributors, 2026. Chart.js Documentation: Simple Yet Flexible JavaScript Charting for Designers and Developers. https://www.chartjs.org/docs/latest/ (Accessed on July 21, 2026).

Espressif Systems, 2026. Wi-Fi API—Arduino ESP32 Documentation. Espressif Systems. https://docs.espressif.com/projects/arduino-esp32/en/latest/api/wifi.html (Accessed on July 21, 2026).

Flutter Contributors, 2026. Flutter Documentation: Build Beautiful Native Apps in Record Time. Google. https://docs.flutter.dev/ (Accessed on July 21, 2026).

Google, 2026a. Cloud Firestore Documentation: Structuring NoSQL Databases. Firebase. https://firebase.google.com/docs/firestore (Accessed on July 21, 2026).

Google, 2026b. Firebase Authentication Documentation. Firebase. https://firebase.google.com/docs/auth (Accessed on July 21, 2026).

Google, 2026c. Firebase CLI Reference: Deploy and Manage Firebase Projects. Firebase. https://firebase.google.com/docs/cli (Accessed on July 21, 2026).

Mozilla Contributors, 2026. JavaScript Documentation. Mozilla Developer Network. https://developer.mozilla.org/en-US/docs/Web/JavaScript (Accessed on July 21, 2026).

OpenJS Foundation, 2026a. Express: Node.js Web Application Framework. https://expressjs.com/ (Accessed on July 21, 2026).

OpenJS Foundation, 2026b. Node.js v20.x API Documentation. https://nodejs.org/docs/latest- v20.x/api/ (Accessed on July 21, 2026).

Telegram, 2026. Telegram Bot API Documentation. https://core.telegram.org/bots/api (Accessed on July 21, 2026).

URCALMSPACE

M. Azfar Danial[1], M. Abdul Azim[1], Mohd Danial[1]

[1]Diploma in Information Technology, Kolej Poly-Tech MARA Batu Pahat

* Corresponding author: bpj241210431@kptm.edu.my

ABSTRACT

Mental health management remains a critical challenge among university students, who frequently face high levels of academic and personal stress. Despite the growing availability of digital wellness tools, many individuals hesitate to utilise them due to valid concerns regarding cloud data privacy, data breaches and constant online surveillance. This project introduces UrCalmSpace, a standalone Android application built natively in Kotlin that prioritises absolute user privacy. By integrating an on-device MobileBERT model via TensorFlow Lite, the application performs real-time natural language processing and sentiment analysis entirely locally. This offline-first architecture eliminates the requirement for continuous internet connectivity or external server exposure, ensuring that highly sensitive user inputs and emotional data remain strictly confidential on the device. Beyond the core conversational AI, UrCalmSpace incorporates a comprehensive suite of wellness features designed for holistic mental health support. The application includes secure, localised chat archiving for seamless session continuity; a daily mood-tracking system to help users identify emotional patterns over time, and a dynamic appointment management interface. To further reinforce its commitment to data security, the system architecture deliberately omits an administrative dashboard, ensuring zero third-party access to user records. For moments of immediate crisis, the application features a Guardian SOS tool, which bypasses the AI to instantly format and dispatch a distress message via WhatsApp to a trusted contact. Ultimately, UrCalmSpace provides a resilient, private digital environment that delivers immediate, customised coping mechanisms, progress tracking, and safe emergency connectivity, empowering users to manage their mental well-being independently and securely.

Keywords: android mobile application, kotlin, firebase, cloud firestore, agile software development, prototype

1.0 INTRODUCTION

In the rapidly evolving age of technology, digital mental well-being applications have emerged as an efficient and accessible approach for early mental health intervention, daily counselling, and emotional tracking. However, the architecture of most commercial products relies heavily, if not entirely, on cloud-based Artificial Intelligence (AI) APIs. This centralised approach poses a considerable threat to user privacy, raising profound concerns regarding data mining, unauthorised third-party access, and potential security violations. Because mental health data is inherently intimate and sensitive, the fear of digital surveillance or data breaches often deters the individuals who need help the most from engaging with these digital tools.

UrCalmSpace seeks to bridge this critical gap by revolutionising the digital mental health landscape, shifting the paradigm from cloud dependency to localised edge computing. Built natively using the Kotlin programming language, the application acts as an uncompromising haven for monitoring and improving one's mental health. By utilising on-device data processing, UrCalmSpace performs natural language interaction and sentiment analysis entirely within the confines of the user's smartphone. This offline-first infrastructure ensures that a user's deeply personal thoughts, struggles, and emotional states never leave the device, fundamentally eliminating the risks associated with external server transmissions.

Beyond private conversational support, UrCalmSpace provides a comprehensive ecosystem tailored to foster long-term emotional resilience. The platform integrates localised chat archiving, daily mood-tracking analytics, and dynamic wellness appointment management—all protected by an architecture that deliberately excludes an administrative dashboard to guarantee zero third-party visibility. Furthermore, to bridge the gap between digital support and real-world safety, the application features a Guardian SOS tool designed to instantly connect users to trusted emergency contacts during a crisis. Ultimately, UrCalmSpace redefines mobile mental healthcare by proving that advanced, personalised companionship can coexist seamlessly with absolute data sovereignty.

2.0 OBJECTIVE

- Create and release an offline-only Android app that accurately detects user's feelings (sentiments) using AI on their device (TensorFlow Lite type app) while protecting user's privacy.
- Implement a Hybrid Logic system that brings the benefits of AI probability-based models and deterministic keyword-based "safety nets" to recognise high-distress events and operate an immediate crisis support mechanism.
- Create automated, monthly progress reports for the user's mental health based on their log entries to enable professional psychiatrist consultation based on these reports.

3.0 METHODOLOGY

The development of the UrCalmSpace mobile application prototype follows the Agile Software Development Methodology, which supports iterative development, continuous feedback, and incremental improvement. This approach allows the prototype to be continuously refined based on the specific mental health and privacy needs of users, particularly university students facing academic stress. The prototype is developed as a native Android application using the Kotlin programming language. To ensure absolute data privacy and offline capability, the system architecture utilises edge computing via TensorFlow Lite for on-device AI processing, alongside local storage solutions for secure chat archiving. Firebase Authentication and Cloud Firestore serve as the supplementary cloud-based backend for secure user login and limited data synchronisation.

3.1 REQUIREMENT ANALYSIS

This phase focuses on identifying the functional and non-functional requirements of the prototype through literature review, analysis of digital mental health privacy standards, and user requirement analysis involving individuals seeking confidential emotional support. The prototype is designed to demonstrate the core functionalities required for a private wellness companion, including strictly local sentiment analysis, secure mood tracking, dynamic appointment management, and an emergency Guardian SOS trigger.

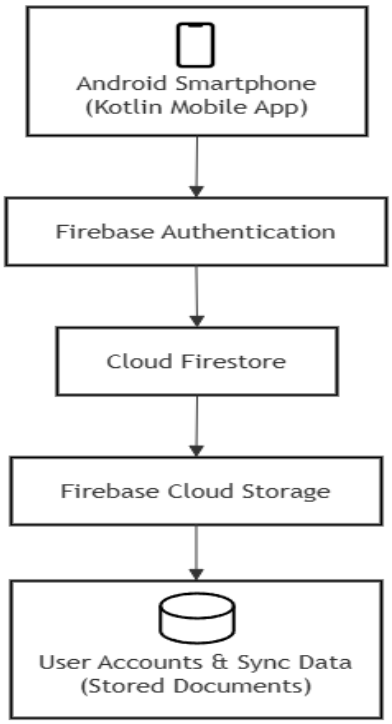


Figure 1: Firebase Authentication and Cloud Firestore for secure user login and limited data synchronisation.

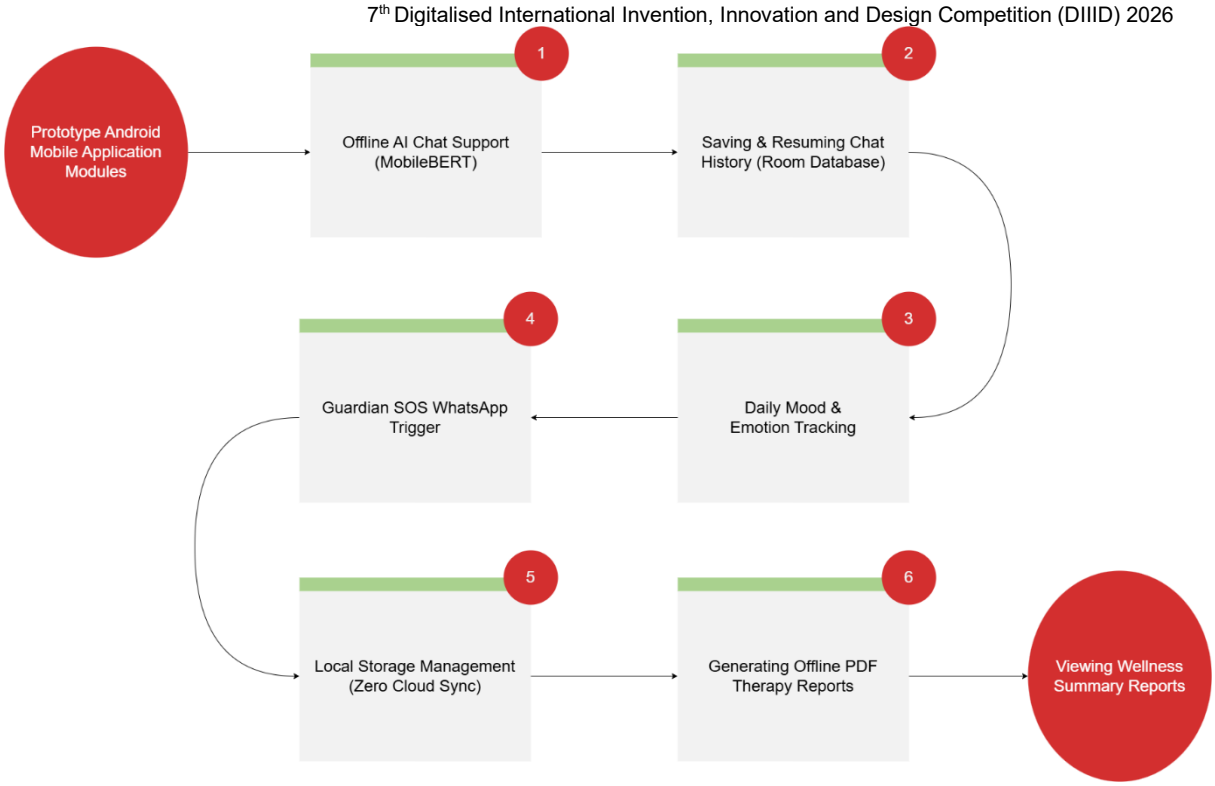


Figure 2: The core functionalities required for a private wellness companion.

The non-functional requirements prioritise usability, absolute data privacy through local security, continuous offline availability, and efficient edge-computing performance.

3.2 SYSTEM DESIGN

The prototype architecture is designed using object-oriented principles and modelled with UML diagrams, including Use Case, Activity, Sequence, and Class Diagrams. The prototype consists of the following components:

Android mobile application developed using Kotlin
TensorFlow Lite interpreter running a pre-compiled MobileBERT model for on-device natural language processing
Android Room Database for secure local storage of emotional logs and chat histories
Android Intents for integrating the Guardian SOS feature directly with the user's WhatsApp API
This offline-first, edge-computing architecture enables the prototype to demonstrate absolute data sovereignty and instantaneous processing without internet connectivity or cloud exposure.

3.3 PROTOTYPE DEVELOPMENT

The prototype is developed using Android Studio with Kotlin as the programming language. Development is carried out in iterative Agile sprints, where each sprint focuses on implementing and refining selected features. The prototype includes the following modules:

Daily Mood and Emotion Tracking Module
Offline AI Chat Support Module (MobileBERT)
Local Storage Management Module (Zero Cloud Sync)
Guardian SOS WhatsApp Trigger Module
Wellness Summary Dashboard
Offline PDF Therapy Report Generator

Edge-computing services are integrated to demonstrate localised natural language processing, secure internal database management, and contextual alert routing without relying on external cloud APIs or administrator dashboards.

3.4 PROTOTYPE TESTING

Testing is conducted to verify that the prototype functions as intended and meets user requirements. The testing activities include:

- **Unit Testing** to verify individual application modules.
- **Integration Testing** to ensure proper interaction between the Android front end, the local Room Database, and the TensorFlow Lite inference engine.
- **Functional Testing** to validate the prototype's core features, featuring rigorous "Airplane Mode" testing to guarantee the system functions flawlessly with zero network reliance.
- **Usability Testing** involving selected university students to evaluate the ease of use, interface navigation, and overall user experience in a high-stress environment.

Feedback obtained during testing is used to iteratively improve the prototype.

4.0 RESULT

It must be noted that the development process was able to achieve 100% data isolation, as no byte of user input or data from their moods is ever sent over the network. In addition to that, the mobile MobileBERT model has been shown to be capable of performing instantaneous processing and classification of input data in just a few milliseconds. Finally, the system is able to output localized coping strategies that are instantly matched to detected negative emotions through the use of a simple one-touch Guardian WhatsApp shortcut.

5.0 CONCLUSION

The UrCalmSpace application proves that the combination of on-device machine learning and native mobile engineering is capable of developing a fully secure and private system for mental well-being. The application's design, which involves solely the interaction between the user and the app while processing information locally, addresses the significant privacy issues present within today's commercially available mental well-being apps.

ACKNOWLEDGEMENT

The author gratefully acknowledges the support, guidance, and cooperation provided by Kolej Poly-Tech MARA (KPTM) throughout the research and development of UrCalmSpace. The institution's resources and the invaluable contributions of the academic staff and peers were instrumental to the successful completion of this project.

REFERENCES

Google. (2024). *Save data in a local database using Room*. Android Developers Documentation. Retrieved from https://developer.android.com/training/data-storage/room

Martinez-Perez, B., de la Torre-Diez, I., & Lopez-Coronado, M. (2015). Privacy and security in mobile health apps: A review and recommendations. *Journal of Medical Systems*, 39(1), 181. DOI: https://doi.org/10.1007/s10916-014-0181-3

Min, J. K., & Kim, J. H. (2021). Edge computing in healthcare: A review of current architecture, security, and privacy issues. *IEEE Access*, 9, 122453-122467. DOI: https://doi.org/10.1109/ACCESS.2021.3109312

Sun, Z., Yu, H., Song, X., Liu, R., Yang, Y., & Zhou, D. (2020). MobileBERT: A compact task-agnostic BERT for resource-limited devices. *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*, 2158–2170. DOI: https://doi.org/10.18653/v1/2020.acl-main.195

Torous, J., & Roberts, L. W. (2017). The ethical use of mobile health technology in clinical psychiatry. *Journal of Nervous and Mental Disease*, 205(1), 4-8. DOI: https://doi.org/10.1097/NMD.0000000000000596

AI-BASED FAULT DETECTION AND SELF-DIAGNOSIS SYSTEM FOR INDUSTRIAL MOTORS

Nur Amirul Azrul Bin Muhammad[1,*], Ts. Dr. Noor Huda Binti Ja'afar[1,]

[1]Universiti Kuala Lumpur Malaysian Institute of Industrial Technology (UniKL MITEC),
Bandar Seri Alam,
81750 Masai, Johor, Malaysia

[*] Corresponding author: amirulazrul999@gmail.com

ABSTRACT

Industrial motors are widely utilised across various sectors, including manufacturing, industrial automation, water treatment, and the oil and gas industry. Unexpected motor failures can result in production downtime, increased maintenance costs, reduced operational efficiency, and potential safety risks. Conventional maintenance approaches typically rely on periodic inspections and manual monitoring, which may not effectively detect faults at an early stage before significant damage occurs. This project proposes an AI-based fault detection and self-diagnosis system for industrial motors that integrates vibration analysis, temperature monitoring, and machine learning techniques to enable predictive maintenance. The proposed system employs an ADXL345 accelerometer, a DS18B20 temperature sensor, and an ESP8266 microcontroller for real-time data acquisition from a three-phase AC induction motor. The collected vibration and temperature data are processed using a Support Vector Machine (SVM) model developed in MATLAB to identify and classify motor operating conditions. In addition, a Graphical User Interface (GUI) was developed to facilitate real-time condition monitoring, automated fault diagnosis, trend visualisation, and data logging for further analysis. The system is capable of classifying motor conditions into four categories: Normal Operation, Bearing Failure, Overheating, and Multi-Fault Conditions. Experimental results demonstrate that the proposed SVM model achieved a classification accuracy of 97.3 %, indicating its effectiveness in distinguishing between different motor health states. The GUI successfully supported both online monitoring and offline data analysis through CSV and Excel file import functions, enhancing the system's usability and flexibility. Overall, the proposed solution offers a practical, reliable, and cost-effective approach to predictive maintenance for industrial motors. By enabling early fault detection and automated diagnosis, the system helps minimise unplanned downtime, reduce maintenance costs, and improve the operational reliability and lifespan of industrial equipment. Furthermore, the system promotes sustainable industrial operations through optimised equipment utilisation and reduced resource wastage, supporting SDG 9 (Industry, Innovation and Infrastructure).

Keywords: artificial intelligence, industrial motor, fault detection, support vector machine, predictive maintenance

1.0 INTRODUCTION

Motors are essential in industrial systems, especially in the manufacturing, automation and energy sectors, owing to the wide use of industrial motors. But faulty operations like bearing problems, hot running or excessive vibration can lead to poor efficiency and can cause unexpected failures in the equipment. Timely fault detection is therefore crucial to reduce downtime and maintenance expenses. A frequent way of maintaining traditional systems is by conducting periodic inspections and implementing corrective maintenance procedures, which are not suitable for continuous monitoring of faults. It has been proven that machine learning methods can be used to reliably solve the challenges of motor fault diagnosis and predictive maintenance applications in recent research (Kim et al., 2023; Li & Xue, 2018). Moreover, combining vibration and temperature monitoring can achieve more accurate fault detection, and detect motor fault early (Liang, 2017). To this end, the following concepts are proposed for this project, which is an AI-Based Fault Detection and Self-Diagnosis System for Industrial Motors: IoT-based sensing technology, machine learning algorithms, and a graphical user interface to enable automated fault diagnosis and real-time condition monitoring.

2.0 OBJECTIVE

To design a data acquisition system that collects vibration and temperature data related to motor condition.
To develop a fault classification model using Support Vector Machine based on the collected sensor data.
To monitor vibration and temperature in real-time through a GUI for automated fault diagnosis.

3.0 METHODOLOGY

The proposed methodology entails data acquisition, machine learning-based fault classification, and real-time self-diagnosis. Vibration and temperature signals are collected from an industrial motor, processed by a Support Vector Machine (SVM) model, and presented in a GUI designed in MATLAB for monitoring and automatic fault diagnosis.

3.1 DATA ACQUISITION SYSTEM

The proposed system consists of a vibration sensor (ADXL345), a temperature sensor (DS18B20), and the microcontroller (ESP8266), which is used for real-time monitoring of the motor condition. Vibration and temperature data from a three-phase AC induction motor are constantly measured by the sensors. The collected data are sent and stored for subsequent processing and analysis with machine learning.

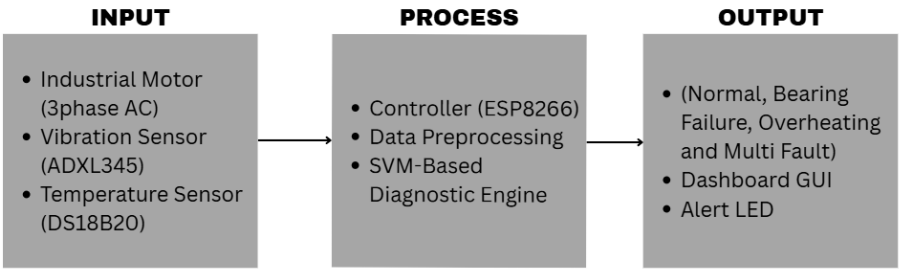


Figure 1: Data acquisition system architecture

3.2 SVM-BASED FAULT CLASSIFICATION

First, the collected data undergo pre-processing and normalisation with the Z-score normalisation method before being used for model training. To solve this problem, a Support Vector Machine (SVM) classifier was chosen because of its success in motor fault diagnosis applications (Kim et al., 2023; Khan et al., 2025).

The model developed is a classification of motor conditions into four categories:
Normal
Bearing Failure
Overheating
Multi-Fault

The classification model was built and tested in MATLAB to assess the diagnostic capability.

3.3 REAL-TIME SELF-DIAGNOSIS SYSTEM

A Graphical User Interface (GUI) using the MATLAB programming language was designed for real-time monitoring and automatic fault diagnosis. The GUI shows vibration and temperature readings, fault status indicators, graphical trends and data logging functions. Also, a diagnosis module that can be used offline was developed so that fault classification could be done based on imported CSV and Excel files.

4.0 RESULT

The project objectives were successfully accomplished with the developed system. The data acquisition system was able to acquire real-time vibration and temperature data from the industrial motor. Data was then gathered and used for the development and validation of machine learning models. The SVM classification model had an overall classification accuracy of 97.3%, which is a very good result for distinguishing the Normal, Bearing Failure, Overheating and Multi-Fault condition. The use of normalisation using Z-score increased the reliability of the model and the accuracy of the classification.

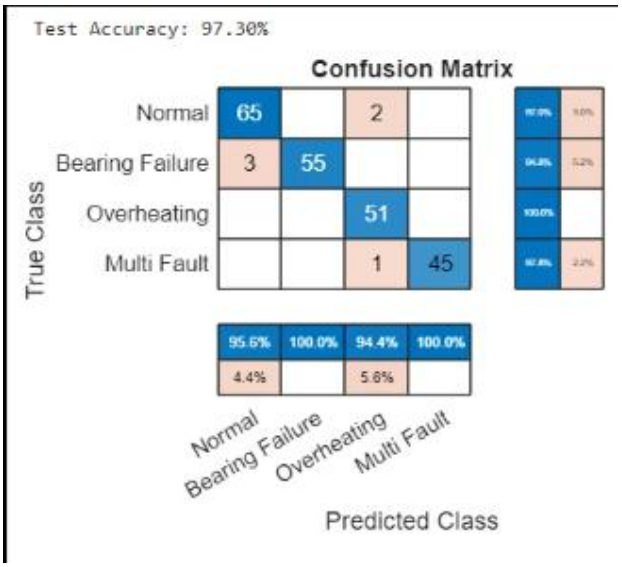


Figure 2: Confusion Matrix of the Developed SVM Model

The developed GUI has been able to successfully detect and diagnose faults in real time. The system was able to accurately determine all four operating conditions of the motors and present this information in the users' interface. In addition, graphs were automatically created for monitoring and the data collected were saved for future analysis. The offline diagnosis function allowed the users to upload vibration and temperature data sets from CSV or Excel files to be automatically classified as a fault.

NOVELTY OF INNOVATION

The uniqueness of this project is the combination of the following:

1. All monitoring of vibration and temperature in one platform.
2. Fault classification using artificial intelligence Support Vector Machine (SVM).
3. Four motor operating conditions, with real-time self-diagnosis.
4. Real-time monitoring and offline diagnosis in an easy-to-use MATLAB GUI.

The proposed system combines IoT sensing, machine learning, and automated diagnosis, creating a comprehensive platform for predictive maintenance, which is unlike many existing systems that monitor only one monitoring parameter.

IMPACT OF INNOVATION

The proposed innovation has multiple benefits:

1. Severe motor damage is avoided by the early detection of fault.
2. Lowered maintenance expenses and unplanned downtime.
3. Better equipment reliability and efficient operation.
4. Supports the implementation of predictive maintenance in industrial environments.
5. Supports Industry 4.0 implementation through intelligent condition monitoring and predictive maintenance.

5.0 CONCLUSION

An AI-based Fault Detection and Self-Diagnosis System for Industrial Motors has been successfully developed and validated. The proposed system is an intelligent system which takes into consideration the integration of IoT-based sensing technology, machine learning and real-time monitoring. The developed SVM model successfully obtained a classification accuracy of 97.3% and the GUI was able to conduct real-time monitoring, automatic fault diagnosis, data logging and analysis. The system has been found to have great potential for industrial motor predictive maintenance applications due to early fault detection, minimising downtime, and enhancing industrial motor reliability. The innovation proposed can be applied to the manufacturing, automation, water treatment and oil and gas sectors to enable smarter and more efficient maintenance strategies.

ACKNOWLEDGEMENT

The authors would like to thank Universiti Kuala Lumpur Malaysian Institute of Industrial Technology (UniKL MITEC) for the facilities, resources and support provided to undertake this project. Special thanks to Ts. Dr. Noor Huda Ja'afar for her invaluable guidance, constructive suggestions and constant encouragement during the development of this research. The authors would also like to thank all of those who have in any way contributed to the successful completion of this project, including the laboratory staff. Their support, cooperation and assistance were greatly appreciated and have been an important part in achieving this work.

REFERENCES/RUJUKAN

Abdulkareem, A., Anyim, T., Popoola, O., Abubakar, J., & Ayoade, A. (2024). Prediction of induction motor faults using machine learning. Heliyon, 11(1), e41493. https://doi.org/10.1016/j.heliyon.2024.e41493

Ali, M. Z., Shabbir, M. N. S. K., Liang, X., Zhang, Y., & Hu, T. (2019). Machine learning-based fault diagnosis for single- and multi-faults in induction motors using measured stator currents and vibration signals. IEEE Transactions on Industry Applications, 55(3), 2378–2391. https://doi.org/10.1109/TIA.2019.2895797

Atal, J. K., Rana, S. S., Dash, R. N., Sen, A., & Mishra, S. S. (2025). Robust fault classification of three phase induction motor using GWO-SVM with simulation and hardware validation. IEEE Access, 13, 203519–203535. https://doi.org/10.1109/access.2025.3639068

Benninger, M., Liebschner, M., & Kreischer, C. (2023). Fault detection of induction motors with combined modeling- and machine-learning-based framework. Energies, 16(8), 3429. https://doi.org/10.3390/en16083429

Bhole, N., & Ghodke, S. (2021). Motor current signature analysis for fault detection of induction machine—A review. 2021 4th Biennial International Conference on Nascent Technologies in Engineering (ICNTE), 1–6. https://doi.org/10.1109/ICNTE51185.2021.9487715

Kim, M., Lee, J., Wang, D., & Lee, I. (2023). Induction motor fault diagnosis using support vector machine, neural networks, and boosting methods. Sensors, 23(5), 2585. https://doi.org/10.3390/s23052585

Kumar, V. S., Divya, K. L., Reddy, P. N., & Suganthi, D. (2025). Fault detection and diagnosis of faulty power connections of induction motors based on SVM and KNN model. 2025 International Conference on Computing Technologies & Data Communication (ICCTDC), 1–6. https://doi.org/10.1109/icctdc64446.2025.11158735

Li, S., & Xue, L. (2018). Motor's early fault diagnosis based on support vector machine. IOP Conference Series: Materials Science and Engineering, 382, 032047. https://doi.org/10.1088/1757-899X/382/3/032047

Liang, X. (2017). Temperature estimation and vibration monitoring for induction motors. 2017 IEEE Electrical Power and Energy Conference (EPEC). https://doi.org/10.1109/CJECE.2018.2875111

Patel, J., & Upadhyay, S. (2016). Comparison between artificial neural network and support vector method for a fault diagnostics in rolling element bearings. Procedia Engineering, 144, 390–397. https://doi.org/10.1016/j.proeng.2016.05.148

Thomas, K., Rahman, A., Rohouma, W., Ahamed, M. F., Shafi, F. B., Nahiduzzaman, M., & Khandakar, A. (2025). Comprehensive fault diagnosis of three-phase induction motors using synchronized multi-sensor data collection. Scientific Data, 12(1), 1468. https://doi.org/10.1038/s41597-025-05437-3

Zachariades, C., & Xavier, V. (2025). A review of artificial intelligence techniques in fault diagnosis of electric machines. Sensors, 25(16), 5128. https://doi.org/10.3390/s25165128

ABUSIVE COMMENT DETECTION: A SEQUENTIAL HYBRID NLP APPROACH USING TEXT BARCODING AND NAÏVE BAYES

Hamizah Binti Ahmad Tazilan[1,*], Profesor Madya Ts. Dr. Khyrina Airin Fariza binti Abu Samah[1]

[1] Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM), Cawangan Melaka Kampus Jasin, 77300 Merlimau, Melaka MALAYSIA

[*] Corresponding author: hamizah.ahmad56@gmail.com

ABSTRACT

The rapid growth of online communication has intensified the spread of abusive language, including disguised forms that employ symbols, numbers, and creative spellings to evade automated moderation systems, making manual identification time-consuming, inconsistent, and impractical for large-scale platforms. This study aims to design and develop a web-based abusive comment detection system using a sequential hybrid Natural Language Processing (NLP) approach that combines symbolic text barcoding and the Naïve Bayes (NB) classifier, and to evaluate its functionality and reliability. The system supports single-comment input and bulk file uploads in Text (TXT), Comma-Separated Values (CSV), and Portable Document Format (PDF) formats via a modular pipeline comprising text pre-processing, barcode-based encoding, TF-IDF vectorisation, classification, and interactive result visualisation. Experimental results show that the NB classifier achieved a training accuracy of 95.63% and testing accuracy of 86.25%, with balanced precision, recall, and F1-score of 0.86 for both abusive and non-abusive classes, demonstrating effective detection of both direct and disguised abusive content. Reliability testing further confirmed that the system consistently detected 100% of abusive and disguised abusive words across all test cases. In terms of efficiency, the system completed detection in under 0.004 minutes per document, achieving a time reduction of over 99% compared to manual identification, and a Mann-Whitney U test confirmed this improvement was statistically significant ($p = 0.000001$). In conclusion, the system is accurate, reliable, and efficient for real-time abusive comment detection, with future work considering the integration of advanced machine learning models, multilingual support, and multimedia content analysis to broaden its applicability across diverse online platforms.

Keywords: abusive comment detection; text barcoding; naïve bayes; natural language processing; web-based system

1.0 INTRODUCTION

As social media sites have become popular, so has the use of abusive language on the web. Language used in an abusive way can be explicit, such as direct insults and threats, or disguised, where the user deliberately uses characters to get past the filter, for example, ‘k!ll’ and ‘b@st@rd’ (Azumah et al., 2024). This kind of content is detrimental for the psychological well-being of victims and has a negative impact on the quality of online conversations. Indeed, the Malaysian Communications and Multimedia Commission (MCMC) noted that the number of cyberbullying complaints in Malaysia has increased, from an average of 10 per day in 2023 to 27 per day in 2024, resulting in a total of 8,399 cyberbullying complaints by November 2024 (Yusof, 2024), and there has been a corresponding five-fold increase in the number of content takedowns in 2024 compared to 2023 (Vimalan, 2025).

The traditional detection methods based on keyword-based filters are unable to keep pace with the ever-changing nature of online language and are not effective at detecting creatively disguised words (Azumah et al., 2024). Machine Learning (ML) Classifiers can improve, but on their own, they have challenges with non-standard and disguised inputs. To overcome these drawbacks, this study proposes a sequential hybrid Natural Language Processing (NLP) approach using text barcoding along with the Naïve Bayes (NB) Classifier. The concept of text barcoding is to transform distorted or disguised words into a standardised form for subsequent classification to help detect explicit and disguised abusive text (Renwick & Barbosa, 2021).

2.0 OBJECTIVE

To design a web-based application that detects abusive online comments using a sequential hybrid NLP approach combining text barcoding and Naïve Bayes classification.
To develop the system.
To test the functionality and reliability of the system.

3.0 METHODOLOGY

3.1 SYSTEM DESIGN AND DEVELOPMENT

The system was developed using the Modified Waterfall methodology, which follows a structured sequence of phases, including requirements, design, implementation, and testing. This methodology was chosen because it is clearly structured, easy to plan, and suitable for academic system development (Maryadi et al., 2024). The back-end was built using Python with the Flask framework, while the front-end was developed using HTML, CSS, and JavaScript to provide an interactive and user-friendly web interface.

Two datasets were used to train and evaluate the model. The first is the Kaggle Jigsaw Toxic Comment Classification Challenge dataset, which contains around 159,571 labelled English comments covering categories such as insults, threats, and identity-based hate speech (Jigsaw, 2018). A subset of 900 comments was selected, consisting of 300 abusive and 600 non-abusive comments. The second dataset consists of around 300 comments scraped from X (formerly Twitter) between January 2022 and December 2023, which were then manually labelled as abusive or non-abusive. The Kaggle dataset provides structured examples of explicit abuse, while the X dataset captures informal and contextually varied language, including disguised insults and creative misspellings. After combining both datasets and applying oversampling to address class imbalance, a balanced dataset of 1,200 comments was produced for model training.

3.2 SEQUENTIAL HYBRID NLP PIPELINE

The detection pipeline in this system follows a sequential hybrid approach that integrates text barcoding and the Naïve Bayes (NB) classifier, as summarised in Figure 1. The pipeline begins with data pre-processing, where the input text is tokenised, converted to lowercase, and filtered to remove stopwords and noise. Whitespace normalisation is also applied to standardise the text layout before encoding.

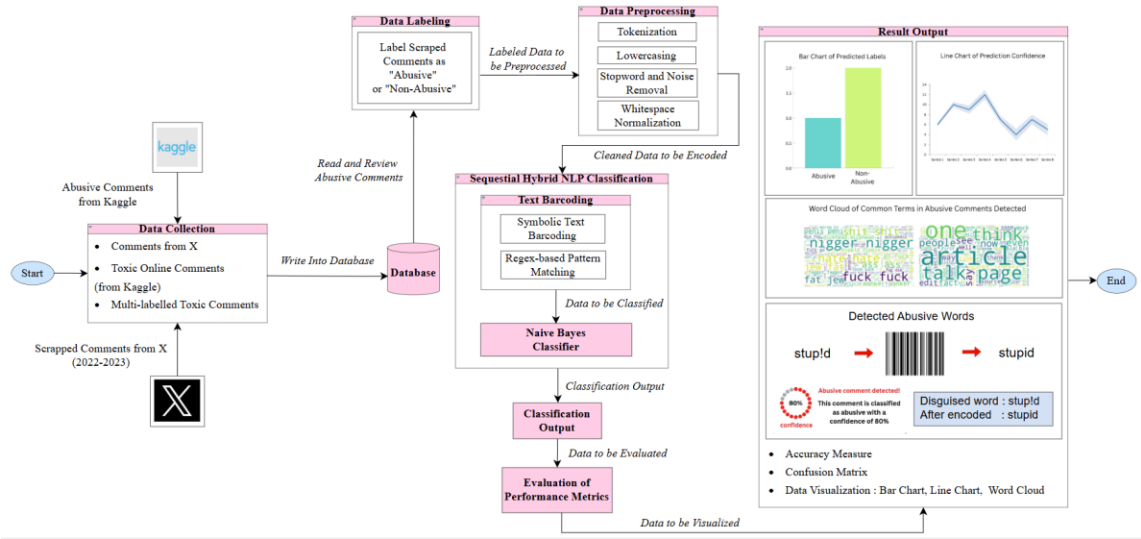


Figure 1: Flow diagram of research design.

The key step in this pipeline is text barcoding, which handles abusive language that is disguised using symbols or character substitution, such as “k!ll”, “b@stard”, or “f#ck”. These types of words are difficult to detect using standard keyword filters. Text barcoding works by using a replacement dictionary

and regular expression pattern matching to decode leetspeak character mappings, for example, converting “@” to “a” or “!” to “I”, and then converting the cleaned text into standardised symbolic barcode sequences (Renwick & Barbosa, 2021). This step ensures that disguised abusive words are normalised before classification, thereby reducing false negatives caused by creative misspellings and obfuscation.

After encoding, the processed text is vectorised using Term Frequency-Inverse Document Frequency (TF-IDF) to extract features, which are then passed to the Multinomial NB classifier. The NB classifier was chosen because it is computationally lightweight, works well with high-dimensional text classification, and is suitable for real-time detection (Chakravarthi et al., 2020). The classifier applies Bayes' theorem to estimate the probability of a comment belonging to a particular class, as shown in Eq. (1):

$$P(c|x) = \frac{P(x|c) \times P(c)}{P(x)} \tag{1}$$

where P(c|x) is the posterior probability of class c given input x, P(x|c) is the likelihood of observing input x in class c, P(c) is the prior probability of class c, and P(x) is the prior probability of the input. Each comment is assigned a predicted class label of either abusive or non-abusive, along with a confidence score derived from the posterior probability of the prediction.

3.3 SYSTEM FEATURES

The web-based system provides users with several features, including single manual comment input with real-time classification results and confidence scores, bulk file upload supporting TXT, CSV, and PDF formats, word decoding visualisation that highlights detected abusive and disguised abusive terms along with their encoded forms, generated barcode representations for each detected abusive word, and interactive dashboards featuring bar charts, line charts, pie charts, and word clouds for analysing patterns in abusive content. Users can also download a PDF report of the analysis results.

4.0 RESULT

4.1 CLASSIFICATION PERFORMANCE

The NB classifier was trained and tested using the Kaggle and X dataset. The training and testing accuracy for the model was 95.63% and 86.25% respectively. The precision, recall and F1 score for the abusive class were 0.87, 0.86 and 0.86 respectively. In the non-abusive class, the precision was 0.86, the recall was 0.87 and the F1 score was 0.86. The results are good with no sign of bias towards any class, suggesting that the actual step of encoding for text barcoding was effective in normalising the disguised language. Figure 2 is a confusion matrix of the model, showing the classification results observed at the test stage.

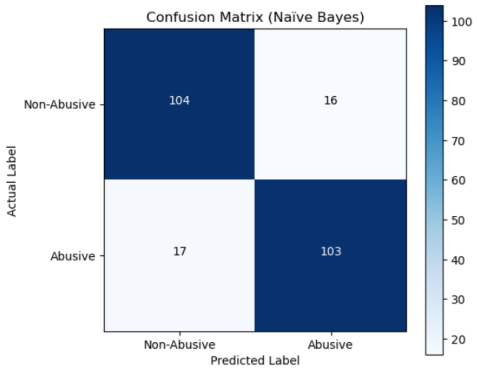


Figure 2: Confusion matrix of NB classifier.

4.2 RELIABILITY AND EFFICIENCY TESTING

The 15 participants were asked to perform reliability testing on a different document for each of them, which comprises a combination of abusive words and disguised words. All the participants were then asked to identify the abusive content manually and record the number and time spent. The outcomes were, then, compared with the outputs from the system. The system was able to detect 100% accuracy in all 15 test documents, whereas the manual detection accuracy obtained was from 81.25% to 100% accuracy. With regard to efficiency, the system detected an average of less than 0.004 minutes per document, while the manual average detection time was 2.03 minutes; resulting in a time reduction of more than 99%. This difference in detection time was statistically significant (p value of 0.000001), well below the significance level of 0.05, when evaluated by Mann-Whitney U test. The result rejected the null hypothesis and showed that the system can reliably detect the abusive content in a much faster way than manual detection.

4.3 FUNCTIONALITY TESTING

Functionality testing was carried out to ensure that all components of the system worked as intended. Key system functions were tested, including comment input processing, file upload processing, abusive word detection, barcode generation, and classification result display. The system was tested using different types of input, including non-abusive comments, normal abusive comments, disguised abusive comments, and mixed abusive comments, submitted both manually and via file upload. All 16 test cases were passed successfully, confirming that the system met its functional requirements.

4.4 NOVELTY

The novelty of this system is the application of symbolic text barcoding, which is a pre-classification encoding step. Unlike traditional keyword filtering or bag-of-words algorithms, adversarially disguised words in the text are pre-classified as normal words using a text normalisation procedure before they are classified by the NB classifier, enabling the NB to identify patterns that are not captured by the other methods. It is also easy to compute and it is able to deliver solid detection performance, which makes it viable for real-time content moderation in high-volume online scenarios, surpassing the computational complexity of deep learning models like BERT or LSTM.

5.0 CONCLUSION

A new approach for developing a web-based abusive comment detection system based on sequential hybrid NLP approach symbolic text barcoding and Naïve Bayes is proposed in this study. The system successfully identifies both explicit and disguised abusive content with an accuracy of 86.25% and lets 100% of testing content pass without any misses, which is statistically significant (p = 0.000001) compared to manual identification and more than 99% detection time reduction. Also, all the system components were checked for functionality, which in turn showed that they were all working properly. In future, more complex models like BERT, LSTM, and the addition of support for more languages can be considered, and the application of multimedia content analysis can be introduced to extend its use.

ACKNOWLEDGEMENT

Alhamdulillah, praises and thanks to Allah Almighty for His blessings and guidance in enabling the completion of this research. I would like to express sincere gratitude to my supervisor, Prof. Madya Ts. Dr. Khyrina Airin Fariza Binti Abu Samah, for her continuous guidance, constructive feedback, and unwavering support throughout this project. Special appreciation also goes to the beloved parents for their endless love, prayers, and encouragement throughout the academic journey.

REFERENCES/ RUJUKAN

Azumah, S.W., N. Elsayed, Z. ElSayed, M. Ozer & A. La Guardia. 2024. Deep learning approaches for detecting adversarial cyberbullying and hate speech in social networks. *arXiv*. https://doi.org/10.48550/arXiv.2406.17793

Chakravarthi, M.A., M. Thillaikarasi & B.P. Battula. 2020. Social media text data classification using enhanced TF-IDF based feature classification using Naive Bayesian classifier. *International Journal of Advanced Science and Technology*, 29 (3): 9044–9055. http://sersc.org/journals/index.php/IJAST/article/view/12381

Jigsaw. 2018. *Toxic Comment Classification Challenge* [Dataset]. Kaggle. https://www.kaggle.com/c/jigsaw-toxic-comment-classification-challenge

Maryadi, T.H.T., R. Priyambudi, R. Badaruddin & M.K.B. Martono. 2024. The design and performance of QR-based recognition software for distribution station components. *Jurnal Pendidikan Teknologi Dan Kejuruan*, 30 (May): 62–77. https://doi.org/10.23887/jptk-undiksha.v30i1.57730

Renwick, T. & D. Barbosa. 2021. Detection and identification of obfuscated obscene language with character level transformers. *Proceedings of the Canadian Conference on Artificial Intelligence*. https://doi.org/10.21428/594757db.cd61e1d6

Vimalan, V. 2025. MCMC recorded five-fold increase in cyberbullying take-downs in 2024. *New Straits Times*. https://www.nst.com.my/news/nation/2025/01/1143211/mcmc-recorded-five-fold

Yusof, S. 2024. Cyberbullying complaints on the rise. *The Star*. https://www.thestar.com.my/news/nation/2024/11/20/cyberbullying-complaints-on-the-rise

MyFYP: A WEB-BASED MANAGEMENT SYSTEM FOR STUDENTS' FINAL YEAR PROJECT

Zatul Amilah Shaffiei[1,*], Nurul Nabila Nadia Khairul Nizal[1], Norkhushaini Awang[1], Surya Sumarni Hussein[1], Saidatul Rahah Hamidi[1]

[1]Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

[*]Corresponding author: zatul093@uitm.edu.my

ABSTRACT

The management of Final Year Projects (FYP) at the Faculty of Computing and Mathematical Sciences (FSKM), Universiti Teknologi MARA (UiTM), is currently constrained by conventional manual processes that contribute to administrative inefficiencies, including delayed supervisor assignments, difficulties in report submission, progress tracking and ineffective communication among the users. These challenges negatively affect the overall coordination and timely completion of students' projects. Hence, to address these issues, this study presents the development of the *MyFYP Management System*, an integrated role-based web application designed to streamline and centralize the FYP management processes. This system provides tailored functionalities for three (3) primary user groups involved FYP lecturers, supervisors, and students to enhance communication effectiveness regarding FYP. The *MyFYP Management System* adopted the Web Development Life Cycle (WDLC) methodology, consisting of Planning until Testing phases. Finally, the evaluation via System Usability Scale (SUS) questionnaires was administered to eight (8) target users from FSKM and the result showed a SUS score of 85.63, indicating an excellent level of usability and system effectiveness. Findings revealed that users perceived the system as intuitive, efficient, and well-integrated in addressing critical FYP management issues, particularly in supervisor allocation, progress monitoring, and report submission management. In conclusion, the *MyFYP Management System* offers a comprehensive digital solution that enhances the efficiency, transparency, and coordination of FYP management at FSKM, UiTM. By centralising workflows and improving users' communication, the system contributes to a more systematic and effective project management environment. In future, enhancements may include the integration of intelligent student-supervisor matching mechanisms, scalability across multiple faculties, and AI-driven analytics for predictive reporting and real-time decision support.

Keywords: final year project, web-based management system, higher education, digital transformation, academic administration

1.0 INTRODUCTION

The Final Year Project (FYP) is an essential capstone component in undergraduate programmes that enables students to integrate theoretical knowledge with practical problem-solving through independent research or system development. Thus, effective management of the FYP process requires close collaboration among lecturers, supervisors, and students throughout the project lifecycle, including supervisor allocation, project registration, proposal approval, progress monitoring, report submission, evaluation, and final assessment (Mohamed et al., 2017; Raihanah, 2012). As higher education institutions continue to experience increasing student enrolment and more complex administrative requirements, managing FYP activities efficiently has become increasingly challenging. The need for a systematic and technology-enabled management approach is therefore critical to ensure transparency, accountability, and timely completion of academic projects.

At the Faculty of Computer and Mathematical Sciences (FSKM), Universiti Teknologi MARA (UiTM), the current FYP management process is largely dependent on manual administrative practices. Students typically contact prospective supervisors individually through email or instant messaging applications, while lecturers manually monitor supervisor quotas, student progress, and submission records using spreadsheets and multiple communication platforms. In addition, project reports are commonly submitted through cloud storage services such as Google Drive, requiring supervisors to manually locate, organise, and review the documents. These fragmented workflows frequently result in delayed supervisor allocation, duplicated communication, inconsistent record management, and

increased administrative workload for lecturers, ultimately affecting the efficiency of project supervision and coordination (Chong et al., 2018; Lim & Hwa, 2019; Sani et al., 2017).

To accommodate the ineffective process, the adoption of web-based management systems has been widely recognised as an effective approach for improving administrative efficiency in higher education. Such systems centralise academic information, facilitate real-time monitoring, improve communication among stakeholders, and reduce dependency on manual administrative processes (Laudon & Laudon, 2020; Nayak et al., 2023; Raghupathi & Wu, 2020). Furthermore, integrated web platforms provide better visibility of project progress, support informed decision-making, enhance collaboration through automated workflows and notification services (Stynes & Pathak, 2022). These capabilities contribute significantly to improving the quality and efficiency of academic management while supporting institutional digital transformation initiatives.

Although several Malaysian universities have implemented digital FYP management systems, including those at Universiti Teknologi Malaysia (UTM), Universiti Malaysia Pahang (UMP), Universiti Malaysia Sarawak (UNIMAS), International Islamic University Malaysia (IIUM), and Open University Malaysia (OUM), many of these platforms primarily emphasised project submission and documentation while providing limited support for lecturer-centric administration, supervisor workload management, integrated communication, automated notifications, and comprehensive progress monitoring. Consequently, the stakeholders continue to rely on manual intervention to oversee supervision activities and monitor project milestones effectively.

To address these limitations, this study proposes MyFYP, a lecturer-centric web-based Final Year Project Management System that centralises and automates the complete FYP administration process. By providing lecturers with comprehensive oversight of the entire FYP process, the proposed system improves administrative efficiency, enhances transparency and collaboration among stakeholders, and supports the digital transformation agenda of higher education institutions.

2.0 OBJECTIVE

The primary objective of this innovation is to develop a lecturer-centric web-based Final Year Project (FYP) Management System that specifically aims to:

To identify the functional and non-functional requirements for MyFYP management system.
To design and develop an integrated web-based MyFYP management system.
To evaluate the usability of MyFYP Management System using the System Usability Scale (SUS).

3.0 METHODOLOGY

The development of MyFYP followed the Web Development Life Cycle (WDLC) introduced by Pressman (2014), a systematic software engineering methodology that provides structured guidance throughout the development process. The WDLC consists of five sequential phases: Planning, Analysis, Design, Development, and Testing.

In the planning phase, an extensive literature review was conducted to identify current challenges in Final Year Project management. Existing FYP systems from several Malaysian universities were analysed to identify common features, strengths, and limitations. This comparative analysis helped identify significant research gaps, particularly the lack of lecturer-centric administrative functions and integrated monitoring capabilities.

Next, the analysis phase focused on identifying system requirements by gathering functional and non-functional specifications. Functional requirements included supervisor allocation, project registration, report submission, progress tracking, dashboard monitoring, user authentication, notification management, and document administration. Non-functional requirements emphasised system usability, responsiveness, security, reliability, and scalability.

Meanwhile, in the design phase, a comprehensive system architecture was developed using storyboard modelling, use case diagrams, flowcharts, relational database models, and user interface prototypes. The system adopted role-based access control to provide customised interfaces for lecturers, supervisors, and students while maintaining data confidentiality and secure access.

Furthermore, the development phase involved implementing the architecture using HTML5, CSS3, JavaScript, PHP, and MySQL. HTML5 and CSS3 were used to develop user interfaces, while JavaScript enhanced client-side interactivity. Moreover, PHP handled the server-side business logic, whereas MySQL was used to store project records, user information, supervision data, and document metadata.

Next, XAMPP served as the local development environment throughout the system implementation process.

Finally, the testing phase evaluated system usability using the internationally recognised System Usability Scale (SUS). Eight (8) representatives from FSKM evaluated system functions including project registration, supervisor management, report submission, communication modules, dashboard monitoring, and notification services. User responses were analysed quantitatively to determine overall system usability.

4.0 RESULT

The completed MyFYP Management System successfully demonstrated the feasibility of digitalising Final Year Project administration within higher institutions. To achieve the first objective of this study, the comparative analysis between several universities' FYP management systems had been done, which indicated the functional and non-functional requirements that should be implemented in this study (Table 1).

table 1: Functional and non-functional features from existing systems.

FEATURES	EXISTING APPLICATIONS					MyFYP MANAGEMENT SYSTEM
	UTM FYP System	e-FYP II (UMP)	FYPMS (UNIMAS)	i-Ma'luum (IIUM)	FYP System (OUM)	
Supervisor Assignment Automation	✗	✗	✓	✓	✗	✗
Student Project Registration	✓	✓	✓	✓	✓	✓
Proposal Submission	✓	✓	✓	✓	✓	✓
Progress Tracking	✗	✓	✗	✓	✗	✓
Evaluation & Grading Module	✓	✓	✗	✓	✗	✗
Notification & Reminders	✗	✗	✗	✓	✗	✓
Document Uploads (Report/Appendix)	✓	✓	✓	✓	✓	✓
Supervisor–Student Communication Tool	✗	✓	✗	✓	✗	✓
Admin Dashboard & Central Monitoring	✗	✗	✗	✗	✗	✓

As illustrated in Table 1, this review used five operational systems: UTM FYP System, e-FYP II (UMP), FYPMS (UNIMAS), i-Ma'luum (IIUM), and FYP System (OUM) and one observable phenomenon was noticed. While all systems had the basic functions of project registration, submission of proposals and uploading of documents, the advanced functions are either absent or poorly assisted. Among the five systems reviewed, only FYPMS and i-Ma'luum had more advanced notification systems and integrated communication tools for supervisor-student pairing. On the other hand, UT, UMP, and OUM systems were entirely devoid of these dual functions, leaving coordination between the parties to be done manually. This practice of relying on the activeness of the users caused a lot of administrative lapses, especially in the management of high data and high event volume (Chong et al., 2018). Also, the more advanced systems like FYPMS and i-Ma'luum had an uncommon presence of an admin dashboard for centralised monitoring. Leveraging this gap analysis, what will make the MyFYP Management System unique is attention to features that are proven necessary for successful management but not currently available in many existing solutions. Specifically, the system implemented *Progress Tracking, Alerts and Reminders, Supervisor-Student Communication Tool, Admin Dashboard and Central Monitoring (lecturers).*

In addition, the system integrates multiple administrative functions into a unified web-based platform, significantly reducing dependence on manual documentation and fragmented communication. One of the most significant innovations introduced by MyFYP is its lecturer-centric administrative dashboard. Unlike many existing FYP systems that primarily facilitate student submissions, the dashboard provides lecturers with a comprehensive overview of supervisor workloads, project status, submission deadlines, pending approvals, and student progress. This centralised monitoring capability enables lecturers to make informed decisions, distribute supervisory responsibilities more effectively, and identify students requiring immediate intervention as demonstrated in Figure 1: MyFYP dashboard interface.

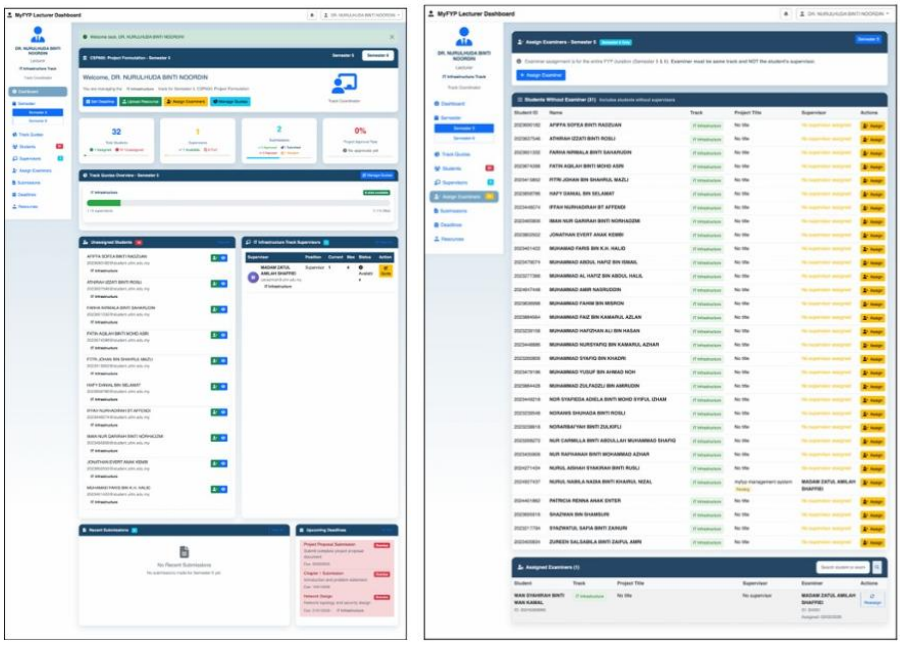


Figure 1: MyFYP dashboard interface.

Based on Figure 1, the integrated communication module further enhances collaboration by allowing lecturers, supervisors, and students to communicate directly within the platform. This eliminates dependency on multiple external applications such as email and messaging services while maintaining complete communication records associated with each project. Automated notification functionality further improves administrative efficiency by reminding users of approaching deadlines, pending submissions, and required approvals. This feature minimises missed deadlines and improves project completion rates while reducing repetitive administrative follow-up. This result successfully met the second objective.

Furthermore, to strengthen the finding, the system evaluation was distributed to the respective respondents, thereby addressing the third objective of this study. In Table 2, there were ten (10) questions related to MyFYP system usability, represented as Task 1 until 10 were asked to eight (8) respondents among lecturers and students in FSKM. The average score demonstrated a highly positive outcome that was 85.63. The score falls within the “excellent” range (Grade A) on the SUS interpretation scale (Bangor et al., 2008).

Table 2: Average SUS Score

Task	R1	R2	R3	R4	R5	R6	R7	R8
1	5	5	4	5	5	5	5	4
2	4	1	4	1	2	1	2	1
3	5	5	4	5	4	5	4	4
4	3	1	2	1	1	1	1	2
5	5	5	4	5	5	5	5	4
6	3	1	4	2	1	1	2	1
7	5	5	4	5	4	5	4	5
8	2	1	2	2	2	1	2	2
9	5	5	4	5	5	5	5	4
10	3	1	3	1	3	1	1	3
X = (Sum of Odd) - 5	20	20	15	20	18	20	18	16
Y = 25 - (Sum of Even)	10	20	10	18	16	20	17	16
SUS Score [(X + Y) * 2.5]	75.0	100.0	62.5	95.0	85.0	100.0	87.5	80.0
Average SUS Score	85.63							

Based on Table 2, the respondents agreed that the system was intuitive, well integrated, easy to learn, and highly effective in simplifying Final Year Project administration. The high usability score suggests strong acceptance among intended users and validates the effectiveness of the proposed design. The system provides comprehensive administrative visibility through real-time dashboards, integrates supervisor workload management with progress monitoring, centralises communication within the platform, and introduces automated notification mechanisms that collectively improve

administrative efficiency. These innovations distinguish MyFYP from conventional systems and establish it as a practical digital transformation initiative for higher institutions.

5.0 CONCLUSION

This study presented MyFYP, an innovative lecturer-centric web-based Final Year Project Management System designed to address longstanding administrative challenges within higher education institutions. By integrating project registration, supervision management, communication, progress monitoring, automated notifications, and administrative reporting into a unified platform, the system significantly improves operational efficiency, transparency, and collaboration among lecturers, supervisors, and students. The successful implementation of the Web Development Life Cycle ensured systematic development, while usability evaluation confirmed excellent user acceptance through a System Usability Scale score of 85.63. The proposed system demonstrates strong potential for broader implementation across universities seeking to modernise Final Year Project administration and support digital transformation initiatives. Future integration of artificial intelligence, predictive analytics, and institution-wide deployment will further increase its value as an intelligent academic management platform capable of supporting sustainable, data-driven higher education.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the Faculty of Computer and Mathematical Sciences (FSKM), Universiti Teknologi MARA (UiTM) for its continuous support, facilities, and resources throughout the development and evaluation of the MyFYP Management System. The valuable contributions of all participants involved in the system evaluation are also sincerely appreciated.

REFERENCES

Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the System Usability Scale. International Journal of Human-Computer Interaction, 24(6), 574–594. https://doi.org/10.1080/10447310802205776

Chong, Y. S., Lee, K. W., & Rahman, A. A. (2018). Challenges in manual final year project supervision in higher education. International Journal of Advanced Computer Science and Applications, 9(5), 112–118.

Laudon, K. C., & Laudon, J. P. (2020). Management information systems: Managing the digital firm (16th ed.). Pearson.

Lim, T. H., & Hwa, C. J. (2019). Inefficiencies in communication and tracking for academic projects. Journal of Computing and Information Science, 12(2), 45–59.

Mohamed, M. A., Hossain, M. S., & Alim, S. A. (2017). Final Year Project as a capstone experience: A comprehensive review. Journal of Engineering Education, 106(4), 543–565. https://doi.org/10.1002/jee.20178

Nayak, R., Jena, A., Korgaonkar, O., Shingate, A., & Gadhire, P. (2023). Online student project management system. Journal of Emerging Technologies and Innovative Research, 10(10), h1–h5.

Pressman, R. S. (2014). Software engineering: A practitioner's approach (8th ed.). McGraw-Hill Education.

Raghupathi, W., & Wu, J. (2020). The role of management information systems in universities: An empirical study. Journal of Information Systems Education, 31(1), 45–56.

Raihanah, R. B. A. (2012). Final year project online management system (FYPOS): Client and server design [Unpublished final year project]. Universiti Teknologi PETRONAS.

Sani, N. A., Abdullah, M. H., & Yunus, N. A. (2017). Issues in manual submission and tracking of academic reports. Malaysian Journal of Learning and Instruction, 14(2), 201–225.

Stynes, P., & Pathak, P. (2022). A research supervision framework for quality and scalability. In M. Cukurova, N. Rummel, D. Gillet, B. McLaren, & J. Uhomoibhi (Eds.), Proceedings of the 14th International Conference on Computer Supported Education (Vol. 2, pp. 395–403). SCITEPRESS. https://doi.org/10.5220/0011093900003182

LUMAREACH: DESIGN, DEVELOPMENT, AND FABRICATION OF A MOTORIZED HIGH-REACH PROTOTYPE FOR RESIDENTIAL LED MAINTENANCE

Aiman Haikal Bin Mohd Nizam[1], Miqdad Bin Khairulmaini[2, *]

[1]Universiti Teknologi MARA (UiTM) Shah Alam, Jalan ilmu 1/1, 40450 Shah Alam, Selangor, Malaysia
[2]UiTM Cawangan Johor Kampus Pasir Gudang, Jalan Purnama, Bandar Seri Alam, 81750 Masai, Johor, Malaysia

[*]Corresponding author: miqdadkos@uitm.edu.my

ABSTRACT

The replacement of LED bulbs fitted in the ceiling is still a challenging and dangerous task, especially in a domestic setting where the traditional method of replacement is often carried out using ladders. The use of ladders is a safety concern, especially for the elderly who would like to live independently. To address this problem, this study presents LumaReach, a ground-operated motorised prototype to provide a safer, more efficient and user-friendly solution for the replacement of high-ceiling LED bulbs. The development of LumaReach is based on a systematic approach involving conceptual design, computer-aided modelling, fabrication and prototype evaluation. The prototype includes a 9V–12V DC motor actuator for automating the rotation and extraction of the light fixtures. The structural frame is 183 cm long and is made from a stainless-steel shaft with a two diameter for its strength-to-weight ratio and durability with a custom-designed gripper manufactured in PLA Pro material using additive manufacturing techniques. The control system utilises a bi-directional 6-pin momentary switch for bulb insertion and removal. Additional development work includes telescopic height adjustment and silicone-lined gripping surfaces to better accommodate various bulb sizes and ceiling heights. LumaReach can promote safer home maintenance practices that improve user independence and operational efficiency.

Keywords: motorized actuator, residential safety, led bulbs

1.0 INTRODUCTION

The bedrock of the current home lighting industry is increasingly formed from semiconductor materials, with Solid-State Lighting (SSL) being the international industry standard. High-power Light-Emitting Diodes (LEDs) serve as a highly efficient source for visible light, as they convert electrical current that passes through micro-scale solid-state chips into light (Slocum, 2005). The continuous change to LED integration is one of the most important engineering trends in commercial and residential lighting (Cheng & Cheng, 2006).

The long service life of modern LEDs notwithstanding, routine household maintenance involving the replacement of depleted, shattered or over-tightened bulbs remains a common and inherently hazardous necessity. In modern residential architecture, light fixtures are often situated in elevated or restrictive locations. Direct manual access is often obstructed by structural interference from surrounding objects or adjacent fixtures, forcing occupants to adopt unsafe physical postures or to use unstable means of elevation. The traditional remedy is heavily reliant on stepladders, which pose a substantial occupational risk. Recent epidemiological data shows that domestic ladder falls are a major cause of trauma, especially in the growing elderly population; ladder falls from heights exceeding one meter often lead to moderate to severe musculoskeletal injuries (Pliner et al., 2021).

In addition, direct manual handling of seized or compromised glass envelopes poses a serious risk of soft tissue injuries to operators. Clinical reviews have shown that deep lacerations to the hands, commonly caused by shattered glass fragments, are one of the most frequent reasons for referral to the emergency department and often require surgical removal to avoid secondary infections (Erturer et al., 2011). At the same time, manual handling of lighting circuitry carries inherent risks of electrocution. Forensic studies on electrical fatalities reveal that deaths related to simple domestic maintenance are

predominantly preventable and are mainly caused by failure to isolate the power supply and direct manual contact with live equipment (Akçan et al., 2012).

2.0 OBJECTIVE

The development of the lumaReach prototype is driven by the following specific objectives:

To design a mechanical device which can be used to replace and install LED Bulbs that eliminates the need for ladders.
To fabricate a structurally reliable prototype that specifically addresses domestic maintenance hazards when replacing LED Bulbs

3.0 METHODOLOGY

The development of LumaReach followed an orderly engineering approach designed to ensure quality and thorough validation at every stage. Figure 1 shows the process flowchart carried out for the development of LumaReach.

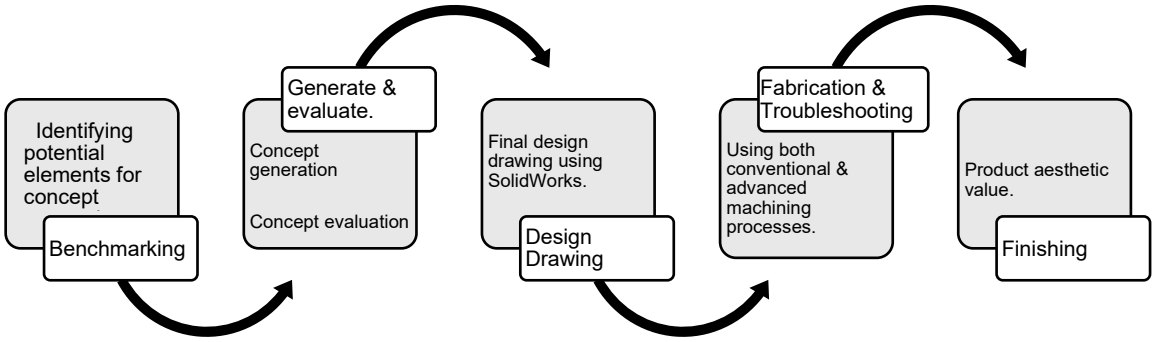


Figure 1: Process flowchart illustrating the development of LumaReach, from design to fabrication.

To determine the technical reference, detailed product benchmarking was conducted to determine the critical functional components, such as a bulb gripping mechanism, bulb unscrewing mechanism, electric current control and a reliable power source. Upon establishing these parameters, a Morphological Chart was developed to systematically produce three different design concepts by combining multiple configurations of these core components. These preliminary concepts were then evaluated by a Pugh Chart, which acts as a decision-making matrix. The designs were assessed for important criteria such as safety, comfortability, durability, ease of use, maintenance and flexibility. As mentioned by Ulrich et al. (2020) this form of structured selection process is vital in engineering to ensure the final product satisfies the safety needs of users.

SolidWorks was used to translate the chosen concept into a 3D model to create 3D depictions of the individual parts, such as the 3D-printed gripper and the gear cover, to ensure that all components would fit together seamlessly. Detailed orthographic and exploded assembly drawings were also produced to allow a visualisation of the interactions of the components internally. As stated by Lombard (2018), CAD modelling is crucial to identifying interference between parts before moving on to the costly manufacturing stage.

The fabrication stage included both standard machining and advanced additive manufacturing. The custom gripper and gear housing were fabricated by using 3D printing technology with Polylactic acid (PLA) Pro filament to produce a lightweight but structurally rigid interface. The main chassis of the device, a dual-diameter stainless steel rod, was mechanically machined by using precise measurement, cutting (sawing) and drilling using a 5 mm drill bit. Once the machining was complete, the rough edges were refined through a grinding process using sandpaper, resulting in a smooth and polished finish.

The mechanical frame and the PLA components were securely integrated by using screws, M5 bolts and nuts. The electrical control system consisting of 9V-12V DC motor, speed controller and 6 pin momentary switch was permanently soldered for consistent conductivity.

4.0 RESULT

The evaluation of conceptual designs using the Pugh Chart is shown in Table 1 below. From the evaluation Concept Design No. 3 had the highest cumulative score of 11 against the baseline datum, scoring well particularly in safety, structural flexibility and user comfortability.

Table 1: Pugh Chart for concept design evaluation.

Description		Datum	Concept Design 1	Concept Design 2	Concept Design 3
Criteria	Weight				
Safety	3	0	+	+	+
Comfortable	2	0	-	0	+
Durability	2	0	+	+	+
Ease of use	2	0	+	+	+
Maintenance	2	0	0	0	0
Flexibility	2	0	-	+	+
+		0	7	9	11
0		0	2	4	2
-		0	4	0	0
Total		0	3	9	11

The concept had successfully materialised in a highly precise 3D digital model using SolidWorks. It yielded complete orthographic and exploded assembly representations providing a conflict-free architectural blueprint for the prototype. Figure 2 shows the 3D model for LumaReach.



Figure 2: 3D Model for LumaReach using SolidWorks.

Table 2 shows the materials that were used to ensure that LumaReach is a fully functional prototype.

Table 2: Material Selection for LumaReach

Component	**Material/Specification**	**Purpose**
Main Rod	Stainless Steel (25mm & 32mm diameter)	Provides structural reach and stability
Gripper & Cover	3D printed PLA Pro Filament	Lightweight, custom-designed.
Actuator	9V-12V DC Motor	Provides the torque required for bulb rotation.
Power Source	9V Heavy Duty Battery	Ensures portability without external wiring
Control Switch	6-pin Momentary Switch	Allows for bidirectional (CW/CCW) control.
Mechanism	High Carbon Steel Brake Cable	Activates the gripping tension for the bulb.

The use of standard M5 bolts, nuts, and springs makes the device easier to assemble and maintain, which is a major selling point for household users. By utilising 3D printing services for the core gripper, the design remains modular and easy to replicate or upgrade in the future.

Figure 3 shows the prototype design for LumaReach, a motorised tool designed for high-reach lighting maintenance. The prototype stands at a total height of 183 cm, allowing for users to reach standard residential ceilings. The core structure consists of a dual-diameter stainless steel hollow rod, utilising a 25 mm diameter for the lower section and 32 mm for the upper assembly to ensure structural rigidity and balance.



Figure 3: Prototype design for LumaReach.

The innovation of LumaReach is the automation of a hazardous height task to a floor-level task. The device integrates a 9V-12V DC motorised actuator with the customised gripping mechanism to allow for controlled rotation and safe removal of bulbs without manual handling of delicate glass envelopes. Figure 4 shows the designed motorised gripper powered by a 9V-12V DC motor for controlled rotation to install and remove bulbs.

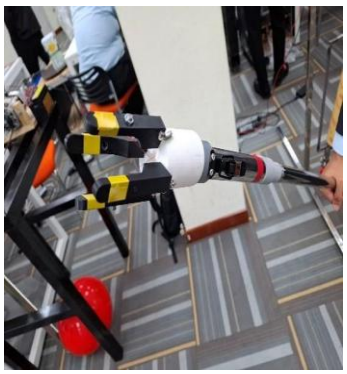


Figure 4: Motorised gripper powered by a 9V-12V DC motor.

Key benefits and impacts of the final LumaReach prototype are:

Improved Safety: The removal of unsafe stepladders is anticipated to greatly reduce the number of domestic fall injuries.

Ergonomic Access: The two-directional 6-pin momentary switch offers an intuitive user interface with minimal physical effort.

Long Term Sustainability & Cost Effectiveness: The device is manufactured using stainless steel and some electrical components, which makes it long-term sustainable.

5.0 CONCLUSION

In conclusion, the LumaReach prototype fulfils all its major engineering objectives by providing a safe, and automatic mechanical device to maintain residential LED bulbs. The combination of a motorised 3D printed gripper, and a stainless-steel chassis allows the device to effectively eliminate the occupational hazards associated with manual ladder use. This project is an accessible and easy-to-use technology for domestic safety, providing an important assistive device for the aging population. From an economic point of view, the prototype demonstrates high commercial feasibility as it can operate fully at a very low fabrication cost, offering an alternative to professional maintenance services. Moreover, its environmentally friendly design with fewer electronic components and battery-operated system ensures long term use and less electronic waste. Future designs will attempt to include adjustable

telescopic rods, silicone lined gripping surfaces for better accommodation of various bulb sizes and ceiling heights.

ACKNOWLEDGEMENT

Sincere thanks to the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang for the academic platform, laboratory facilities and technical support in fabricating and testing the prototype successfully.

REFERENCES/ RUJUKAN

Akçan, R., Karacaoğlu, E., Keten, A., Odabaşı, A. B., Kanburoğlu, Ç., Tümer, A. R., & Alkurt-Alkan, H. (2012). Electrical fatalities in Ankara over 11 years. *Turkish Journal of Medical Sciences*, 42(3), 533–538. https://doi.org/10.3906/sag-1010-1243

Cheng, Y. K., & Cheng, K. W. E. (2006). General study for using LED to replace traditional lighting devices. *2006 2nd International Conference on Power Electronics Systems and Applications*. https://doi.org/10.1109/pesa.2006.343093

Erturer, R. E., Sever, C., Sonmez, M. M., Ozcelik, I. B., Akman, S., & Ozturk, I. (2011). Evaluation of patients undergoing removal of glass fragments from hand injuries: A retrospective study. *Annals of Plastic Surgery*, 67(2), 114–118. https://doi.org/10.1097/SAP.0b013e3181f211e1

Lombard, M. (2018). *Mastering SolidWorks*. John Wiley & Sons. pp. 1–1248. ISBN: 978-1-119-30057-1.

Pliner, E. M., Campbell, A. M., Hile, M. E., & Beschorner, K. E. (2021). Ladder use in older people: Type, frequency, tasks and predictors of risk behaviours. *International Journal of Environmental Research and Public Health*, 18(18), 9799. https://doi.org/10.3390/ijerph18189799

Slocum, A. (2005). *A technology assessment of light emitting diode (LED) solid-state lighting for general illumination*. EPA NCEE Working Paper. https://doi.org/10.22004/ag.econ.280841

Ulrich, K. T., Eppinger, S. D., & Yang, M. C. (2020). *Product design and development* (7th ed.). McGraw-Hill Education. pp. 1–448. ISBN: 978-1-260-04365-5.

e-KHAIRAT: A DIGITAL COMMUNITY WELFARE MANAGEMENT SYSTEM FOR KHAIRAT KEMATIAN

Muhammad Zahir bin Zainal Abidin[1], Yusnita binti Sokman[2,*], Ts. Ahmad Kamalrulzaman bin Othman[2]

[1]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Cawangan Terengganu, Malaysia
[2]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Cawangan Johor, Malaysia

[*] Corresponding author: yusni996@uitm.edu.my

ABSTRACT

Khairat Kematian is an essential community welfare mechanism that provides financial assistance to bereaved families following the death of a registered member. Despite its importance, many Khairat organisations continue to rely on manual administrative practices involving paper records, spreadsheets, and physical verification processes. Such practices often lead to inefficient record management, delayed claim approvals, data inconsistencies, and limited transparency. As organisations increasingly embrace digital transformation to improve service delivery, operational efficiency, and stakeholder engagement, there is a growing need for digital solutions that modernize community welfare administration (Mergel et al., 2019; United Nations, 2024; Verhoef et al., 2021). This project introduces e-Khairat, a web-based digital community welfare management system designed to streamline Khairat Kematian administration through centralised member registration, contribution management, death claim processing, automated notifications, and reporting functions. The system was developed using the Evolutionary Prototyping Model to enable continuous improvement based on stakeholder feedback (Lasminiasih et al., 2022). The design and evaluation of the system were guided by the Unified Theory of Acceptance and Use of Technology (UTAUT), which provides a comprehensive framework for understanding user acceptance of information systems (Venkatesh et al., 2003). The platform incorporates role-based access control, digital record management, payment monitoring, receipt generation, and online claim submission to improve efficiency, accessibility, and transparency. Evaluation involving 36 respondents demonstrated strong user acceptance, with Social Influence ($r = 0.960$) and Performance Expectancy ($r = 0.950$) showing very strong relationships with Behavioural Intention. Facilitating Conditions also exhibited a strong positive relationship ($r = 0.786$). Functionality testing achieved a 100% success rate across all major modules. Furthermore, usability evaluation using the System Usability Scale (SUS) recorded a score of 86, indicating excellent usability and high user satisfaction (Brooke, 1996). The implementation of e-Khairat significantly reduces administrative workload while enhancing accountability, transparency, and service quality within community welfare organisations. The system demonstrates strong potential for wider deployment among mosques, welfare associations, cooperatives, and community organisations seeking to support digital transformation initiatives and improve community welfare management.

Keywords: e-Khairat, digital welfare management, community information system, digital transformation, khairat kematian

1.0 INTRODUCTION

Khairat Kematian serves as an important social welfare initiative that provides financial assistance and support services to families during bereavement. Traditionally, the administration of Khairat Kematian relies heavily on manual procedures such as paper-based registration, handwritten records, physical documentation, and spreadsheet management. While these methods have supported local communities for many years, increasing membership numbers and growing administrative demands have exposed significant challenges in record management, contribution monitoring, claim verification, and reporting activities.

Digital transformation has become a critical strategy for organisations seeking to improve service quality, operational efficiency, transparency, and stakeholder engagement. The integration of digital technologies enables organisations to streamline processes, improve governance, and deliver more accessible and user-centred services (Mergel et al., 2019; United Nations, 2024; Verhoef et al., 2021). As governments and community-based organisations increasingly embrace digitalisation, the adoption of digital welfare management systems has become essential for improving service delivery and organisational sustainability.

At Felda Bersia, the Khairat Kematian committee manages more than 800 registered members. The absence of a centralised digital platform creates difficulties in maintaining accurate records, monitoring contribution payments, processing claims promptly and generating comprehensive reports. Consequently, there is a need for a digital solution that supports efficient management and enhances transparency within the organisation.

To address these challenges, e-Khairat was developed as a web-based digital community welfare management system that centralises membership administration, contribution tracking, claim processing, notification management, and reporting functions within a single platform.

2.0 OBJECTIVE

The objectives of this innovation are:

To identify the requirements for a digital community welfare management system for Khairat Kematian administration.

To design and develop a web-based platform that supports member registration, contribution monitoring, claim processing, and reporting activities.

To improve transparency, accessibility, and efficiency in community welfare management through digital transformation.

To evaluate the functionality, usability, and user acceptance of the developed system.

3.0 METHODOLOGY

The e-Khairat system was developed using the Evolutionary Prototyping Model, which supports iterative development and continuous improvement through user feedback (Lasminiasih et al., 2022). Requirements were gathered through interviews, observations, questionnaires, and reviews of existing Khairat management practices. This approach helped ensure that the system addressed the actual needs and challenges faced by both administrators and community members. The system provides two primary user roles:

The system was developed as a web-based platform using PHP, MySQL, HTML, CSS, and JavaScript. It provides functionalities for member registration, contribution monitoring, receipt management, death claim processing, notification services, and report generation. A centralised database was implemented to ensure efficient and secure management of member and transaction records.

To evaluate the system, user acceptance was assessed using the Unified Theory of Acceptance and Use of Technology (UTAUT), which measures factors influencing technology adoption, namely Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions (Venkatesh et al., 2003). Usability was evaluated using the System Usability Scale (SUS), while functionality testing was conducted to verify that all modules operated according to the specified requirements. A total of 36 respondents participated in the evaluation process.

Figure 1 illustrates the architecture of the e-Khairat system. Users access the platform through a secure web interface with role-based access control, while the application integrates membership management, contribution management, claim processing, notification services, and reporting functions within a centralised database environment.

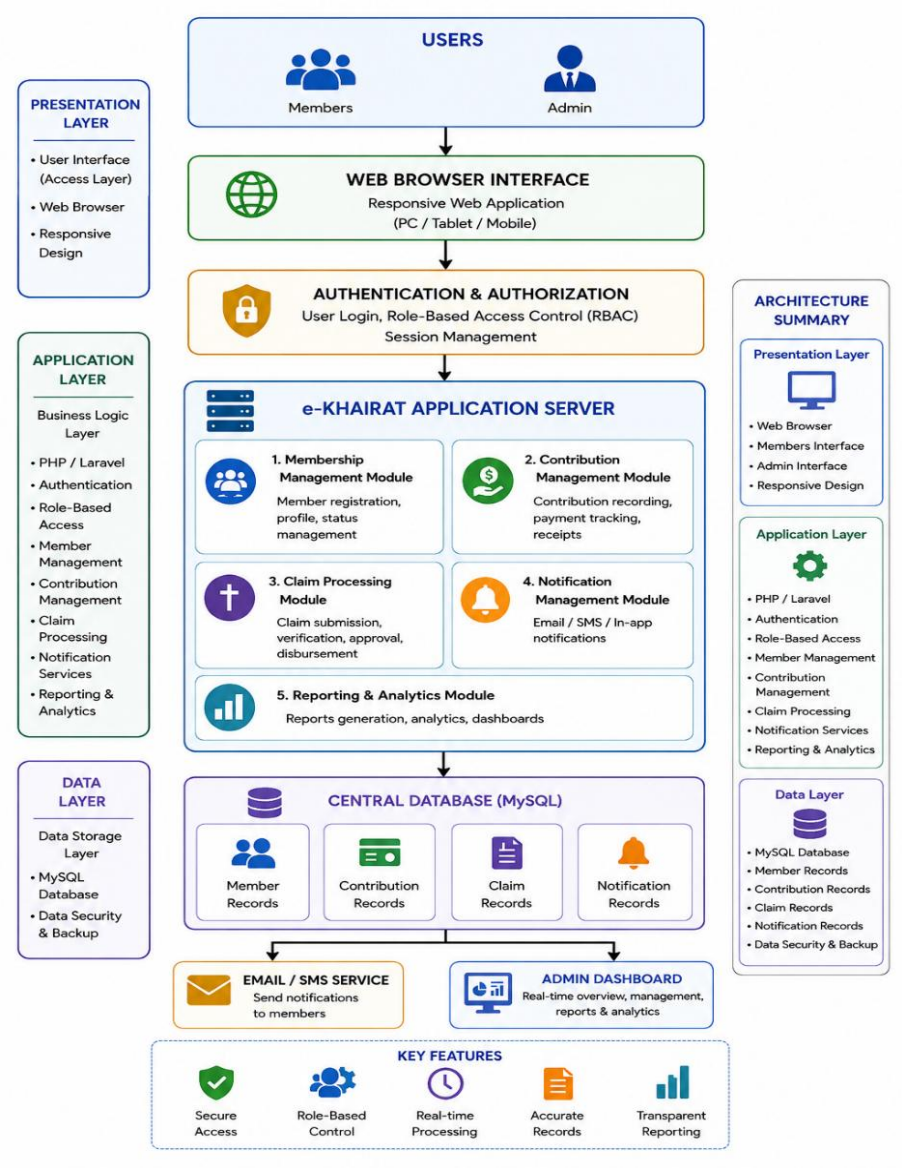


Figure 1: Architecture of the e-Khairat system

4.0 RESULT

The implementation of e-Khairat has improved the management of Khairat Kematian by replacing manual record-keeping with a centralised digital platform. Through the system, members can register, monitor their contributions, access receipts, and submit death claims online. At the same time, administrators can manage member information, verify claims, and generate reports more efficiently. This has simplified administrative processes, improved access to information, and enhanced transparency in welfare management.

A UTAUT-based evaluation involving 36 respondents was conducted to assess user acceptance. The findings revealed very strong positive relationships between Behavioural Intention and Social Influence ($r = 0.960$) and Performance Expectancy ($r = 0.950$). Facilitating Conditions demonstrated a strong positive relationship ($r = 0.786$), whereas Effort Expectancy showed a moderate positive relationship ($r = 0.594$). Overall, the findings suggest that users are receptive to adopting e-Khairat and recognize its benefits in supporting welfare management activities. Functionality testing achieved a 100% success rate across all system modules, while usability evaluation using the System Usability Scale (SUS) yielded a score of 86, indicating Excellent Usability (Grade A). These results demonstrate that the system is reliable, easy to use, and capable of supporting the needs of both administrators and members.

A key strength of e-Khairat is its ability to bring together membership management, contribution monitoring, online claim processing, automated notifications, and reporting functions within a single platform. Compared to conventional manual practices, the system improves efficiency, accountability, and accessibility while supporting the digital transformation of community welfare organisations. Its features and positive evaluation outcomes indicate strong potential for wider adoption by mosques, welfare associations, cooperatives, and other community-based organisations.

5.0 CONCLUSION

e-Khairat successfully transforms traditional Khairat Kematian administration into a modern digital community welfare management system. The innovation addresses key challenges associated with manual record management, contribution tracking, claim processing, and communication by providing a centralised and user-friendly platform. Evaluation results demonstrated excellent usability, strong user acceptance, and reliable functionality, confirming the effectiveness of the proposed solution. The system improves operational efficiency, transparency, and accessibility while reducing administrative burden on welfare committees. Furthermore, its scalable architecture makes it suitable for adoption by mosques, welfare organisations, cooperatives, and community associations seeking to modernise community welfare services. Although the findings indicate strong user acceptance, future studies involving larger and more diverse populations are recommended to improve the generalisability of the results. Future enhancements may include mobile application development, cloud deployment, automated payment verification, and advanced reporting analytics.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to the Felda Bersia Khairat Kematian Committee and Masjid Shuhada for their valuable cooperation, support, and feedback throughout the development and evaluation of the e-Khairat system.

REFERENCES

Brooke, J. (1996). SUS: A quick and dirty usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & I. L. McClelland (Eds.), Usability evaluation in industry (pp. 189–194). Taylor & Francis.

Lasminiasih, L., Saputra, G. E., Rooswhan Budhi Utomo, & Elbi Wiseno. (2022). USING PROTOTYPING METHOD FOR ANALYSIS AND DESIGN OF INFORMATION SYSTEMS FOR STUDENT REGISTRATION IN SEKOLAH MASTER. International Journal Science and Technology, 1(2), 19–29. https://doi.org/10.56127/ijst.v1i2.140

Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert interviews. Government Information Quarterly, 36(4), 101385. https://doi.org/10.1016/j.giq.2019.06.002

United Nations Department of Economic and Social Affairs. (2024). *United Nations E-Government Survey 2024: Accelerating digital transformation for sustainable development*. United Nations. https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2024

Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D. (2003). User Acceptance of Information Technology: Toward a Unified View. MIS Q., 27, 425-478. https://doi.org/10.2307/30036540

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital Transformation: A Multidisciplinary Reflection and Research Agenda. Journal of Business Research, 122, 889–901. https://doi.org/10.1016/j.jbusres.2019.09.022

DESIGN AND ANALYSIS OF A LINEAR ELECTROMAGNETIC PROPULSION SYSTEM FOR INTERNAL LOGISTICS TRANSPORT IN SMART COMPOUNDS

Aziz Abdul Bagas[1, *], Khairul Nisak Md Hasan[1]

[1]Department of Electrical and Electronics Engineering, Universiti Teknologi PETRONAS, 32610 Bandar Seri Iskandar, Perak Darul Ridzuan, Malaysia

[*] Corresponding author: aziz_21000361@utp.edu.my

ABSTRACT

Smart compounds show limited innovation in their internal logistics transportation, resulting in inefficient materials transportation, weather and manual handling dependency, limited payload and users' dissatisfaction. This project aims to propose, design, and validate an electromagnetic propulsion system for smart compounds internal logistics. The proposed design of a single-sided, short-primary, slotted, heteropolar, longitudinal-flux linear induction motor with air-forced cooling, ladder-type conductive secondary and a steel back iron has been shown to be suitable in terms of produced thrust as per the pre-determined requirements for the internal logistics application, validated through simulation. An analytical design procedure was developed for a target duty of a 200 kg payload at a rated speed of 3 m/s over a 1 km route, producing an 8-pole, 48-slot, 640 mm × 160 mm primary operating at 25 Hz, with a rated thrust requirement of 218.7 N and an estimated thrust capability of 815 N. Two-dimensional transient finite-element analysis predicts a mean thrust of 648 N, three times more than the requirement, and shows that there is an attraction force of 15 kN. A 4-pole, 24-slot scaled prototype preserving the pole pitch, slip, synchronous speed and per-area magnetic loading of the full-scale machine was then fabricated and tested. Despite operating at twice the design frequency (50 Hz instead of 25 Hz) owing to laboratory supply limitations, the prototype produced a standstill thrust of 2.26 N at 3.5 A, 92 percent of the finite-element prediction, and the shuttle transported its full 2 kg design payload drawing 3.0 A. The results validate the proposed design methodology as a conservative lower bound and demonstrate the technical feasibility of linear induction motor propulsion for smart compound intralogistics.

Keywords: linear induction motor, finite element analysis, intralogistics, smart compound, prototype validation

1.0 INTRODUCTION

Interconnected infrastructure is used by smart cities to increase efficiency, sustainability and improve living standards, and intelligent transportation and logistics are regarded as the cornerstones of this architectural concept (Silva et al., 2018). In a smart city, a separate facility such as campus, hospitals, airport and residential complex becomes a smart compound, where advanced technology solutions are implemented in order to provide additional services within the facility (Dong et al., 2020).

Moving goods internally is one such service, and there already exist a few dedicated solutions for that purpose: an autonomous delivery robot like Starship, having delivered millions of last-mile shipments but operating at the speed of up to 6 km/h, having small capacity and being limited to outdoor operations depending on the weather conditions (Starship Technologies, n.d.); warehouse transport robots such as the Amazon Titan, which can operate only on the structured indoor surfaces (Greenawalt, 2025); pneumatic tubes, currently serving as the main system of intralogistics in hospitals, but still limited to moving light canisters (Weinmeyer, 2023); and underground transport systems like Cargo Sous Terrain (Cargo Sous Terrain, n.d.). All of them have some common limitations like small payload capacity, low speed, weather sensitivity or costly maintenance, which makes a dedicated transport system necessary.

Linear electric machines (LEMs) generate thrust directly, without rotary-to-linear conversion, and therefore offer adhesion-free propulsion, an absence of gearing and backlash, high reliability and

precise motion control (Boldea et al., 2018). The linear induction motor (LIM) combines a simple wound primary with an entirely passive conductive secondary, giving the lowest track cost, a single power supply and straightforward manufacture over long distances (Palka & Woronowicz, 2021). For a short-distance, low-speed indoor application in which track length dominates the system cost, the LIM is the appropriate choice.

Published LIM research has concentrated on large-scale rail transit and electromagnetic launch systems, while design studies of low-speed machines have addressed efficiency and power-factor optimization (Isfahani et al., 2008) and secondary topology improvement (Lv et al., 2018). The application of a compact LIM propulsion system to internal logistics transportation within smart compounds, however, remains largely unexplored. This project addresses that gap with a fully electric, zero direct emission, low-maintenance propulsion system running over a passive track, in direct support of the DIIID 2026 theme of smart innovations for a sustainable and resilient future.

2.0 OBJECTIVE

1. To design and analyse an electromagnetic propulsion system for smart compounds' logistics network transportation channel.

2. To develop a small scale 1-1.5m long track proof-of-concept prototype of the proposed system.

3.0 METHODOLOGY

The project adopts a deductive and experimental approach, focusing on literature mainly based on IEEE, design using AutoCAD, simulation in Ansys Maxwell, and the prototype development for performance validation through quantitative and qualitative analysis.

3.1 TARGET SPECIFICATIONS AND MACHINE TOPOLOGY

The propulsion system specifications are given for a track-guided cart that delivers the loads to various points at an indoor or sheltered passageway of a length of up to 1 km. The load capacity of 200 kg is sufficient for consolidation of residential orders, medical supplies, and lightweight industrial items in one go. A maximum speed of 3 m/s is adequate for movement in a confined environment where pedestrians can also be nearby, giving satisfactory transit times. Table 1 gives the design criteria.

Table 1: Target specifications of the propulsion system.

Parameter	**Value**
Payload per trip	200 kg
Vehicle mass	130 kg
Rated / maximum speed	3 / 5 m/s
Acceleration	0.5 m/s²
Route length	1 km (or longer)
Guidance	Profiled linear guideway
Power transfer	Conductor bars + collector shoes

The machine will have a short-primary, slotted, heteropolar, single-sided, and longitudinal flux LIM using forced-air cooling. A short primary relative to the passive reaction rail will reduce the cost of the long guideway and the longitudinal flux structure is easier to construct and has a better power factor compared to its transverse counterpart. As the reaction rail, a ladder-slit aluminum sheet backed by a solid steel back iron will be used: compared to a simple flat sheet, the ladder-slit design will confine the eddy current effects in the active zone to their productive transverse components leading to an improvement of about 15% in thrust and 6% in efficiency and this is specifically recommended for short-range applications (Lv et al., 2018). Figure 1 shows the resulting machine concept.

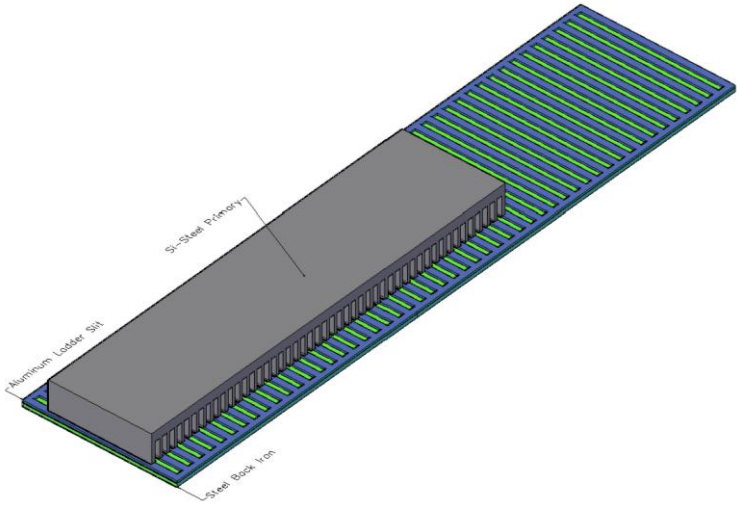


Figure 1: Three-dimensional view of the full-scale single-sided LIM: slotted short primary above the ladder-slit aluminum secondary with solid steel back iron.

3.2 ANALYTICAL DESIGN OF THE FULL-SCALE MACHINE

Because the carriage runs on recirculating bearing blocks, the resistance to motion is rolling friction. For the total mass m = 330 kg, W = 3237 N; the normal force follows from the air-gap magnetic pressure as F_n = 10.19 kN, giving a bearing load of 13.43 kN and F_{rr} = 53.7 N. Adding the inertial force for the specified acceleration,

$$F_{th} = F_{rr} + m_T a = 218.7N \quad (1)$$

which is the rated thrust requirement of Eq. (1). The corresponding mechanical power is 656 W during acceleration at 3 m/s, so the rated output power is set to 1 kW. A rated slip of s = 0.25 places the synchronous speed at 4 m/s; 25 Hz with a pole pitch of 80 mm is selected as the best compromise between primary length and iron utilisation. Eight poles suppress the longitudinal end effect, fixing the active length at 640 mm with a stack width of 160 mm. Conservatively assuming a tangential-to-normal stress ratio of 8 percent, the thrust capability over the 0.1024 m² active area is 815 N, 3.7 times the 218.7 N requirement, leaving margin for the effects excluded from the analytical model.

3.3 SCALED PROTOTYPE DESIGN AND FABRICATION

The prototype validates the propulsion concept and the design chain at benchtop cost rather than reproducing full-scale performance. The guiding principle is to conserve every parameter that governs the electromagnetic analysis, including pole pitch, slip, synchronous speed and per-area magnetic loading, while freely reducing the parameters that only add size and cost. The primary core is stacked from 0.5 mm non-oriented M19 silicon-steel laminations, wound with enamelled copper in Nomex-lined slots and wye-connected through brass binding posts. The secondary is an aluminium plate on a mild-steel back iron. Table 2 contrasts the two machines, and Figure 3 shows the completed shuttle.

Table 2: Prototype versus full-scale machine.

Parameter	Full scale	Prototype
Poles	8	4
Primary length	640 mm	320 mm
Stack width	160 mm	100 mm
Slots (q = 2)	48	24
Turns per coil	20	40
Back iron	15 mm	10 mm
Pole pitch	80 mm	80 mm
Design frequency	25 Hz	25 Hz
Rated excitation	18 A	3.54 A rms
Design payload	200 kg	2 kg



Figure 3: Fabricated prototype shuttle: hand-wound 4-pole primary in the PETG carriage on polyurethane wheels over the aluminium reaction plate.

4.0 RESULT

This work makes four key contributions. The first is an analysis-based design of a single-sided LIM based on requirements for a 200 kg, 3 m/s indoor logistics shuttle using ladder slit secondary. The second contribution is the verification of the design through two-dimensional transient FEA, where the thrust margin and the most significant normal attraction force are evaluated. The third contribution is a cost-based scaling procedure which retains the electromagnetic operating condition of the full-scale machine in a benchtop prototype. The fourth contribution is building and testing of the prototype including the frequency derating due to laboratory power limitations.

Only a 50 Hz three-phase supply (a 0–300 V variac) was available for testing, twice the design frequency. At equal current, the thrust at 50 Hz is predicted to fall to about 60 percent of the 25 Hz value, so all measurements are conservative with respect to the design point. The standstill thrust was measured with a spring balance and follows the expected quadratic law $F = kI^2$ with no sign of saturation up to 3.7 A: 1.08 N at 2.0 A and 2.26 N at 3.5 A. The key result, 2.26 N at 3.5 A, amounts to 92 percent of the 25 Hz finite-element prediction of 2.47 N at 3.54 A despite being taken at 50 Hz, where the derating analysis predicts only about 1.5 N. The analytical and finite-element chain is thereby confirmed as a safe lower bound on the delivered thrust.

In free running over 0.5 m, the shuttle reached an average speed of 0.32 m/s at 4 A, with an acceleration of about 0.4 m/s². Under load, the shuttle transported its full 2 kg design payload at 0.128 m/s drawing 3.0 A below the 3.54 A rating and at twice the design frequency, thereby meeting the primary objective of the prototype with margin. The rolling resistance back-calculated from these runs is only 0.3–0.4 N, several times below the conservative 1.7 N budget.

Consolidating the analysis of the preceding sections, the complete transport system is proposed as nine subsystems: the primary (mover), the secondary reaction track, the carriage, the guidance system, the power-transfer system, the carrier, the corridor, thermal management and safety. The intent is a simple and compact installation suited to a smart compound rather than a large-scale transit system, with each component selected on a performance-versus-cost basis. Figure 4 shows the resulting system.

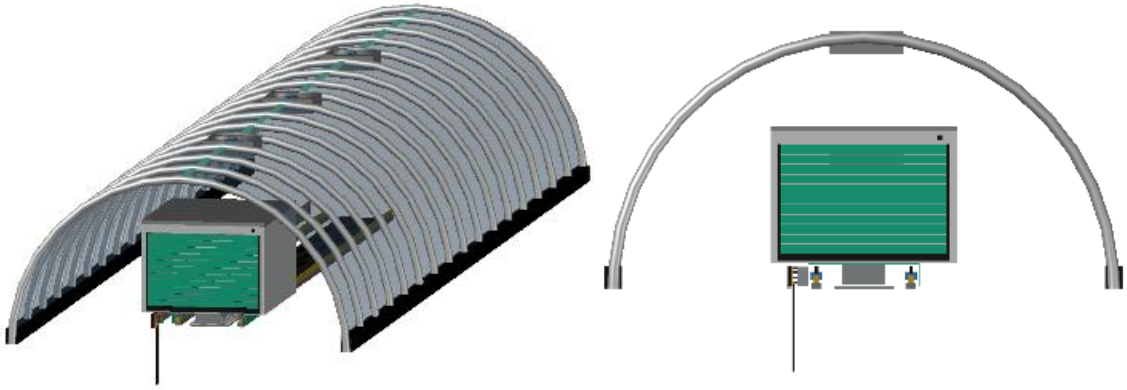


Figure 4: Complete drawing of the proposed full-scale system, integrating the linear motor, reaction track, carriage, guideway, power-transfer bars, carrier and covered corridor.

The novelty of the work lies in translating a technology so far reserved for large-scale rail transit into a compact, requirement-driven intralogistics machine, validated end-to-end from analytical sizing through finite-element simulation to a working hardware prototype. Because the guideway is entirely passive, the incremental cost of extending the route is limited to an aluminum sheet and a steel back iron, giving the system strong commercial value for hospitals, university campuses, airports and warehouse complexes where frequent, repetitive point-to-point deliveries are required. Its fully electric, zero direct emission, low-noise and low-maintenance operation contributes towards a sustainable and resilient future, in line with Sustainable Development Goal 9 (Industry, Innovation and Infrastructure) and Goal 11 (Sustainable Cities and Communities).

5.0 CONCLUSION

Through a structured deductive approach from literature review to analytical design and later to simulation, a single-sided, short-primary, slotted, heteropolar, longitudinal-flux linear induction motor with air-forced cooling, ladder-type conductive secondary and a steel back iron was proposed for the electromagnetic propulsion system for internal logistics transportation in smart compounds. These results validate the complete design chain, from analytical sizing through finite-element simulation to hardware, and confirm that the analytical model constitutes a safe, conservative lower bound on machine performance. The project therefore demonstrates that linear induction motor propulsion is a technically feasible, low-maintenance and scalable alternative to autonomous mobile robots and pneumatic tube systems for internal logistics transportation in smart compounds, and it provides a validated design methodology and a working proof-of-concept upon which a full-scale system can be developed. This work contributes a complete, experimentally validated design chain for low-speed linear induction motor propulsion in an application domain, smart compound intralogistics where published research has so far concentrated on large-scale rail transit and electromagnetic launch systems. Economically, the passive-track architecture concludes that the route extension costs are limited to aluminum sheet and steel back iron, giving the system strong potential as a scalable, cost-effective installation for smart compounds.

REFERENCES/ RUJUKAN

Boldea, I., Tutelea, L. N., Xu, W., & Pucci, M. (2018). Linear electric machines, drives, and MAGLEVs: An overview. IEEE Transactions on Industrial Electronics, 65(9), 7504–7515. https://doi.org/10.1109/TIE.2017.2733492

Cargo Sous Terrain. (n.d.). Sustainable logistics system Switzerland. https://www.cst.ch/en/project-2/ (Accessed on July 14, 2026)

Dong, Z. Y., Zhang, Y., Yip, C., Swift, S., & Beswick, K. (2020). Smart campus: Definition, framework, technologies, and services. IET Smart Cities, 2(1), 43–54. https://doi.org/10.1049/iet-smc.2019.0072

Greenawalt, T. (2025, June). Amazon has more than 750,000 robots that sort, lift, and carry packages. About Amazon. https://www.aboutamazon.com/news/operations/amazon-robotics-robots-fulfillment-center (Accessed on July 14, 2026)

Isfahani, A. H., Ebrahimi, B. M., & Lesani, H. (2008). Design optimization of a low-speed single-sided linear induction motor for improved efficiency and power factor. IEEE Transactions on Magnetics, 44(2), 266–272. https://ieeexplore.ieee.org/document/4432696

Lv, G., Zhou, T., Zeng, D., & Liu, Z. (2018). Design of ladder-slit secondaries and performance improvement of linear induction motors for urban rail transit. IEEE Transactions on Industrial Electronics, 65(2), 1187–1195. https://ieeexplore.ieee.org/document/7979556

Palka, R., & Woronowicz, K. (2021). Linear induction motors in transportation systems. Energies, 14(9), Article 2549. https://doi.org/10.3390/en14092549

Silva, B. N., Khan, M., & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. Sustainable Cities and Society, 38, 697–713. https://doi.org/10.1016/j.scs.2018.01.053

Starship Technologies. (n.d.). Last-mile delivery autonomous robots. https://www.starship.xyz/about/ (Accessed on July 14, 2026)

Weinmeyer, M. (2023, February). Pneumatic tube system. Swisslog Healthcare. https://www.swisslog-healthcare.com/en-gb/company/blog/how-a-pneumatic-tube-system-works (Accessed on July 14, 2026)

AN AI-POWERED ANIME COMPANION APPLICATION FOR PERSONALISED INTERACTION, WELLBEING, AND LANGUAGE LEARNING

Mar Wei Jun[1], Chua Sheng Yang[1], Chin Cheah Choon[1], Nur Shamilla Selamat[1,*]

[1]Department of Computer Science, Faculty of Engineering and Information Technology, Southern University College, Skudai, 81300, MALAYSIA

[*]Corresponding author: nurshamilla@sc.edu.my

ABSTRACT

The global anime and manga market has grown into a multi-billion-dollar cultural phenomenon, yet fans have few meaningful ways to engage with their favourite characters. Existing platforms rely on scripted chatbots and generic avatar tools that fail to capture a character's personality or let users see themselves within that world. Separately, students and young fans often lack accessible, low-pressure tools for emotional regulation and confidence-building in everyday situations such as public speaking. This project addresses both gaps by unifying AI-driven character interaction with practical self-development features in a single mobile application. The app allows users to generate and view personalised anime-style avatars from their own photographs using AI image generation, and to converse with fine-tuned anime character personas that go beyond scripted dialogue. Embedded within these conversations are evidence-based well-being tools, including the 5-4-3-2-1 grounding technique for anxiety management and a confidence-booster module to support public speaking and presentation preparation. To extend the app's educational value, it also offers gamified micro-lessons in basic daily Japanese and basic sign language, reinforced through an interactive mini-game. Supporting features, such as user profiles, customisable app settings, and secure login, round out the platform into a cohesive, personalised experience rather than a single-function tool. By combining generative AI, character-driven engagement, and accessible wellbeing and language-learning content, this project demonstrates how entertainment technology can be repurposed for meaningful social and educational impact, offering a novel model for youth-focused digital wellbeing applications.

Keywords: artificial intelligence, character chat, image generation, mental wellbeing, language learning

1.0 INTRODUCTION

The global anime streaming market was valued at approximately USD 7.50 billion in 2024 and is projected to reach USD 14.65 billion by 2030, growing at a compound annual growth rate (CAGR) of 11.8% (Arizton Advisory & Intelligence, 2026), reflecting anime's transition from a niche subculture into a mainstream form of global entertainment, particularly among Gen Z audiences. Despite this growth, existing anime platforms remain oriented toward passive content consumption, whereby character engagement is typically limited to scripted chatbots or generic avatar filters that fail to capture a character's personality or allow fans to see themselves represented within the anime world they follow (Pataranutaporn et al., 2021).

Separately, university students frequently experience anxiety and low self-confidence in everyday academic situations such as public speaking and presentations (Kaewmak et al., 2025), yet accessible, low-pressure tools for emotional regulation remain scarce, particularly tools that integrate naturally into environments students already use recreationally. Evidence-based practices such as the 5-4-3-2-1 grounding technique have been shown to reduce state anxiety by redirecting attention to present-moment sensory experience (Koniver, 2024), while conversational AI agents have demonstrated measurable reductions in depression and distress symptoms when delivered through accessible, mobile-based formats (Li et al., 2023). However, these wellbeing tools and entertainment-driven AI companion technologies have developed largely in parallel, with few platforms combining them into a single, coherent user experience.

This project addresses this gap by developing a mobile application that unifies AI-driven anime character interaction, personalised avatar generation, embedded wellbeing support, and accessible

language and sign language learning within a single platform. Rather than treating entertainment, mental wellbeing, and education as separate product categories, the system uses one consistent character identity to deliver all three, offering a novel model for youth-focused digital engagement.

2.0 OBJECTIVE

To design and develop an AI-powered mobile application that integrates personalised avatar generation, anime character conversational AI, and gamified educational modules within a unified platform.

To incorporate evidence-based emotional wellbeing techniques, namely the 5-4-3-2-1 grounding technique and structured public-speaking confidence coaching, into the character chat experience.

To provide an accessible language-learning module for basic conversational Japanese and basic sign language, in support of inclusive and lifelong learning aligned with Sustainable Development Goal 4 (Quality Education).

3.0 METHODOLOGY

This section describes the software development life cycle (SDLC) adopted to plan, design, implement and verify the application, covering the Requirements, Design, Implementation and Verification phases.

3.1 SOFTWARE DEVELOPMENT LIFE CYCLE

The project adopts the Waterfall Methodology, a linear and sequential approach to software development that emphasises comprehensive upfront planning, detailed documentation, and a structured progression through distinct phases. Rather than working in short, iterative cycles, the project moves through four defined stages, specifically Requirements, Design, Implementation, and Verification, where each phase is completed and reviewed before the next begins. This methodology was selected because its structured nature provides a clear, predictable roadmap for integrating complex AI components, ensuring that architectural requirements are rigorously established prior to development and minimising scope creep.

3.2 REQUIREMENTS

The core problem identified is that, despite rapid market growth, existing anime platforms lack deep, AI-based character interaction, personalised avatar creation, and integrated wellbeing or language-learning support. To address this, the requirement specification defined four core modules, which are Image, Chat, Learn, and Game, supported by user authentication, profile management, and application settings. Scope control was maintained using the MoSCoW method, prioritising the character chat and image-generation modules as Must-Have requirements, with the language, sign language, and mini-game modules classified as Should-Have and Could-Have requirements, respectively to preserve feasibility within the development timeframe.

3.3 DESIGN

The design phase established the technical blueprint for the system. A Use Case Diagram defined the primary user interactions, such as Generate Avatar, Chat with Character, Learn Language, and Play Mini-Game, while an Activity Diagram mapped the sequential steps and decision paths for each workflow, such as the prompt-to-image generation cycle and the character-selection-to-conversation loop. A System Architecture diagram outlined the integration of the core technical components, including the AI service layer, a role manager for maintaining consistent character identity across modules, and supporting data stores for user profiles and generation history.

3.4 IMPLEMENTATION

Implementation followed a cross-platform mobile development approach using Flutter framework, with native modules employed where required for device-level functionality such as audio playback and microphone access. Core AI functionality, including character dialogue, language translation, and image generation, was integrated through third-party large language model and generative-image APIs, specifically Groq API rather than training foundational models from scratch, consistent with feasibility constraints identified during the requirements phase. Text-to-speech playback for the language-learning module was implemented using the Flutter TTS package.

3.5 VERIFICATION

Testing followed an integrated strategy combining black-box testing to verify UI/UX and functional workflows, white-box testing to assess the quality and reliability of the underlying application code, and User Acceptance Testing (UAT) to validate prototype feasibility and overall user satisfaction ahead of any future pilot deployment.

4.0 RESULT

This section presents the resulting features, functionality, usefulness and practicality of the application, organised by module. While the requirements and design phases in Section 3.0 initially scoped the AI components around general-purpose large language model and diffusion APIs, the delivered implementation consolidates the character chat, wellbeing coaching, language translation, and image-generation functionality onto the Groq API, providing a single, consistent AI foundation across the platform.

4.1 SYSTEM OVERVIEW

The application is built as a complete, production-ready mobile platform comprising user authentication, profile management, account security, and application settings, in addition to four core functional modules, which are Image, Chat, Learn, and Game. The Groq API serves as the technological foundation of the system, providing the underlying language-model inference that powers the character chatbot, the language-translation engine, and the AI image-generation pipeline. A single, consistent anime character identity persists across all four modules, so the persona a user interacts with in the chat module is the same one guiding avatar creation, language learning, and gameplay. This design reflects an emerging body of research showing that AI-generated characters can be effectively deployed across multiple contexts to support both learning and wellbeing outcomes when their identity remains stable and recognisable to the user (Pataranutaporn et al., 2021).

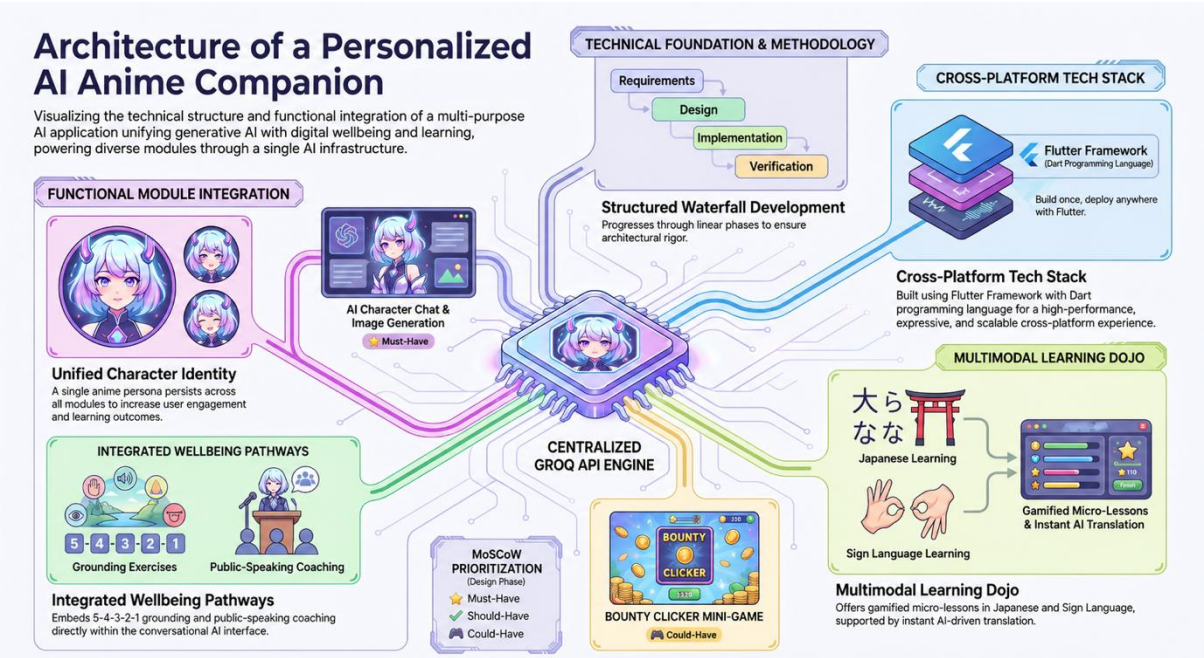


Figure 1: AI Anime companion app system architecture.

4.2 AI IMAGE GENERATION MODULE

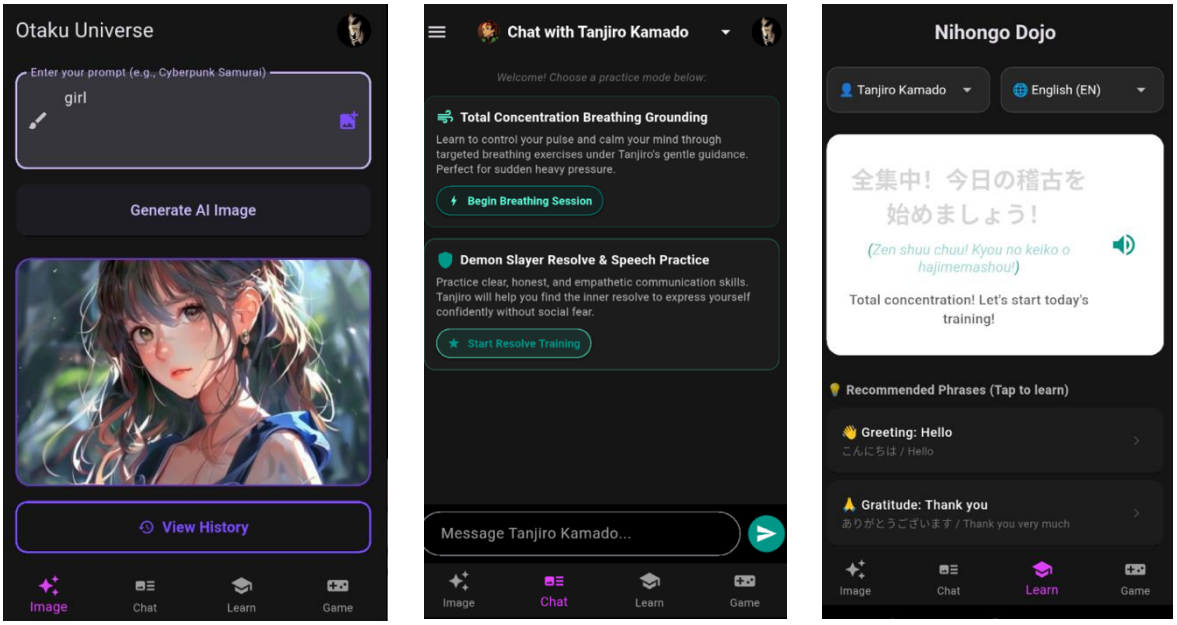
Users provide a short text prompt describing a desired appearance, and the Groq API-driven pipeline generates a personalised anime-style portrait within seconds. Every generated image is saved to a personal history gallery, allowing users to revisit, download, or delete past creations, thereby building a cumulative, personalised visual identity within the application over time.

4.3 CHARACTER CHAT AND WELLBEING MODULE

The character chat module allows users to converse with a selected anime persona beyond scripted dialogue. Embedded within the chat interface are two structured wellbeing pathways, such as a Total Concentration Breathing Grounding session, which guides users through a 5-4-3-2-1 sensory grounding exercise shown to help regulate the autonomic nervous system and reduce state anxiety (Koniver, 2024) and a Resolve & Speech Practice session, which functions as a structured confidence-building exercise for public speaking and presentation preparation, consistent with intervention research showing that structured, low-stakes speaking practice significantly improves self-reported confidence and reduces anxiety among university students (Kaewmak et al., 2025). This integration is consistent with findings that generative-AI-based, mobile-delivered conversational agents produce more pronounced reductions in depression and distress symptoms than non-generative formats (Li et al., 2023).

4.4 LANGUAGE AND SIGN LANGUAGE MODULE

The Nihongo Dojo module teaches basic conversational Japanese through a combination of curated common phrases and free-text translation, whereby users may type any word or phrase of their choosing for instant translation. Pronunciation support is provided through an embedded Flutter Text-to-Speech (TTS) engine, allowing users to listen to and practise native-like pronunciation, an approach consistent with evidence that gamified, mobile-delivered language content improves learner motivation and engagement relative to non-gamified formats (Shortt et al., 2023). For characters who are non-verbal within their source material, the same module instead teaches basic sign language, beginning with common everyday phrases and familial terms. This design mirrors the documented demand for accessible, mobile-delivered sign language learning tools within the Malaysian context, specifically, where such applications remain scarce despite clear user interest (Siong et al., 2021). Collectively, the language and sign language modules position the application as a contribution toward Sustainable Development Goal 4: Quality Education, by using generative AI to make language learning more accessible and personally motivating (Nedungadi et al., 2024).



(a) (b) (c)

Figure 2: (a) AI image generation interface and personal generation history gallery; (b) character chat interface showing the grounding and confidence-practice options; (c) Nihongo Dojo language-learning interface with recommended phrases and audio playback.

4.6 NOVELTY

The primary novelty of this project lies not in any single feature but in the integration of four capabilities, specifically avatar generation, conversational AI, structured wellbeing coaching, and gamified language/sign-language learning, around one consistent character identity, delivered through a shared AI infrastructure. Individually, each of these techniques has established evidence, specifically

grounding techniques measurably reduce anxiety (Koniver, 2024), AI conversational agents reduce depression and distress (Li et al., 2023), gamified language tools improve learner motivation (Shortt et al., 2023), and AI-generated characters support both learning and wellbeing outcomes (Pataranutaporn et al., 2021). However, existing literature and existing commercial platforms have not combined these elements into a single, anime-character-mediated experience.

5.0 CONCLUSION

This project demonstrates that entertainment-driven AI technologies, typically developed for engagement and monetisation purposes, can be intentionally repurposed to deliver measurable social and educational value. By unifying personalised avatar generation, character-driven conversational AI, evidence-based wellbeing coaching, and accessible language and sign language learning within a single mobile platform, the system offers university students and young anime fans a low-friction entry point into anxiety management, public-speaking confidence-building, and language learning.

Beyond its immediate application, the project contributes to the growing body of work on AI-generated companion characters as vehicles for education and wellbeing (Pataranutaporn et al., 2021) and aligns with Sustainable Development Goal 4: Quality Education by demonstrating a scalable, low-cost model for embedding learning content into platforms young users already find engaging (Nedungadi et al., 2024). Future work should prioritise a structured pilot study measuring whether the grounding and confidence-building modules produce statistically significant reductions in self-reported anxiety among student users, alongside expansion of the character library to support broader commercial deployment.

ACKNOWLEDGEMENT

The authors would like to thank the Institute of Graduate Research Studies and the Department of Computer Science, Faculty of Engineering and Information Technology at Southern University College for institutional support throughout the development of this project.

REFERENCES/ RUJUKAN

Arizton Advisory & intelligence. (2026). *Anime Streaming Market Size, Growth, Trends, Industry Report 2030*. https://www.arizton.com/market-reports/anime-streaming-market

Kaewmak, S., Ueangchokchai, C., & Meepan, W. (2025). Enhancing Public Speaking Confidence: A Program for Higher Education Students with Fear of Public Speaking. *Higher Education Studies*, *15*(4), 470. https://doi.org/10.5539/hes.v15n4p470

Koniver, L. (2024). Grounding To Treat Anxiety. *Medical Research Archives*, *12*(12). https://doi.org/10.18103/mra.v12i12.6024

Li, H., Zhang, R., Lee, Y.-C., Kraut, R. E., & Mohr, D. C. (2023). Systematic review and meta-analysis of AI-based conversational agents for promoting mental health and well-being. *Npj Digital Medicine*, *6*(1), 236. https://doi.org/10.1038/s41746-023-00979-5

Nedungadi, P., Tang, K.-Y., & Raman, R. (2024). The Transformative Power of Generative Artificial Intelligence for Achieving the Sustainable Development Goal of Quality Education. *Sustainability*, *16*(22), 9779. https://doi.org/10.3390/su16229779

Pataranutaporn, P., Danry, V., Leong, J., Punpongsanon, P., Novy, D., Maes, P., & Sra, M. (2021). AI-generated characters for supporting personalized learning and well-being. *Nature Machine Intelligence*, *3*(12), 1013–1022. https://doi.org/10.1038/s42256-021-00417-9

Shortt, M., Tilak, S., Kuznetcova, I., Martens, B., & Akinkuolie, B. (2023). Gamification in mobile-assisted language learning: A systematic review of Duolingo literature from public release of 2012 to early 2020. *Computer Assisted Language Learning*, *36*(3), 517–554. https://doi.org/10.1080/09588221.2021.1933540

Siong, T. J., Nasir, N. R. M., & Salleh, F. H. M. (2021). A mobile learning application for Malaysian sign language education. *Journal of Physics: Conference Series*, *1860*(1), 012004. https://doi.org/10.1088/1742-6596/1860/1/012004

ECO-RESILIENT BEACH CLEANER MACHINE

Muhamad Nazrin bin Halim[1], Arif Lutfirahman bin Kamarul Ariifn[2], Nur Kamarliah Binti Kamardin[1,*], Ahmad Idzwan Bin Yusuf [2], Ana Syahidah Binti Mohd Rodzi[1]

[1]Faculty of Mechanical Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Malaysia
[2]Faculty of Civil Engineering, Universiti Teknologi MARA, Cawangan Johor, Malaysia

[*]Corresponding author: nurkamarliah@uitm.edu.my

ABSTRACT

Marine debris, particularly plastics and microplastics, poses an escalating threat to coastal ecosystems and the ecotourism sector. Traditional manual beach cleaning using hand rakes is highly inefficient and physically exhausting, while industrial-scale motorised beach cleaners are commercially non-viable for small-scale operators due to exorbitant costs, bulky dimensions, and fossil-fuel dependency. To address this critical gap, this project introduces the Eco-Resilient Beach Cleaner Machine, a compact, semi-automated machine engineered for efficient, low-cost coastal waste management. Designed with an optimised spatial footprint of 89 cm × 57 cm × 77 cm, the machine features an ergonomic push-and-pull handlebar configuration that ensures high manoeuvrability and a zero-turning radius on loose coastal terrains. The core innovation lies in its battery-powered motorised conveyor-sifting mechanism, which utilises a robust chain-and-sprocket transmission system driven by a DC motor. As the operator steers the unit, the automated conveyor scoops the sand bed, continuously lifting, separating, and depositing debris into a high-capacity, removable rear collection bin while allowing clean sand to filter through naturally. Rigorous physical testing indicates that this dual-action design operates effectively in both dry and wet sand conditions, significantly reducing human labour and accelerating cleaning times. By offering a lightweight, affordable, and 100% zero-emission alternative to heavy machinery, this innovation directly lowers operational expenditures for small resorts, local municipalities, and eco-NGOs. Ultimately, this project directly aligns with Sustainable Development Goal (SDG) 14 and SDG 11, providing a resilient, accessible, and scalable solution for global beach preservation and sustainable cities and communities.

Keywords: beach cleaner machine, sustainable coastal management, microplastic extraction

1.0 INTRODUCTION

Coastal ecosystems and marine environments worldwide are under severe threat due to the rapid accumulation of anthropogenic debris, particularly plastics and microplastics (Ebrahim et al., 2022). Beach pollution not only disrupts local biodiversity and marine food chains but also directly degrades the aesthetic and economic viability of coastal ecotourism (Bolong et al., 2021, Hafsa et al., 2023, R Praveen et al., 2020). Traditional coastal sanitation heavily relies on manual raking, which is labour-intensive, time-consuming, and physically taxing, often leading to high occupational health risks and poor efficiency in capturing smaller debris. Conversely, existing commercial beach-cleaning machinery consists of heavy, motorised vehicles that are economically non-viable for small-scale operators due to exorbitant capital costs, high maintenance requirements, and excessive carbon emissions from fossil fuels. Furthermore, these bulky vehicles lack the manoeuvrability required for narrow or restricted beach terrains (Bhavani et al., 2019).

To bridge this critical technological and economic gap, this study presents the Eco-Resilient Beach Cleaner Machine, a compact, semi-automated machine engineered for accessible, low-cost, and sustainable coastal waste management. Designed with a spatial footprint of $89\ cm \times 57\ cm \times 77\ cm$, the innovation integrates an ergonomic handlebar with a battery-powered motorised conveyor system driven by a high-torque chain-and-sprocket transmission. As the machine moves forward, the continuous conveyor scoops the sand bed, efficiently sifting and depositing debris into a removable rear collection bin while allowing clean sand to filter back onto the shore. By providing a 100% zero-emission and highly maneuverable alternative to heavy machinery, this innovation aligns directly with Sustainable Development Goal (SDG) 14 (Life Below Water) and SDG 11 (Sustainable Cities and Communities), delivering a resilient, cost-effective solution for global beach preservation

2.0 OBJECTIVE

To design and fabricate a compact, semi-automated beach cleaner machine
To evaluate the operational performance and waste-sifting efficiency of the beach cleaner machine

3.0 METHODOLOGY

The fabrication of the beach cleaner machine followed a structured and rigorous engineering methodology to ensure operational reliability during field performance testing. Critical design parameters were systematically evaluated to achieve a low-cost, highly durable, and user-friendly architecture. This involved meticulous selection of raw materials and mechanical components, precise fabrication workflows, and comprehensive cost-efficiency analysis. Functionally, the drive mechanism incorporates an integrated gear-and-sprocket assembly mounted on the main drive shaft to optimise power transmission and continuous conveyor motion.

3.1 FIND CONCEPT AND SKETCH DESIGNS

The initial phase focused on defining the overall machine framework and technical specifications. Conceptual design ideas were brainstormed and translated into preliminary sketches alongside concurrent 3D CAD modelling in SolidWorks to establish functional layouts, as illustrated in **Figure 3.1**



Figure 3.1: Concept and sketch design of the beach cleaner machine.

3.2. FINAL DESIGN SELECTION

From multiple proposed concepts, the optimal design was selected based on a structured evaluation matrix. Key selection criteria included sifting performance, ease of fabrication, material cost-effectiveness, structural durability, and minimal maintenance requirements, as shown in **Figure 3.2**.

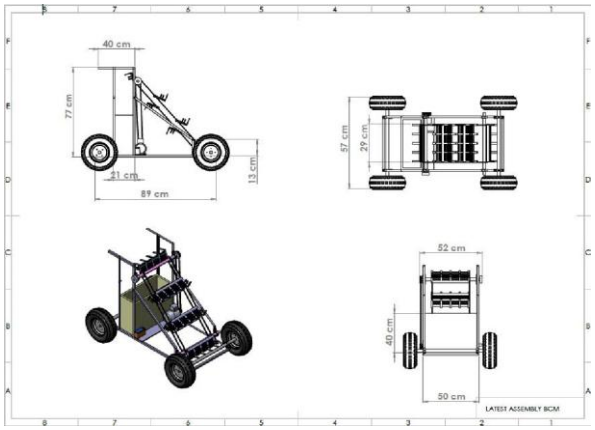


Figure 3.2: Final design of the beach cleaner machine.

3.3 SOLIDWORKS DRAWING

Following concept selection, a comprehensive Computer-Aided Design (CAD) model was developed using SolidWorks as shown in **Figure 3.3**. This step enabled precise 3D spatial visualisation, component fit analysis, and structural evaluation, while generating accurate engineering drawings with specified dimensions, material thicknesses, and assembly tolerances.



Figure 3.3: SolidWorks 3D Model of the beach cleaner machine.

3.4 RAW MATERIAL SELECTION

Materials were carefully selected based on environmental resilience, mechanical strength, and cost-effectiveness. Primary consideration was given to lightweight, corrosion-resistant metals capable of withstanding harsh, saline coastal conditions and operational wear without compromising affordability.

3.5 FABRICATION PROCESS

The physical prototype was constructed starting with the main chassis frame. Fabrication processes involved precise measuring, cutting, and joining via Shielded Metal Arc Welding (SMAW). Concurrently, the electrical drive system was integrated by wiring the rechargeable power supply to the high-torque DC motor. Figure 3.4 shows the welding process of the beach cleaner machine.



Figure 3.4: Welding process of the beach cleaner machine.

3.6 FINISHING PROCESS

To enhance longevity in marine environments, surface finishing was applied to all fabricated metal structures. Protective anti-rust coatings and paint were applied to prevent oxidation, while moving mechanical components, including the chain drive and sprocket assembly, were lubricated to minimise friction and wear.

3.7 TESTING

The fully assembled machine underwent rigorous quality inspection and functional verification. Field tests evaluated structural alignment, operational balance, and the continuous rotational stability of the motorized conveyor belt, ensuring the final machine satisfied all design requirements and project objectives.

4.0 RESULT

The main outcome of this project successfully validated both research objectives, culminating in the design, structural simulation, and full physical fabrication of the functional prototype, as shown in Figure 4. The completed build successfully achieved the targeted compact dimensions of $89\ cm \times 57\ cm \times 77\ cm$, confirming that the physical machine adhered precisely to the initial 3D CAD model and ergonomic specifications. Integrating a lightweight, corrosion-resistant chassis with a high-torque DC motor and a heavy-duty chain-and-sprocket drive system demonstrated exceptional structural stability and smooth mechanical rotation during operational power-on testing.

Preliminary field testing of the fabricated unit verified the practical capability and efficiency of the semi-automated sifting mechanism. When activated, the battery-powered chain-driven belt rotated continuously without mechanical slippage, allowing the front scoop to effectively engage the sand bed. The machine successfully lifted and separated surface waste including plastics, bottle caps, and organic debris from the sand matrix, transferring the collected litter directly into the removable rear collection bin while allowing clean sand to filter back onto the shoreline. Furthermore, the ergonomic handlebar configuration enabled a single operator to manoeuvre the machine effortlessly across loose beach terrain, significantly reducing physical exertion compared to manual raking and proving its viability as a low-cost, zero-emission solution for coastal sanitation.



Figure 4: Final prototype of the beach cleaner machine.

5.0 CONCLUSION

In conclusion, the Eco-Resilient Beach Cleaner Machine successfully demonstrates the viability of an affordable, compact, and semi-automated solution for sustainable coastal sanitation. By successfully achieving its design and fabrication goals, the project proves that integrating a battery-powered DC motor with a chain-and-sprocket conveyor mechanism can effectively automate sand-debris separation without relying on fossil fuels. The final prototype provides a high-impact, zero-emission alternative to physically demanding manual raking and costly, heavy industrial machinery. Ultimately, this innovation significantly lowers operational barriers for low-budget NGOs, small coastal resorts, and local municipalities, offering a scalable and accessible approach that directly supports United Nations Sustainable Development Goal (SDG) 11 (Sustainable Cities and Communities) and SDG 14 (Life Below Water) in building resilient coastal spaces and preserving marine ecosystems for the future.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude and appreciation to the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Cawangan Pulau Pinang, Kampus Permatang Pauh for providing the necessary facilities, technical guidance, and continuous encouragement throughout the execution of this project. Special thanks are also extended to the academic staff, laboratory technicians, and fellow researchers whose invaluable insights, constructive feedback, and unwavering support significantly contributed to the successful design, fabrication, and completion of the Eco-Resilient Beach Cleaner.

REFERENCES/ RUJUKAN

Bolong, N., Saad, I., & Madlan, M. A. (2021). Manufacturing of beach cleaning machine at Universiti Malaysia Sabah (UMS): Prototype design and analysis. *Transactions on Science and Technology*, *8*(3-2), 281–289. https://tost.unise.org/pdfs/vol8/no3-2/ToST-CoFA2020-281-289-OA.pdf

Hafsa, M. N., Mohd Karim, M. A. A., Rosli, A. S., & Mohd Zulkifli, M. H. S. (2023). Beach cleaner crab machine. *Multidisciplinary Applied Research and Innovation*, *4*(3), 244–255. https://doi.org/10.30880/mari.2023.04.03.034

Bhavani, M., Kalaiselvan, S., Jagan, S., & Gopinath, S. (2019). Semi-automated wireless beach cleaning robot vehicle. *International Journal of Recent Technology and Engineering*, *8*(1S2), 108–110. https://www.ijrte.org/wp-content/uploads/papers/v8i1S2/A00220581S219.pdf.

Ebrahim, H., Sheikh, W., y Saeed, A. (2022). Design and analysis of sustainable beach cleaner. *3C Tecnología. Glosas de innovación aplicadas a la pyme, Edición Especial,* (febrero 2022), 167-179. https://doi.org/10.17993/3ctecno.2022.specialissue9.167-179

Praveen, R., Prabhu, L., Premjith, P., Mohan, A. K., & Ajayraj. (2020). Design experimental of RF controlled beach cleaner robotic vehicle. *IOP Conference Series: Materials Science and Engineering*, *993*(1), Article 012030[cite: 4]. https://doi.org/10.1088/1757-899X/993/1/012030

DUN COMMUNITY MOBILE APP (e-KITA)

Tan Kah Meng[1], Noor Fatihah Bt Mazlam[1,*]

[1]Department of Computer Science, Faculty of Engineering and Information Technology, Southern University College, PTD 64888, Jalan Selatan Utama, KM15, Off Jalan Skudai, 81300 Skudai, Johor

[*]Corresponding author: b240218c@sc.edu.my

ABSTRACT

Effective communication between local residents and their state assembly office is important to ensure that community issues, feedback, and announcements are managed efficiently. However, many residents still rely on different communication channels such as social media, WhatsApp, email, or physical visits to contact their local representatives, making communication less organised. Residents also face difficulties in finding official contact information, as online sources may be outdated or unreliable, and there is no centralised platform for submitting complaints, reporting local issues, or receiving community updates. As a result, feedback and complaints are scattered across multiple platforms, making it difficult for the ADUN office to manage and respond effectively. Therefore, this project aims to develop e-KITA, a community mobile application that provides a centralised communication platform between residents and the state assembly office. The application allows residents to access official contact information, submit complaints and feedback, report local issues, participate in community polls, and receive the latest news and announcements. It also provides a management dashboard that helps ADUN staff organise, monitor, and manage community interactions more efficiently. The system is developed using the Prototype Model, with Flutter for the mobile application, Laravel for the backend, and MySQL as the database. The proposed system is expected to improve communication efficiency, increase access to reliable information, simplify complaint management, and strengthen engagement between residents and the state assembly office. In conclusion, e-KITA provides a practical digital solution that enhances community communication while supporting a more responsive and efficient public service.

Keywords: community mobile application, e-KITA, DUN, centralised platform

1.0 INTRODUCTION

The e-KITA mobile application is a centralised digital platform that serves to strengthen the communication between residents and their State Assembly (DUN) offices. The application shall allow users to access the latest information published by their respective assembly office and government departments regarding matters such as upcoming events, public service announcements and emergency notices without having to rely on printed notices or social media. The application also fetches social media posts across platforms such as Facebook and Twitter from the official public pages of government departments into a single feed so that residents can access all this information in one place. In case of emergency alerts such as water supply disruption, road blockages or power outages in the area, residents will receive push notifications that are directly sent to their mobile devices to ensure that they are notified as soon as possible and can prepare ahead of time. The application (e-KITA) also includes a feedback & complaint section where users can find all official online submission links for where users can submit their feedback or complaints directly to respective departments regarding issues such as poor road conditions or faulty streetlights. Lastly, since Malaysia is a multicultural and multilingual country, the application also provides an AI translation tool that supports 3 languages (English, Chinese & Bahasa Melayu) for any news article/announcement displayed on the app so that residents from different language backgrounds can understand them without any language barrier. The application also includes an AI summarisation feature to help residents to quickly grasp the key points of long news articles/announcements since most of the time people don't like reading long articles/announcements.

The reason why this application was developed is because currently there is a lack of a centralised platform where residents can easily access or receive notifications about the latest community

news/announcements. Usually, whenever there are important announcements that the state assembly members would like to share with their residents such as upcoming event schedules, government programs, dengue fogging operations or scheduled maintenance activity, they are usually shared through printed notices, social media pages or announced using vehicles equipped with loudspeakers that will drive around the area to broadcast the message around the neighbourhood. However, this kind of method is inefficient, time-consuming and unreliable. For example, whenever there is a power outage or water supply disruption that will be happening around the area, the assembly office would need to hire people to deliver the printed notices to each house or one, post announcements on social media or drive a vehicle with loud speakers to broadcast the notice to the residents. In some cases, the person who is delivering the notices could have accidentally missed certain houses or overlooked specific areas, or that some residents might not have heard the announcements at all due to them being asleep at the time or they were not home or they don't actively check or use social media. Not only that, since government departments such as Ranhill SAJ, MBIP, Majlis Bandaraya Johor Bahru (MBJB) etc each have their own social media pages, it can be quite inconvenient for residents to keep track of important updates because they would have to check each one individually. As a result, some residents might not be aware of the situation, causing them to not be able to make any preparations in advance. This lack of an efficient and centralised information-sharing system causes inconvenience to the residents. Thus to address these challenges faced by the current community communication system, the development of a community mobile application called (e-KITA) was proposed.

2.0 OBJECTIVE

The objectives of this project are as follows:

1. To identify the existing issues faced in the current community communication system and reviewing existing community communication mobile applications to understand the key requirements and features necessary for an effective community communication mobile application.
2. To design a centralised community communication mobile application with an intuitive and user-friendly interface that consolidates announcements, feedback, and communication features into a single platform.
3. To develop a centralised community communication mobile app called e-Kita that allows residents to receive real-time community updates and conveniently gain access to official links for submitting feedback & complaints to respective departments through a single, accessible platform.
4. To test and evaluate the developed system to ensure that the final product functions correctly without any bugs and aligns with customer's requirements and expectations.

3.0 METHODOLOGY

The Prototype Model was adopted as the software development methodology for e-KITA. This model is a software development life cycle (SDLC) model that focuses on building a mock-up version of the system known as a prototype which will be evaluated by the stakeholders, who will provide feedback that will be used to further refine the system to ensure that the final product is accurate and meets stakeholder expectations. This process is iterated as many times as needed until eventually the customer is satisfied with the system. Once the prototype has been finalised and approved, then the actual development and implementation of the system will be carried out using the finalised prototype as a reference. The Prototype Model was selected for this project because it allows for early user involvement and feedback. Since the application (e-KITA) will be used by both community members and ADUN staff, by building an early prototype that allows these stakeholders to test and evaluate the system's layout and functions such as issue reporting/feedback submission, news & announcements, and event calendars before the actual development begins, it can help ensure that the system design and features truly meet the users' expectations and needs. Another reason why this model was chosen is because it is flexible and supports requirement refinement through iteration unlike other process models such as the waterfall model. In community-based applications, user needs and system expectations may evolve as users test the prototype. Therefore, by implementing this model, developers can easily adjust or add new features based on stakeholder's feedback, ensuring the final system satisfies stakeholder expectations. The figure for the project framework is shown below:

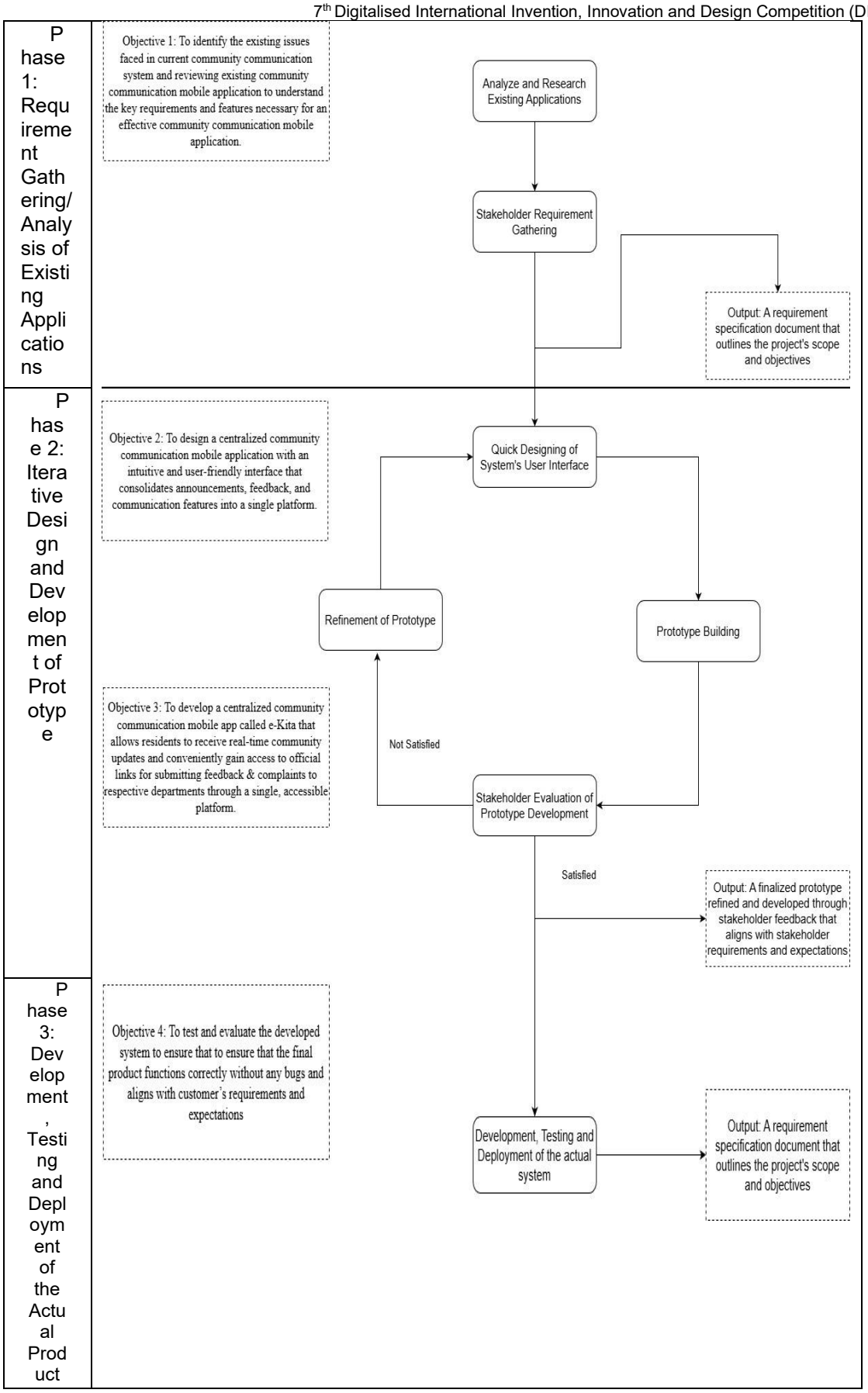


Figure 3.2: Project framework.

PHASE 1: REQUIREMENT GATHERING AND ANALYSIS OF EXISTING APPLICATIONS

In this phase, communication was carried out between the developers and the stakeholders to understand their needs, expectations and goals of the system and analysis was also conducted on three existing community communication mobile applications which are SeeClickFix, My Civic, and Info Groove to identify the key features that the proposed system should have. After that, a requirement specification document was created based on the requirements gathered from the stakeholder and existing applications.

PHASE 2: ITERATIVE DESIGN AND DEVELOPMENT OF PROTOTYPE

For this phase, a mock-up version of the system's user interface and core functionalities is developed based on the gathered requirements and presented to the stakeholders for evaluation and testing and feedback is gathered. Based on the feedback that was gathered, the prototype is then further refined and the cycle is repeated until the stakeholder is satisfied with the prototype system then we will move on to the next phase which is developing the actual system.

PHASE 3: DEVELOPMENT, TESTING AND DEPLOYMENT OF THE ACTUAL PRODUCT

For the last phase, the finalised prototype that was built during the previous phase is then used as reference for developing the actual product. The developers begin by coding and implementing the system based on the refined requirements and design gathered from the prototype. Once the system has been developed, it then undergoes testing to ensure that all the system functionalities works as intended and that there are no errors or bugs in the system. Once the system is deemed to be fully working with no issues, the system is then deployed to the public for real world usage.

4.0 RESULT

e-KITA is a centralised community mobile application specifically designed to serve residents and state assembly offices (DUN).What makes e-KITA stands out is that it fetches social media posts across platforms such as Facebook and Twitter from the official public pages of government departments such as Ranhill Saj, JPJ Johor, MBIP etc into a single feed, saving residents the trouble from having to navigate across multiple platforms or pages to stay informed. Besides that, the application also includes AI-powered news summarisation and trilingual translation (English, Bahasa Melayu, and Chinese) so that residents do not have to go through the trouble of reading lengthy articles or announcements or having to translate the text themselves to understand it. Another advantage of the application is that it also serves as a guidance system by teaching residents on where they should submit their reports or issues to the respective government departments and understanding what they are responsible for to prevent misunderstandings or delays in addressing the problem. This can also help to reduce the amount of extra work that the ADUN staff might have faced in the past since they mentioned that often residents would contact to report an issue or problem that they are not responsible for and would need to waste time relaying the issue to the right department or explaining to the customer about it. Lastly, the application also provides real-time push notifications in case of emergency situations such as water supply disruption or road blockage directly on their mobile devices so that they are notified as soon as possible and can prepare ahead of time. Functional testing was conducted with all test cases across user and admin modules showing that both passed successfully. User Acceptance Testing was also conducted by having 30 respondents above the age of 18 test the application and answering a survey form. The results from the survey showed that the majority of the people found e-KITA to be useful, easy to use, and satisfactory in meeting their needs.

5.0 CONCLUSION

In conclusion, e-KITA successfully addresses the problem faced by residents such as news * announcement being scattered across different social media platforms or pages by providing a centralised mobile platform that consolidates news and announcements, event calendars, government aid information, community polls, and feedback guidance in one accessible application. The system was developed using the Prototype Model as the methodology with Flutter and Laravel for the front-end and back-end and using the MySQL as the database for the system, ensuring a responsive and scalable cross-platform solution for both Android and iOS users. Functional testing also confirmed that the system modules function as expected when handling both valid and invalid inputs, while 30 respondents from the User Acceptance Testing provided their feedback and majority considered that the application is user-friendly, useful, and meets their expectations. The AI-powered summarisation and translation

feature (English, Bahasa Melayu, Chinese) also make it possible for residents with different language backgrounds to access the app, making the app inclusive for a multilingual community. It also includes real-time push notifications to ensure that residents are informed of any emergency announcements as soon as possible.

REFERENCES/RUJUKAN

Berkowitz, B. (2018, March 27). SeeClickFix iOS 5.0 – A more efficient 311 app. Medium. https://medium.com/@benberkowitz/seeclickfix-ios-5-0-a-more-efficient-311-app-2ccbff7423a9

Info Grove. (n.d.). Mobile app development for municipalities, unions & associations. https://info-grove.com/

Tyler Technologies. (n.d.). My Civic app. https://www.tylertech.com/products/my-civic

AN INNOVATIVE NSM CFRP AND FE-SMA STRENGTHENING SYSTEM FOR CORROSION-DAMAGED RC BEAMS

Siti Shahidah Sharipudin[1,*], Ruqayyah Ismail[2], Muhammad Solihin Md Rodhi[2], Khairul Azwar Kamaruddin[2]

[1]Faculty of Civil Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Jalan Purnama, Bandar Seri Alam, 81750 Masai Johor Darul Ta'zim, Malaysia.
[2]Faculty of Civil Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

[*]Corresponding author: sitishahidah1873@gmail.com

ABSTRACT

Corrosion of steel reinforcement is one of the primary causes of deterioration in reinforced concrete (RC) structures, leading to steel cross-sectional loss, bond degradation, concrete cracking, reduced flexural capacity, and diminished service life. Conventional strengthening methods often increase structural self-weight and require extensive installation. This innovation presents an advanced strengthening approach for corrosion-damaged RC beams using Near-Surface Mounted (NSM) Carbon Fiber Reinforced Polymer (CFRP) and Iron-Based Shape Memory Alloy (Fe-SMA) strips. The proposed strengthening system is designed to restore structural performance while providing a lightweight, durable, and practical solution for extending the service life of aging concrete infrastructure. The innovation integrates two high-performance materials with complementary mechanical characteristics. NSM CFRP offers high tensile strength, excellent corrosion resistance, and efficient load transfer through embedded installation. Meanwhile, Fe-SMA strips provide recovery stress through thermal activation, introducing a prestressing effect that enhances crack control, stiffness, and flexural behaviour. Unlike conventional strengthening approaches that rely on passive reinforcement, this innovation exploits the unique self-prestressing capability of Fe-SMA to improve structural performance without increasing the member dimensions or disrupting existing structures. Although NSM CFRP and Fe-SMA have individually demonstrated promising strengthening performance, limited studies have investigated their application as rehabilitation solutions for corrosion-damaged RC beams. The present strengthening system was experimentally implemented using accelerated corrosion techniques followed by four-point bending tests on strengthened RC beams. Structural performance was evaluated in terms of ultimate load capacity, deflection response, crack pattern, and failure mode. Findings demonstrate that both NSM CFRP and NSM Fe-SMA effectively restored the flexural capacity of corrosion-damaged RC beams, with NSM Fe-SMA exhibiting greater load recovery. This innovation contributes to sustainable infrastructure rehabilitation by enhancing structural durability, reducing maintenance costs, and extending the service life of aging reinforced concrete structures, thus supporting Sustainable Development Goal 9: Industry, Innovation and Infrastructure.

Keywords: Corrosion-damaged RC beams, Near-Surface Mounted, Carbon Fiber Reinforced Polymer (CFRP), Iron-Based Shape Memory Alloy, flexural strengthening

1.0 INTRODUCTION

Corrosion of steel reinforcement is one of the most significant causes of deterioration in reinforced concrete (RC) structures, particularly those exposed to marine environments. The corrosion process reduces the cross-sectional area of steel reinforcement, weakens the bond between steel and the surrounding concrete, and induces cracking and spalling of the concrete cover. Furthermore, corrosion degrades the mechanical properties of reinforcing steel, including its ductility, yield strength, and ultimate tensile strength, thereby reducing the structural load-carrying capacity and potentially leading to premature structural failure (Al-Huri et al., 2022). Over the years, numerous studies have been conducted to develop a variety of advanced materials and techniques for the comprehensive strengthening of RC beams (Ganesh & Murthy, 2019; Siddika et al., 2019; Jahami & Issa, 2023). Fiber Reinforced Polymer (FRP) systems have been widely used to strengthen corrosion-damaged reinforced concrete RC beams due to their lightweight properties, ease of installation, and excellent corrosion resistance. Externally bonded FRP enhances the bond performance of deteriorated concrete and

improves structural behaviour (Tiwary et al., 2022). However, its effectiveness is limited by the condition of the concrete surface, as premature debonding may occur when applied to severely deteriorated concrete. Triantafyllou et al. (2019) reported that patch repair combined with Near-Surface Mounted (NSM) CFRP laminates improved the load-carrying capacity of heavily corroded beams. Similarly, Biswas et al. (2023) demonstrated that applying an Ultra-High Performance Concrete (UHPC) layer enhanced the structural performance of severely corroded RC beams, although its effectiveness was limited by bond degradation between corroded reinforcement and concrete. In addition, Zheng et al. (2021) reported improved flexural capacity using FRP grid-reinforced engineered cementitious composites (FGREM). Despite the benefits of existing strengthening methods, their performance is often limited by bond failure and durability issues. The NSM technique offers a more durable strengthening solution with improved bond performance and reduced risk of premature debonding. Shape Memory Alloys (SMAs) have recently emerged as intelligent materials for structural strengthening due to their superelasticity and shape memory effect (SME). These unique properties enable SMAs to recover their original shape after deformation through heating, generating recovery stress that provides a self-prestressing effect without the need for hydraulic actuators (Izadi et al., 2018; Ghafoori et al., 2022). This makes SMAs a promising solution for civil engineering strengthening applications. The self-prestressing mechanism of Fe-SMA enhances the structural performance of RC beams by increasing cracking and ultimate loads while reducing deflection (Strieder et al., 2019). In addition, Fe-SMA offers low production costs, making it a practical and cost-effective solution for large-scale structural rehabilitation. Although most researchers have reported on the application of Fe-SMA for the strengthening of RC structures, its use for strengthening corroded RC beams remains limited. This study aims to evaluate the flexural performance of corrosion-damaged reinforced concrete RC beams strengthened using Near-Surface Mounted (NSM) CFRP and Fe-SMA strips.

2.0 OBJECTIVE

The objectives of this study are:

- To investigate the effect of corrosion on the flexural performance of reinforced concrete RC beams.
- To evaluate the effectiveness of NSM CFRP and Fe-SMA strips in restoring the flexural performance of corrosion-damaged RC beams.
- To compare the strengthening performance of NSM CFRP strips and NSM Fe-SMA strips in terms of load-carrying capacity, deflection behaviour, and failure mode.

3.0 EXPERIMENTAL PROGRAM

3.1 RC BEAM SPECIMENS

The study consisted of eight RC beam specimens, of which four specimens were selected for performance evaluation. Beam CB served as the uncorroded control specimen, while beam CRB represented a specimen with approximately 5% reinforcement mass loss due to corrosion. Two additional corroded beams were strengthened using the NSM technique with CFRP (CRB-CFRP) and Fe-SMA strip (CRB-SMA), as depicted in Figure 1. Corrosion was induced using an accelerated corrosion technique. Each beam measured 750 mm × 150 mm × 150 mm and was reinforced with two 10 mm diameter steel bars at both the tension and compression zones, together with 6 mm diameter stirrups spaced at 100 mm.

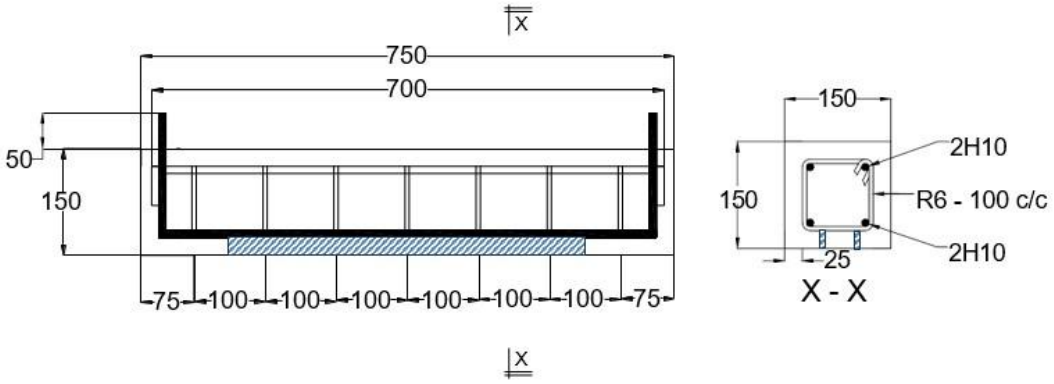


Figure 1: Details of beam specimens and strengthening configurations (unit: mm).

3.2 CONSTITUENT MATERIALS

The strengthening materials comprised CFRP and Fe-SMA strips, measuring 500 mm × 25 mm × 1.4 mm (length × width × thickness). The tensile strengths of the steel reinforcement, CFRP strips, and Fe-SMA strips were 500 MPa, 3300 MPa, and 1000 MPa, respectively. An epoxy adhesive with a modulus of elasticity of 2 GPa and a cement-based grout with a compressive strength of 30 MPa were used for strip installation. All beam specimens were cast using normal concrete G30. The specimens were air-cured for 28 days before undergoing the accelerated corrosion process.

3.3 NSM STRENGTHENING SCHEME

Two corroded beam specimens were strengthened using NSM CFRP and Fe-SMA strips, respectively. Two grooves measuring 6 mm × 25 mm (width × depth) were cut along the bottom of each beam using a diamond saw, with a 50 mm spacing between the grooves. The grooves were cleaned using a wire brush to remove dust and debris before installation. For the strengthened beam with CFRP, the grooves were partially filled with epoxy adhesive before inserting the CFRP strips. The remaining groove volume was then filled with epoxy and levelled with the concrete surface. For the strengthened beam with Fe-SMA, the strips were installed in the grooves using cement-based grout and subsequently activated by heating to approximately 160°C with a heat gun to generate recovery stress and a self-prestressing effect. The specimens were allowed to cool to ambient temperature before flexural testing.

3.4 ACCELERATED CORROSION METHOD

An accelerated corrosion technique was employed to induce corrosion in the beam specimens using an impressed current method. The positive terminal of a DC power supply was connected to the bottom reinforcement bars, while the negative terminal was connected to a stainless-steel plate. The specimens were partially immersed to one-third of their depth in a 5% NaCl solution for 14 days. Figure 2 illustrates the experimental setup used for the accelerated corrosion process.



Figure 2: Accelerated corrosion setup.

3.5 EXPERIMENTAL FLEXURAL TEST

All beam specimens were tested under four-point bending using a hydraulic actuator at a displacement-controlled loading rate of 0.4 mm/min until failure. The applied load was transferred through a steel spreader beam, producing two symmetrically positioned point loads 200 mm from the beam midspan. Beam deflection was monitored using three linear variable displacement transducers (LVDTs) positioned along the span.

4.0 RESULT AND DISCUSSION

The flexural performance of all beam specimens was evaluated through four-point bending tests. Table 1 summarizes the first cracking load, maximum deflection, and ultimate load, while Figure 4 presents the corresponding load–deflection curves. The uncorroded control beam (CB) achieved the highest ultimate load of 61.87 kN with a maximum mid-span deflection of 8.34 mm. In contrast, beam CRB exhibited a 25.72% reduction in ultimate load due to reinforcement corrosion, which indicates a reduction in the steel cross-sectional area and weakened the bond between steel and concrete. These findings are consistent with previous studies reporting the detrimental effects of corrosion on the flexural behaviour of RC beams. Beam CRB-CFRP significantly restored its flexural performance, increasing the ultimate load to 56.33 kN, representing a 22.51% improvement over the unstrengthened corroded beam. This improvement agrees with previous findings on the effectiveness of NSM CFRP strengthening. Beam CRB-SMA exhibited the highest load recovery among the strengthened specimens. In addition to achieving a greater ultimate load, the specimen demonstrated larger deflection before failure, indicating enhanced ductility and improved post-yield behaviour attributed to the self-prestressing effect of Fe-SMA. All specimens exhibited flexural failure characterised by vertical cracks initiating at the tensile zone and propagating towards the compression zone. Beam CB showed a typical flexural crack pattern, whereas the CRB exhibited wider cracks and premature failure due to reinforcement corrosion. Strengthening with NSM CFRP strips resulted in finer and more uniformly distributed cracks, indicating improved stress distribution and crack control. Similarly, the CRB-SMA specimen exhibited the most refined crack pattern, demonstrating enhanced crack control and ductility owing to the self-prestressing effect of the Fe-SMA strip.

Table 1: Summary of flexural testing result.

Beam Specimen	First Cracking Load (kN)	Ultimate Load (kN)	Ultimate Load Recovery (%)	Maximum Deflection (mm)	Failure Mode
CB	4.49	61.87	—	8.34	Flexural
CRB	4.61	45.98	0	5.72	Flexural
CRB-CFRP	6.84	56.33	22.5	8.20	Flexural
CRB-SMA	13.40	57.30	24.6	8.04	Flexural

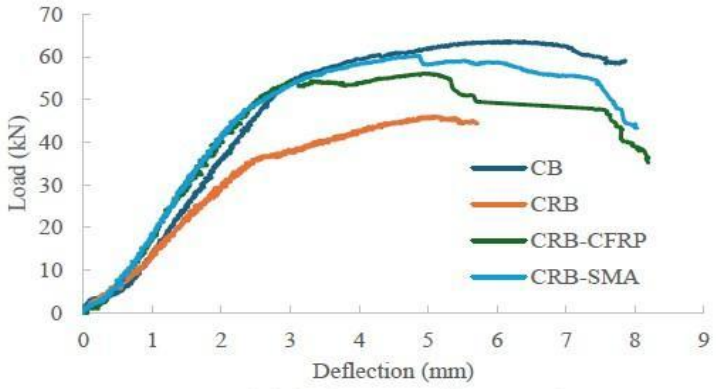


Figure 4: Load-deflection curve.

5.0 CONCLUSION

This study demonstrated the effectiveness of NSM CFRP and Fe-SMA strips as innovative strengthening systems for corrosion-damaged RC beams. Corrosion significantly reduced the flexural performance of the beams, while NSM strengthening systems successfully restored the structural capacity and improved crack control. Among the two systems, NSM Fe-SMA achieved the highest load recovery and exhibited superior ductility due to its self-prestressing capability. These findings highlight the potential of NSM Fe-SMA as a sustainable and practical solution for extending the service life of deteriorated reinforced concrete structures.

ACKNOWLEDGEMENT

This research was funded by the Fundamental Research Grant Scheme (FRGS) under the Ministry of Higher Education (KPT) Malaysia with the grant No. FRGS/1/2024/TK06/UITM/02/5. Special thanks are extended to the Faculty of Civil Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, for their essential support and assistance during this research work.

REFERENCES/ RUJUKAN

Al-Huri, M. A., Al-Osta, M. A., & Ahmad, S. (2022). Finite element modelling of corrosion-damaged RC beams strengthened using the UHPC layers. Materials, 15(21), Article 7606. https://doi.org/10.3390/ma15217606

Biswas, R. K., Saito, T., Misawa, T., & Iwanami, M. (2023). Structural behavior of severely corroded RC beams retrofitted with UHPC layer: An experimental study. Innovative Infrastructure Solutions, 8(12). https://doi.org/10.1007/s41062-023-01295-3

Ganesh, P., & Murthy, A. R. (2019). Repair, retrofitting and rehabilitation techniques for strengthening of reinforced concrete beams: A review. Advances in Concrete Construction, 8(2), 101–117. https://doi.org/10.12989/ACC.2019.8.2.101

Ghafoori, E., Wang, B., & Andrawes, B. (2022). Shape memory alloys for structural engineering: An editorial overview of research and future potentials. Engineering Structures, 273, Article 115138. https://doi.org/10.1016/j.engstruct.2022.115138

Izadi, M. R., Ghafoori, E., Shahverdi, M., Motavalli, M., & Maalek, S. (2018). Development of an iron-based shape memory alloy (Fe-SMA) strengthening system for steel plates. Engineering Structures, 174, 433–446. https://doi.org/10.1016/j.engstruct.2018.07.073

Jahami, A., & Issa, C. A. (2024). An updated review on the effect of CFRP on flexural performance of reinforced concrete beams. International Journal of Concrete Structures and Materials, 18(1). https://doi.org/10.1186/s40069-023-00651-y

Siddika, A., Mamun, M. A. Al, Alyousef, R., & Amran, Y. H. M. (2019). Strengthening of reinforced concrete beams by using fiber-reinforced polymer composites: A review. Journal of Building Engineering, 25, Article 100798. https://doi.org/10.1016/j.jobe.2019.100798

Strieder, E., Aigner, C., Petautschnig, G., Horn, S., Marcon, M., Schwenn, M., Zeman, O., Castillo, P., Wan-Wendner, R., & Bergmeister, K. (2019). Strengthening of reinforced concrete beams with externally mounted sequentially activated iron-based shape memory alloys. Materials, 12(3), Article 345. https://doi.org/10.3390/ma12030345

Tiwary, A. K., Singh, S., Kumar, R., Sharma, K., Chohan, J. S., Sharma, S., Singh, J., Kumar, J., & Deifalla, A. F. (2022). Comparative study on the behavior of reinforced concrete beam retrofitted with CFRP strengthening techniques. Polymers, 14(19), Article 4024. https://doi.org/10.3390/polym14194024

Triantafyllou, G., Rousakis, T., & Karabinis, A. (2019). Corroded RC beams at service load before and after patch repair and strengthening with NSM CFRP strips. Buildings, 9(3), Article 67. https://doi.org/10.3390/buildings9030067

Zheng, A., Liu, Z., Li, F., & Li, S. (2021). Experimental investigation of corrosion-damaged RC beams strengthened in flexure with FRP grid-reinforced ECC matrix composites. Engineering Structures, 244, Article 112779. https://doi.org/10.1016/j.engstruct.2021.112779

PLANTPAL

Ahmad Haikal Bin Muhammad Fauzi[1,*], Nur Aini Binti Mohamed[1], Nur Amalin Binti Bongsu[1], Hafiy Al-Fateh Bin Zainul Anuar[1] , Nurul Afiqah Binti Ahmad Nasrul[1]

[1]Kolej MARA Seremban, Jalan Aminuddin Baki, 70100 Seremban, Negeri Sembilan

*Corresponding author: ahmadddhaikal@gmail.com

ABSTRACT

The implementation of technology in gardening systems has brought numerous benefits that cater to the needs of both hobbyists and commercial growers, especially in addressing pressing global challenges (GrowerTalks, 2022). Studies show that indoor gardening significantly improves air quality, boosts mental well-being, and addresses urban food security through highly efficient, sustainable agricultural methods. However, as urban areas continue to develop, shrinking living spaces have posed challenges to enthusiasts of this increasingly popular hobby. Reports claim that conventional gardening approaches are often slow and labour-intensive to practice in confined spaces, with the average size of a micro house nowadays typically under 37 m² (400 sq. ft.).

To support the unprecedented growth of indoor gardening, the use of artificial intelligence with the integration of Internet of Things (IOT) has been considered to tackle this challenge. Here is a glimpse into the future within our very own backyard sanctuaries: a PlantPal application (APP) was developed to display the real-time profiles of environmental factors, including temperature, humidity, and light intensity, through a built-in device equipped with sensors including DHT11 and BH1750.

Through image recognition, PlantPal will recommend a suitable location based on the user's plant species and suggest a suitable agricultural method, including aquaponics, hydroponics, vertical gardening, and hanging gardens. Through this advancement, urban gardeners can optimize their limited spaces without influencing household finances, as it reduces the need to care for the plant.

This innovation contributes to both amateur and professional gardeners by maximizing yields while minimizing environmental impact and aligns with the United Nations Sustainable Development Goals (SDG), particularly SDG11 (Sustainable cities and communities) and SDG12 (Responsible consumption and production).

Keywords: Temperature and humidity DHT11, Light intensity BH1750, Application (APP)

1.0 INTRODUCTION

This project proposes the development of an intelligent mobile application that assists users throughout the entire plant-care journey, from selecting an appropriate plant and identifying the best placement location to monitoring plant health and providing personalized maintenance recommendations. The application integrates artificial intelligence, computer vision, environmental analysis, and augmented reality technologies to create a comprehensive and user-friendly plant management system through its main feature, the “Smart Plant Placement System”. Users can obtain the intended value from the Plantpal device into their application. The application will analyse factors such as natural light exposure, temperature conditions, and humidity levels. Based on these environmental factors, the system will recommend the most suitable location for a particular plant species. The application may also provide suitable agricultural methods.

2.0 OBJECTIVE

1. To promote sustainable urban living and environmental awareness by encouraging successful indoor gardening practices, increasing urban greenery, and educating users on responsible plant care.
2. To develop an intelligent indoor plant management application that assists users in selecting and placing indoor plants through the integration of artificial intelligence and smart technologies.

3.0 METHODOLOGY

3.1 DESIGN

This study adopted a research and development (R&D) design, which is an experimental approach because the aim is to develop and evaluate PlantPal. The study focused on testing its functionality and evaluating its ability to provide suitable plant placement recommendations based on indoor environmental conditions. This design was selected because it allows both the creation of a product and the assessment of its effectiveness.

3.2 MATERIALS USE

Hardware components:

1) DHT11

   It is a temperature and humidity sensor to measure in a room. It provides free space by combining two different measurements with their own devices. Capacitance is used for the moisture of the surroundings, and a thermistor for temperature by its resistance.

2) BH1750

   A light sensor measures the light intensity in lux as its unit. This provides a large range of values to detect, from its minimum of 1 lux to a maximum of 65535 lux. The photodiode inside it senses light and then converts it to electricity. The electricity produced is also directly proportional to the light intensity.

3) LCD

   To display real-time data taken from the two sensors (DHT11 & BH1750) clearly for the user to monitor.

4) Arduino UNO

   It is a microcontroller board that provides the energy in order for the two sensors (DHT11 & BH1750) to operate. Compatible with Arduino IDE to store data taken by the two sensors, which provides a self-operating feature without being connected to a laptop to program the code.

Table 1: The component and cost.

Component	**Cost(RM)**
DHT11	5.00
BH1750	7.90
LCD	11.10
Arduino UNO	23.20
Breadboard	4.00
Jumper wire	3.00
Total Cost	**54.20**

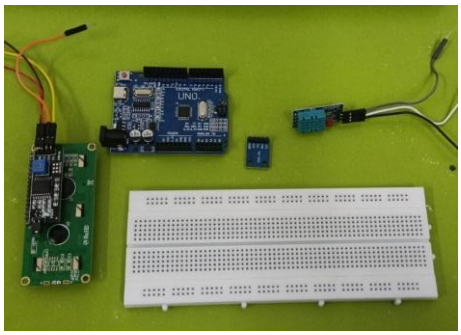


Figure 1: The components.

3.3 DATA COLLECTION

Environmental data were collected using the PlantPal prototype consisting of an Arduino UNO microcontroller connected to a DHT11 temperature-humidity sensor and a BH1750 light intensity sensor. Three environmental parameters, namely temperature (°C), relative humidity (%) and light intensity (lux), were recorded to evaluate the effectiveness of PlantPal. Measurements were taken from three different indoor locations with varying lighting conditions:

(1) a shaded corner (2) beneath artificial lighting (3) near a window exposed



Figure 2: Data collected from three different locations.

A cactus was selected as the sample plant because of its well-established environmental requirements and tolerance to different indoor conditions. Each location was scanned individually, and the sensor readings were displayed on the LCD before being transmitted to the PlantPal application for AI-based environmental assessment.

3.4 DATA ANALYSIS

The environmental data collected from each location were analysed using the PlantPal application. Temperature, humidity, and light intensity values were processed by the AI recommendation system, which compared the measured environmental conditions with the optimum growth requirements stored for the selected plant species.

For this study, cactus was used as the reference plant. The AI evaluated each location by analysing the suitability of its environmental conditions and generated a recommendation indicating the most appropriate placement.

The location producing environmental values closest to the plant's preferred growing conditions was identified as the optimal placement. The recommendation generated by the AI was then compared with the actual environmental readings to validate the effectiveness of the PlantPal system.

Table 2: The cactus plant.

Location	**Temp**	**Humidity**	**light**	**Result**
Corner	28	57	17	Unsuitables
Artificial light	28	88	88	Most suitable
Near window	28	57	199	Moderately suitable

3.5 JUSTIFICATION

Agile is the approach chosen for the methodology of the PlantPal application and sensor. This is due to PlantPal having the flexibility to change and further develop when new issues arise. Agility opens pathways to discovering new ways to improve while understanding the improvement cycle. After further testing, improvement, and development, PlantPal can be polished in terms of its system, coding,

minimising the space required for components, and enhancing the aesthetics and functionality of its application.

These processes work in parallel to resolve issues at the early stages of innovation by adding new features or refining old models catered to consumer suitability. This approach ensures the satisfaction of end users without having to create new product evolutions that stray from customer motives. To conclude, Agile proves that PlantPal's progression provides the best workflow for resolving the problems experienced by urban gardeners and enhancing the capabilities of plants to survive in their outward nature.

4.0 RESULT

PlantPal is an intelligent indoor plant management application that recommends suitable plant species and optimal placement based on indoor environmental conditions. The application simplifies plant selection and care by providing personalised recommendations instead of relying on general guidelines.

The main advantage of PlantPal is its ability to help users maintain healthier indoor plants while reducing time, effort, and the risk of incorrect plant placement. Its potential impact includes promoting sustainable indoor gardening and increasing awareness of proper plant care in urban areas.

The novelty of PlantPal lies in its personalised recommendation system, which analyses environmental conditions using sensors and matches them with the best surrounding requirements of different plant species. This provides users with practical and accurate recommendations tailored to their indoor environment.

5.0 CONCLUSION

PlantPal demonstrates success in collecting data on the surroundings from the device and determining the best spots for the plant with integrated AI in PlantPal's app. The system is able to differentiate between the three locations to make a deduction based on the temperature, relative humidity, and light intensity. This shows the possibility of smart agriculture approaches on a larger scale, like monitoring and managing plantations with an inexpensive cost of production. Plus, using economically available and inexpensive components gives a wider option other than household, such as in educational institutions and small-scale agriculture. Further enhancement for the device: a more compact and portable device with less weight and extended range detection.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our supervisor teacher for valuable guidance and continuous support throughout the development of the PlantPal project.

Not to forget our friends and family who generously shared their knowledge and provided technical assistance during the Arduino hardware setup and programming process; we truly appreciate that.

Finally, we are grateful to many YouTube content creators who produced clear and informative tutorials on Arduino programming and project development. Their educational concepts clearly assisted us in overcoming technical challenges and expanding our understanding throughout the project.

REFERENCES/ RUJUKAN

1. Journal Paper:

Wang, X., Li, Y., Zhang, C., & Chen, J. (2022). *Plant identification based on deep learning and mobile applications*. In *Adjunct Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology (UIST '22 Adjunct)*. Association for Computing Machinery

Ghimire, S., Lamsal, R., Sankuratri, A., Lakkarsu, P., & Vutla, S. (2026). Artificial intelligence-driven plant disease detection and diagnosis: A comprehensive review of deep learning approaches, multimodal sensing technologies, and future perspectives in precision agriculture.

Mäder, P., Boho, D., Rzanny, M., Seeland, M., Wittich, H. C., Deggelmann, A., & Wäldchen, J. (2021). *The Flora Incognita app – Interactive plant species identification*. **Methods in Ecology and Evolution, 12**(7), 1335–1342

2. Online Publications:

https://open.substack.com/pub/flossyfay/p/how-to-start-a-research-project?r=5fxan2&utm_medium=ios

CROWDSOURCED GEOTAGGED REPORTING SYSTEM

Chang Zi Wei[1,*], Choong Qian Er[1], Shaffika Bte Mohd Suhaimi[1]

[1]Southern University College (SUC), PTD 64888, KM15, Jalan Skudai, 81300 Skudai, Johor, Malaysia

*Corresponding author:B250049A@sc.edu.my

ABSTRACT

Non-emergency incidents such as potholes, faulty street lighting, illegal dumping, vandalism, traffic obstruction, and public disturbances steadily erode the quality and safety of urban life in Malaysia. These issues are still reported mainly through telephone hotlines, e-mails, or in-person visits to municipal counters and police stations channels that are slow, fragmented across agencies, and often produce incomplete or inaccurate information. Reports frequently lack a precise location, arrive in a single language in a multilingual society, and offer citizens no feedback, which discourages participation and leaves recurring problems unresolved. This project proposes an AI-powered crowdsourced geotagged reporting system with two connected interfaces: a citizen mobile application and a web-based command dashboard for law enforcement and local authorities. Residents can log an incident in under 180 seconds using automatic GPS location, photo evidence, and guided multilingual input. The system is driven by four artificial-intelligence capabilities: (1) multilingual AI voice reporting that converts spoken reports in Malay, English, or Chinese into text; (2) AI photo analysis that recognises the incident type, estimates its severity, and verifies that the photo matches the description to deter false submissions; (3) AI classification and routing that categorises each report, assigns a priority level, rewrites it into a standard record, and directs it to the correct department; and (4) an AI heat-map dashboard that identifies incident hotspots and generates natural-language patrol and dispatch recommendations. Demonstrated in the context of Johor, the system improves the speed, accuracy, and accessibility of reporting while strengthening authorities' coordination and resource deployment. It supports Sustainable Development Goal 11 Sustainable Cities and Communities by helping build safer, smarter, and more sustainable urban environments.

Keywords: crowdsourced reporting, geotagging, artificial intelligence, public safety, smart cities

1.0 INTRODUCTION

Rapid urbanisation across Malaysian cities has been accompanied by a rising volume of non-emergency public-safety and municipal problems: damaged roads and potholes, faulty street lighting, illegal dumping, vandalism, traffic obstruction, and public disturbances. Individually minor, these incidents accumulate to degrade road safety, public order, and residents' confidence in local governance (Abdullah et al., 2026).

At present, most residents report such problems through telephone hotlines, e-mails, social-media posts, or in-person visits to municipal councils and police stations. These conventional channels are slow and labor-intensive; reports are frequently logged without an accurate location; information is scattered across different agencies with weak coordination; and citizens rarely receive any confirmation or status update. In a multilingual society where residents communicate in Malay, English, and Chinese, a single-language reporting channel further discourages participation (Wu, 2020). The combined effect is low citizen engagement, delayed municipal response, and recurring issues that remain unresolved despite repeated complaints.

Crowdsourced, location-aware reporting has emerged internationally as an effective way to close this gap, allowing citizens to act as distributed sensors for their own communities (Goodchild, 2007). However, many existing civic-reporting tools remain one-directional: they collect a report but provide little intelligence to verify it, classify it, or help authorities act on it (King & Brown, 2007). This motivates the system not only to make reporting fast and multilingual for citizens, but also to equip law enforcement and local authorities with an AI-assisted operational picture. The system is designed for Malaysia and demonstrated in the context of Johor, where the authors are based, so that its localisation and impact can be expressed clearly (Lim et al., 2020).

2.0 OBJECTIVE

The objectives of the system are:

1. To enable residents to submit a geotagged non-emergency incident report in under 180 seconds through a mobile application, using photo evidence, automatic GPS location, and multilingual voice or text input.
2. To provide law enforcement and local authorities with a centralised, AI-assisted command dashboard that classifies, prioritises, routes, and maps incoming reports, and recommends patrol and dispatch actions for high-incidence areas.
3. To improve the speed, accuracy, accessibility, and inter-agency coordination of non-emergency incident handling, in support of Sustainable Development Goal 11 (Sustainable Cities and Communities).

3.0 METHODOLOGY

Figure 1 illustrates a crowdsourced geotagged reporting system connecting citizens and police through a single Claude API across four AI capabilities. The architecture consists of six layers.

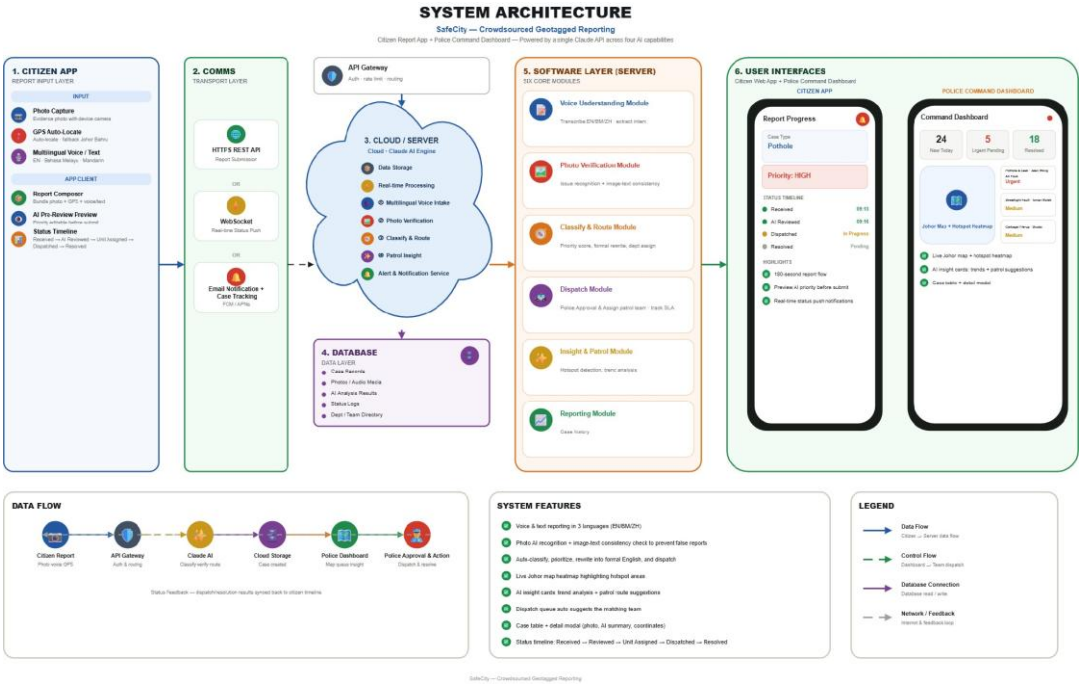


Figure 1: System architecture of the SafeCity crowdsourced geotagged reporting system.

The Citizen App (report input layer) lets users capture evidence photos, auto-locate via GPS with a Johor Bahru fallback, and submit reports by voice or text in English, Bahasa Melayu, or Mandarin. The app client bundles these inputs through a Report Composer, shows an AI pre-review preview with editable priority before submission, and tracks progress through a five-step status timeline:

Received → AI Reviewed → Unit Assigned → Dispatched → Resolved.

The Comms layer transports data via HTTPS REST API for report submission, WebSocket for real-time status pushes, and email notification with case tracking, all passing through an API Gateway that handles authentication, rate limiting, and routing. The Cloud/Server layer, powered by the Claude AI engine, handles data storage, real-time processing, multilingual voice intake, photo verification, classification and routing, patrol insights, and alert/notification services.

The Database layer stores case records, photos/audio media, AI analysis results, status logs, and the department/team directory. The Software layer comprises six core modules: Voice Understanding (EN/BM/ZH transcription and intent extraction), Photo Verification (issue recognition with image-text consistency), Classify & Route (priority scoring, formal rewriting, department assignment), Dispatch (police approval and patrol team assignment with SLA tracking), Insight & Patrol (hotspot detection and

trend analysis), and Reporting (case history). Finally, the User Interfaces include the citizen web app (a 60-second report flow with AI priority preview and real-time status updates) and the Police Command Dashboard (live Johor map with hotspot heatmap, AI insight cards, case statistics, and a case table with detail modal). The overall data flow runs:

Citizen Report → API Gateway → Claude AI → Cloud Storage → Police Dashboard → Police Approval & Action;

with dispatch and resolution results synced back to the citizen's status timeline as feedback. Human-in-the-loop officer approval is required before dispatch, and the system supports multilingual reporting, false-report prevention through image-text consistency checks, and AI-driven patrol route suggestions.

4.0 RESULT

As an interactive prototype, the system demonstrates the following expected outcomes. On the citizen side, the guided multilingual flow allows an incident to be reported in under 180 seconds with an accurate, automatically captured location, which is expected to raise participation and data quality relative to hotline or e-mail reporting (Figure 2).

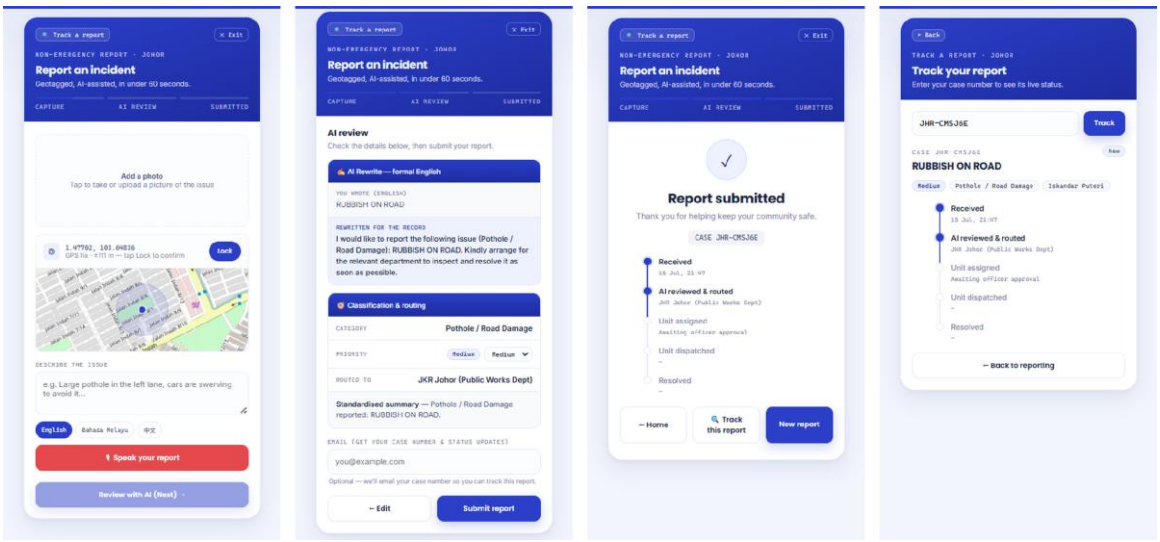


Figure 2: Citizen reporting flow: geotagged capture, AI review with formal-English rewrite, submission with case number, and live status tracking.

On the authority side, automatic classification, prioritisation, and routing shorten the time from report to the responsible department, while the hotspot heat-map and patrol recommendations support data-driven deployment of limited enforcement resources (Figure 3).

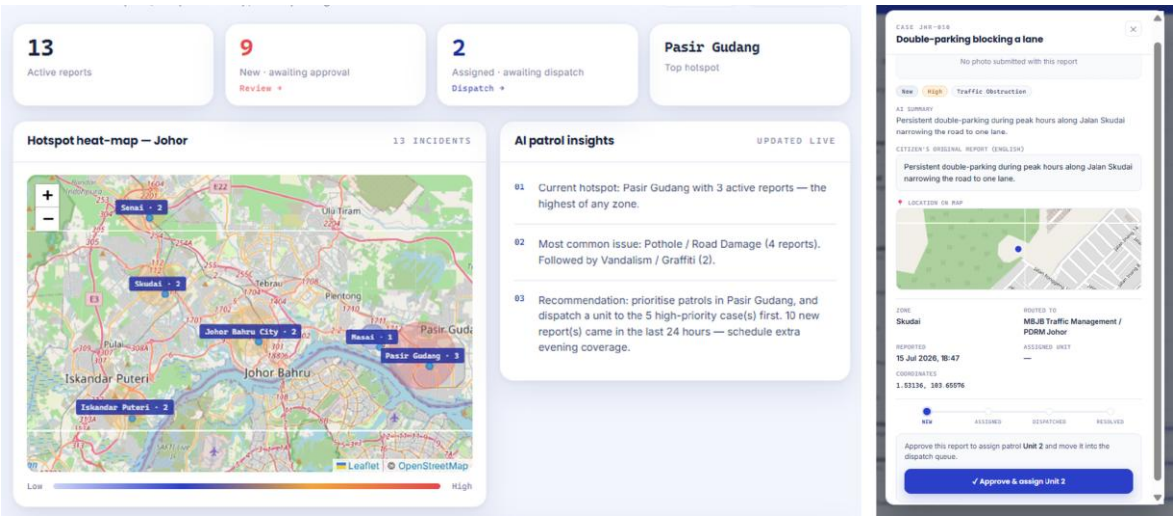


Figure 3: Police command dashboard hotspot heat-map with AI patrol insights (left) and case detail with human-in-the-loop officer approval (right).

The novelty of the system lies in combining, within a single platform, four capabilities that are usually absent or isolated in existing citizen-reporting tools: multilingual voice reporting, AI photo verification to deter false reports, automatic classification and routing, and AI-generated patrol and dispatch guidance. Where conventional municipal apps and international tools largely provide one-directional reporting (King & Brown, 2007; Wu, 2020), the system closes the loop by linking the citizen report directly to enforcement-side decision support and by adapting to Malaysia's multilingual context.

5.0 CONCLUSION

The system shows how artificial intelligence, geolocation, and crowdsourcing can be integrated to modernise the handling of non-emergency incidents in Malaysian cities, as demonstrated in the context of Johor. Its contribution is threefold: it lowers the barrier to civic participation through rapid multilingual reporting; it improves municipal and enforcement responsiveness through automatic verification, classification, and routing; and it supports smarter allocation of patrol and maintenance resources through hotspot analytics. Economically, reducing manual triage and enabling earlier intervention can lower the cost of handling recurring problems and slow the deterioration of public infrastructure. By strengthening the link between residents and the authorities that serve them, the system contributes to safer, more responsive, and more sustainable urban communities, in line with Sustainable Development Goal 11. Future work will focus on a real deployment pilot with a local authority and integration with existing municipal information systems.

ACKNOWLEDGEMENT

The authors would like to acknowledge Southern University College for providing the funding, resources, and research facilities that enabled the successful execution of this project. Special thanks are extended to the project supervisor and domain expert for their invaluable contributions in shaping the research idea, conceptual framework, motivation, and overall direction of the study. Their continuous guidance and encouragement have been instrumental in the completion of this work.

REFERENCES/ RUJUKAN

Abdullah, A., Roslan, N., Hedayati Marzbali, M., & Maghsoodi Tilaki, M. J. (2026). Spatial correlates of perceived safety: Natural surveillance and incivilities in Bayan Baru, Malaysia. *Urban Science, 10*(1), 44. https://doi.org/10.3390/urbansci10010044

Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. *GeoJournal, 69*(4), 211–221. https://doi.org/10.1007/s10708-007-9111-y

King, S. F., & Brown, P. (2007). Fix my street or else: Using the internet to voice local public service concerns. *Proceedings of the 1st International Conference on Theory and Practice of Electronic Governance (ICEGOV '07)*, 72–80. https://doi.org/10.1145/1328057.1328076

Lim, S. B., Abdul Malek, J., Hussain, M. Y., & Tahir, Z. (2020). Participation in e-government services and smart city programs: A case study of Malaysian local authority. *Planning Malaysia, 18*(13). https://doi.org/10.21837/pm.v18i13.794

Wu, W.-N. (2020). Determinants of citizen-generated data in a smart city: Analysis of 311 system user behavior. *Sustainable Cities and Society, 59*, 102167. https://doi.org/10.1016/j.scs.2020.102167

MALAYSIA CULTURAL HERITAGE LENS

Soh Shen[1], Lee Wen Zhe Dickson[1], Sim Zhe An[1], Shaffika Bte Mohd Suhaimi[1]

[1]PTD 64888, Jalan Selatan Utama, KM 15, Off, Skudai Lbh, 81300 Skudai, Johor Darul Ta'zim

*Corresponding author: B250104A@sc.edu.my

ABSTRACT

Malaysia has many cultural stories shown in daily life, such as food, festivals, clothes, crafts, and family traditions. UNESCO recognized Malaysia's breakfast culture as intangible cultural heritage in 2024, while Mek Mulung was listed as a heritage element that needs urgent safeguarding. This shows that Malaysian culture should not only be celebrated during special events but also recorded and shared in a way that younger users can understand. However, the younger generation may have difficulties in identifying the facts from the elements they observe. Plus, they do not have a valid person to ask and verify their knowledge. Malaysia Cultural Heritage Lens is an AI and mobile AR platform for cultural story sharing. Users can write short posts of up to 200 words; upload culture-related pictures or use AI assistance for picture generation with AI labels, and place them under category of Malay, Chinese, Indian or other culture. The platform supports SDG 4 because it encourages learning about cultural diversity. The system uses Google Gemini API for text and image analysis. AI helps to check grammar, detect unsuitable or biased content, and recognize cultural items in uploaded pictures before the post is shown publicly. The app is designed for mobile, touch and multimedia interaction because users browse stories, tap buttons, upload images and read short content on the phone. The AR feature allows users to scan a cultural object with the smartphone camera and view labels, such as the object name, culture category and meaning. Users can like, love, share or flag a post instead of writing comments, so the platform stays focused on positive sharing.

Keywords: culture sharing, ai verification, malaysian culture, cultural awareness, digital platform

1.0 INTRODUCTION

Malaysia has different forms of cultural heritage, including food traditions, festivals, performing arts and traditional crafts. Intangible cultural heritage includes living traditions and expressions that are passed from one generation to another. It also gives communities a sense of identity and continuity (UNESCO, 2003). In Malaysia, UNESCO has recognised breakfast culture as intangible cultural heritage, while Mek Mulung is listed as an element that needs urgent safeguarding (UNESCO, 2023, 2024). These examples show why Malaysian cultural knowledge should continue to be recorded and shared with future generations.

Albattat et al. (2016) found that most university students in their study had limited knowledge of traditional dances in Sarawak. This finding suggests that some young people may not be familiar with the names, origins or meanings of local cultural practices. Based on this issue, the proposed platform brings short cultural stories, pictures and basic explanations into one place.

A mobile application was selected as a practical way to deliver this cultural information. In Malaysia, mobile phone usage reached 99.5%, while Internet usage reached 98.0% in 2024 (Department of Statistics Malaysia, 2025). These high usage rates suggest that a mobile platform can be accessible to many members of the public. Guest users can browse cultural stories without creating an account, while only Admin users need to log in to create and manage posts. The project also relates to SDG 4 by providing an accessible way to learn about cultural diversity.

Therefore, this project proposes Malaysia Cultural Heritage Lens, an AI-assisted mobile AR platform for cultural learning and story sharing. The prototype allows users to browse cultural

categories, read short stories, scan cultural objects and interact with published posts. Admin users can create a cultural story and review its content before publication. By combining cultural stories, AI assistance and mobile AR, the prototype is designed to offer a more interactive way to discover and understand Malaysia's cultural heritage.

2.0 OBJECTIVE

The main objective of this project is to design a mobile application prototype that helps users to learn about and share Malaysia's cultural heritage. The specific objectives are:

To design a clear mobile navigation flow where Guest users can browse cultural stories and Admin users can log in to create and manage posts.

To show how AI assistance can check grammar, sensitive content, and cultural information before publication, and generate an AI-labelled supporting image when no picture is uploaded.

To present an AR interaction where the Guest can scan a cultural object and receive its suggested name, category, and meaning.

3.0 METHODOLOGY

The prototype was designed using a simplified System Development Life Cycle (SDLC), which included requirement analysis, system and prototype design, and prototype development. These stages were used to identify the users and functions, prepare the system flow, design the mobile screens, and review the overall prototype.

3.1 REQUIREMENT ANALYSIS

During the requirement analysis stage, the target users and main functions of the platform were identified. The system has two types of users: Guest and Admin. Guest users can browse cultural stories, search by cultural category, and use the AR Scan without logging in. Admin users need to log in before they can create, upload, and manage cultural posts.

The main requirements were identified based on the project objectives and the planned user flows. The platform should be simple and interactive, especially for teenagers and younger users. Cultural stories can include food, clothing, festivals, history, crafts, and personal cultural experiences. Open comments are not included to reduce negative discussions. Instead, users can use the Like, Love, Share and Flag functions.

3.2 SYSTEM AND PROTOTYPE DESIGN

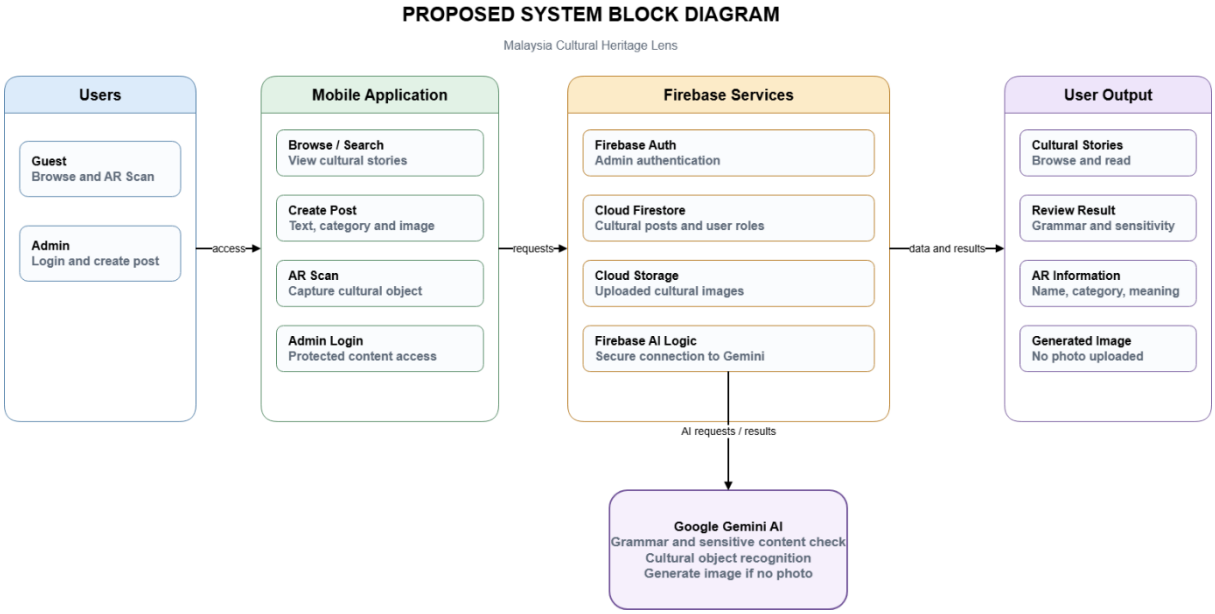


Figure 1: Proposed system block diagram for Malaysia Cultural Heritage Lens.

The proposed system design consists of the mobile application, Firebase services, Google Gemini AI and mobile AR. Flutter is proposed for the development of the mobile application. Firebase Authentication manages the Admin login, while Cloud Firestore stores cultural stories and user roles. Cloud Storage is used for uploaded images. Firebase AI Logic connects the mobile application to Google Gemini AI.

Google Gemini AI is the significant technology proposed for the platform. When an Admin creates a story, the AI checks grammar, spelling and sensitive content before the post is approved. The AI can also analyse an uploaded picture and suggest its cultural object or category. If the Admin does not upload a picture, an optional AI-generated image can be provided. The generated picture must include an AI label before it is published.

The mobile AR function supports cultural learning through object scanning. A Guest user points the smartphone camera at a cultural object, and the captured image is sent through Firebase AI Logic to Google Gemini AI. The AI analyses the image and returns the suggested object name, cultural category and a short explanation. The result is then displayed on the AR screen together with related cultural stories.

3.2.1 GUEST ACCESS

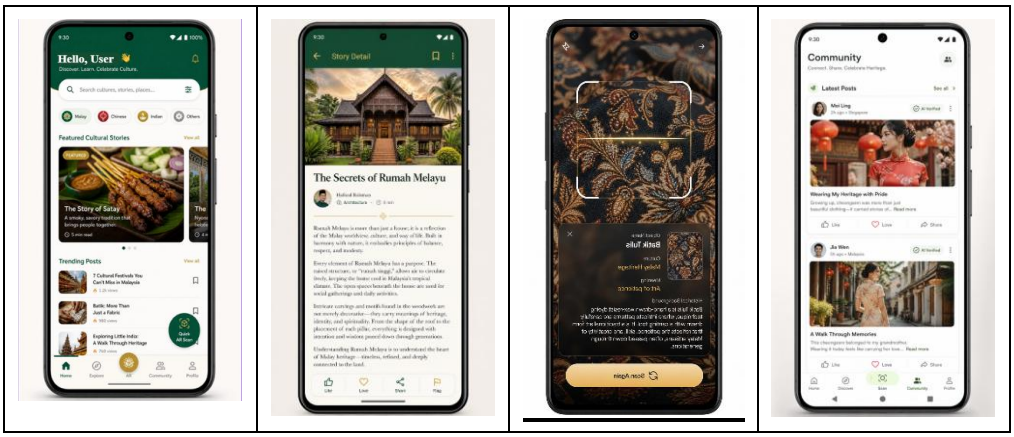


Figure 2: Guest screens: Homepage, Story Detail Page, AR Scan pages and Community Page.

A mobile prototype was designed to demonstrate the main user flows. The Guest screens include the Home, Story Detail, AR Scan pages, and Community. From these screens, Guest users can search for stories, browse cultural categories, read cultural information, interact with published posts, and also AR scan the object, then can detect the cultural detail and view related culture.

3.2.2 ADMIN ACCESS

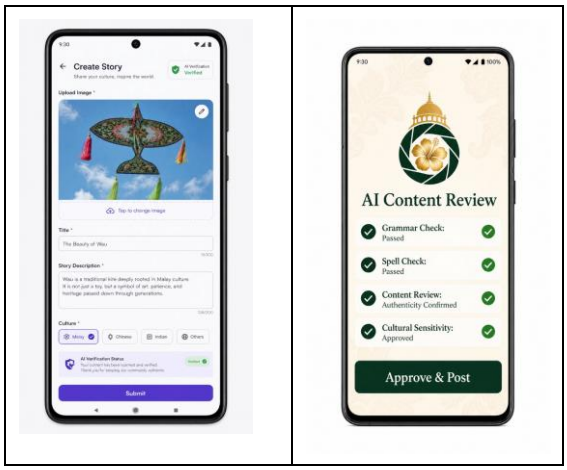


Figure 3: Admin screens: Create Story Page and AI Content Review Page.

The Admin screens include Admin Login, Create Story, and AI Content Review. An Admin can upload an image, enter a title, write a description of up to 200 words, and select a cultural category. Before publication, the AI Content Review screen displays the grammar and sensitive-content checking results for the Admin to review.

3.3 PROTOTYPE DEVELOPMENT

During the prototype development stage, the designed screens were connected to present two main user flows. The Guest flow includes browsing cultural categories, opening a cultural story, and accessing the AR Scan. The Admin flow includes Admin Login, image upload, story creation,

category selection and AI Content Review. These screens demonstrate how Guest and Admin users can complete the main tasks in the proposed mobile application.

4.0 RESULT

A prototype of Malaysia Cultural Heritage Lens was completed with the Home, Story Detail, Community, AR Scan, Admin Login, Create Story and AI Content Review screens. Guest users can browse cultural stories and access the AR Scan without logging in, while Admin users can log in to create and manage cultural posts.

The completed prototype presents two main user flows. In the Guest flow, users can select a cultural category, open a story and access the AR Scan to view the suggested name, category and meaning of a cultural object. In the Admin flow, users can log in, upload an image, enter the story details, select a category and continue to the AI Content Review page.

5.0 CONCLUSION

In conclusion, Malaysia Cultural Heritage Lens is a mobile application prototype designed for cultural learning and story sharing. Guest users can browse cultural stories and access the AR Scan without creating an account, while Admin users can log in to create and manage cultural posts. The prototype combines short cultural stories, AI-assisted content review, optional AI-generated images and mobile AR in one platform. It provides a more accessible and interactive way for users to discover and share Malaysia's cultural heritage while supporting SDG 4.

ACKNOWLEDGEMENT

The authors would like to acknowledge Southern University College for providing the funding, resources, and research facilities that enabled the successful execution of this project. Special thanks are extended to the project supervisor and domain expert for their invaluable contributions in shaping the research idea, conceptual framework, motivation, and overall direction of the study. Their continuous guidance and encouragement have been instrumental in the completion of this work.

REFERENCES/RUJUKAN

Albattat, A. R., Amir, I. D., & Nik Muhammad, N. S. (2016). Students awareness towards traditional cultural dances in Sarawak, Malaysia. Almatourism—Journal of Tourism, Culture and Territorial Development, 7(13), 117–128. https://doi.org/10.6092/issn.2036-5195/5886

Department of Statistics Malaysia. (2025, April 24). ICT use and access by individuals and households survey report, 2024. https://www.dosm.gov.my/index.php/portal-main/release-content/ict-use-and-access-by-individuals-and-households-survey-report-2024

UNESCO. (2003). Convention for the safeguarding of the intangible cultural heritage. https://ich.unesco.org/en/convention

UNESCO. (2023). Mek Mulung. https://ich.unesco.org/en/USL/mek-mulung-01610

UNESCO. (2024). Breakfast culture in Malaysia: Dining experience in a multi-ethnic society. https://ich.unesco.org/en/RL/breakfast-culture-in-malaysia-dining-experience-in-a-multi-ethnic-society-02113

CROWDSOURCED "ADORN AND MAINTAIN" SITE MONITORING APP

Lee Chen Yi[1,*], Wong Yong Zhen[1], Shaffika Mohd Suhaimi[1]

[1]Southern University College,PTD 64888, KM15, Jalan Skudai, 81300 Skudai, Johor, Malaysia

* Corresponding author: B250001A@sc.edu.my

ABSTRACT

Tangible heritage sites such as historical buildings, monuments, and cultural landmarks represent valuable cultural assets that preserve a nation's history, identity, and traditions. In Malaysia, particularly with the implementation of Visit Johor Year 2026, effective heritage preservation has become increasingly important to support sustainable tourism growth and community development. However, municipal councils face significant challenges in continuously monitoring heritage sites due to limited manpower, financial constraints, and the increasing number of sites requiring maintenance. As a result, issues such as structural deterioration, vandalism, and unauthorised modifications are often detected late, leading to costly restoration efforts and irreversible damage. To address these challenges, this project proposes WARISAN, a crowdsourced heritage site monitoring application that enables citizens, local communities, and tourists to actively participate in preserving tangible heritage assets. The system is developed as a mobile web application that allows users to submit reports containing photographs, descriptions, and GPS coordinates of observed issues. An integrated Artificial Intelligence (AI) image analysis module assists users by automatically suggesting report categories based on the uploaded images. All reports are securely stored in a cloud-based database and displayed through a centralised dashboard accessible to municipal councils for monitoring, verification, prioritisation, and maintenance planning. In addition, WARISAN incorporates a gamification-based reward mechanism using points, badges, and community recognition to encourage active public participation. The proposed solution facilitates real-time issue reporting, improves communication between stakeholders and local authorities, and promotes stronger community engagement in heritage conservation. Ultimately, WARISAN offers a sustainable digital approach to proactive heritage site maintenance and long-term cultural preservation.
Keywords: tangible heritage, crowdsourcing, heritage preservation, ai image analysis, community participation

1.0 INTRODUCTION

Tangible heritage sites such as historical buildings, monuments, and cultural landmarks preserve national history, identity, and cultural value (Harun, 2011; Ariffin et al., 2023; Ismail et al., 2014). In Malaysia, protecting these assets also supports heritage tourism and wider tourism development (Harun, 2011; Ismail et al., 2014; Aisyah, 2023). However, many sites face weak maintenance, poor coordination, and development pressures, which can lead to decay and loss of heritage value (Ismail et al., 2014; Aisyah, 2023). Community involvement and integrated management are important for more effective preservation (Ariffin et al., 2023; Aisyah, 2023; Harun, 2011). Therefore, WARISAN is proposed as a mobile web crowdsourced application to support faster reporting and more proactive monitoring of tangible heritage sites.

2.0 OBJECTIVE

The objectives of this project are:

- To develop a crowdsourced mobile web application for reporting maintenance and vandalism issues at heritage sites.
- To integrate AI-based image analysis for automated issue categorisation and reporting assistance.
- To provide municipal councils with a centralised dashboard for efficient monitoring and management of reported cases.

3.0 METHODOLOGY

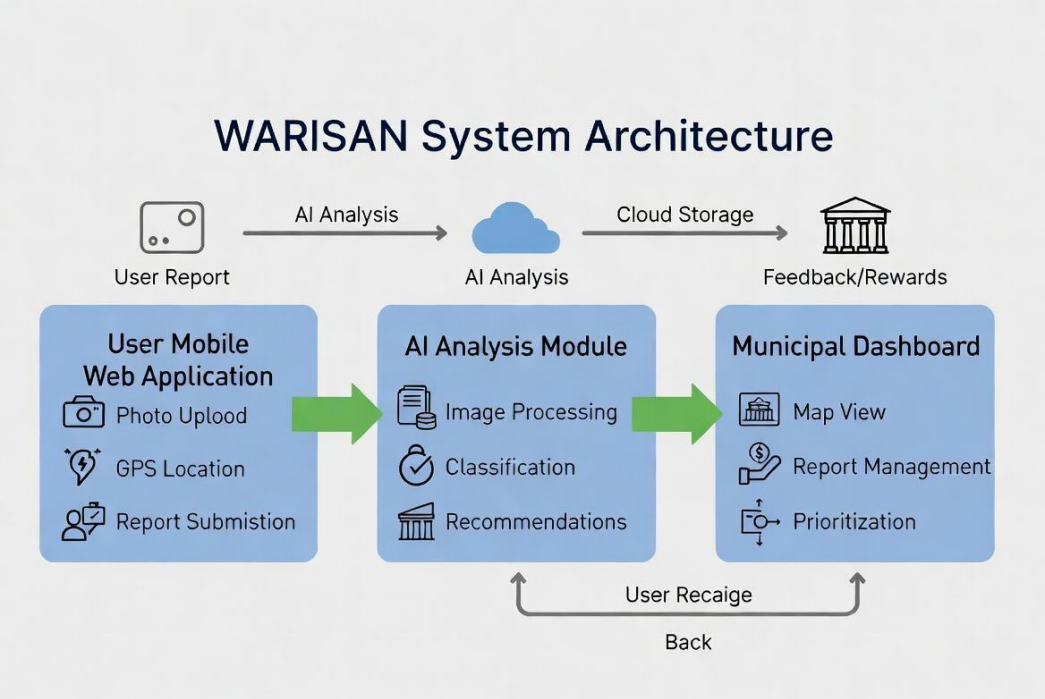


Figure 1: Agile methodology workflow for WARISAN development.

Figure 1 illustrates the overall system architecture of the WARISAN application. Users submit reports through the User Mobile Web Application by uploading photos, capturing GPS locations, and providing descriptions. The reports are then processed by the AI Analysis Module, which performs image processing and automatic classification and provides recommendations. Processed data are stored in the cloud and forwarded to the Municipal Dashboard, where authorities can view reports on a map, manage cases, and prioritize maintenance tasks. The system also supports feedback and rewards to encourage user participation, with a feedback loop back to users.

4.0 INNOVATION PROTOTYPE

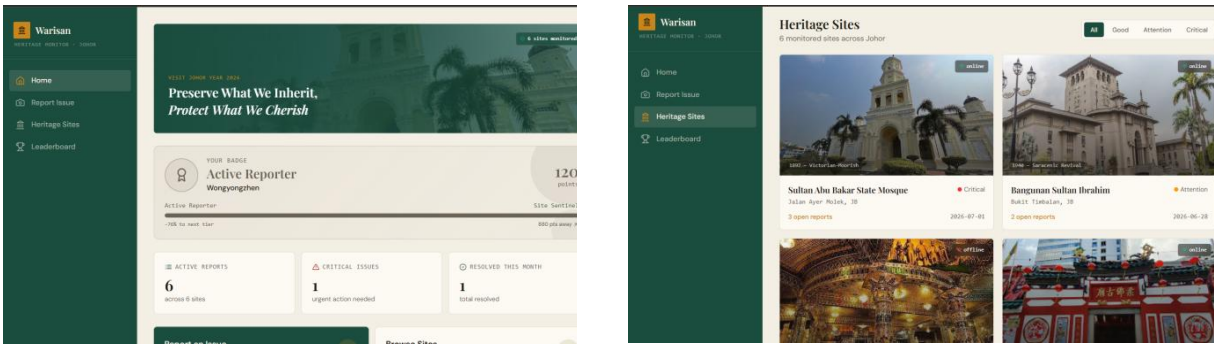


Figure 2: WARISAN Home Page and Heritage Sites Page.

Figure 2 shows the home page of the WARISAN application. The interface provides users with access to heritage site information, issue reporting, reward points, and navigation to other system functions. The heritage sites page provides information on heritage sites in the Johor area. It also includes images to show what they look like.

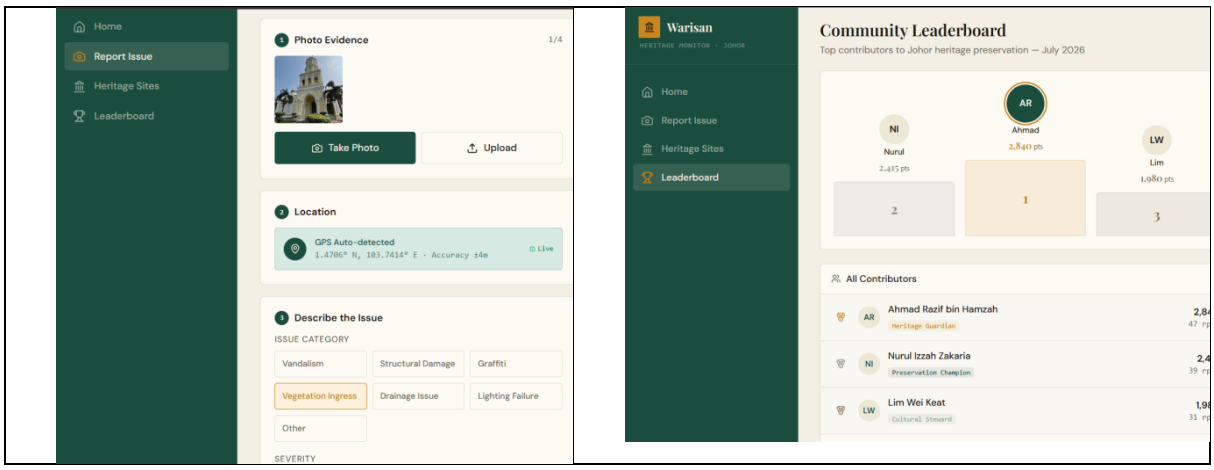


Figure 3: Issue Reporting Page and Community Leaderboard Page.

Figure 3 illustrates the issue reporting interface where users upload photographs, enter descriptions, and submit maintenance reports together with GPS location information. The community leaderboard page displays the points and rankings.

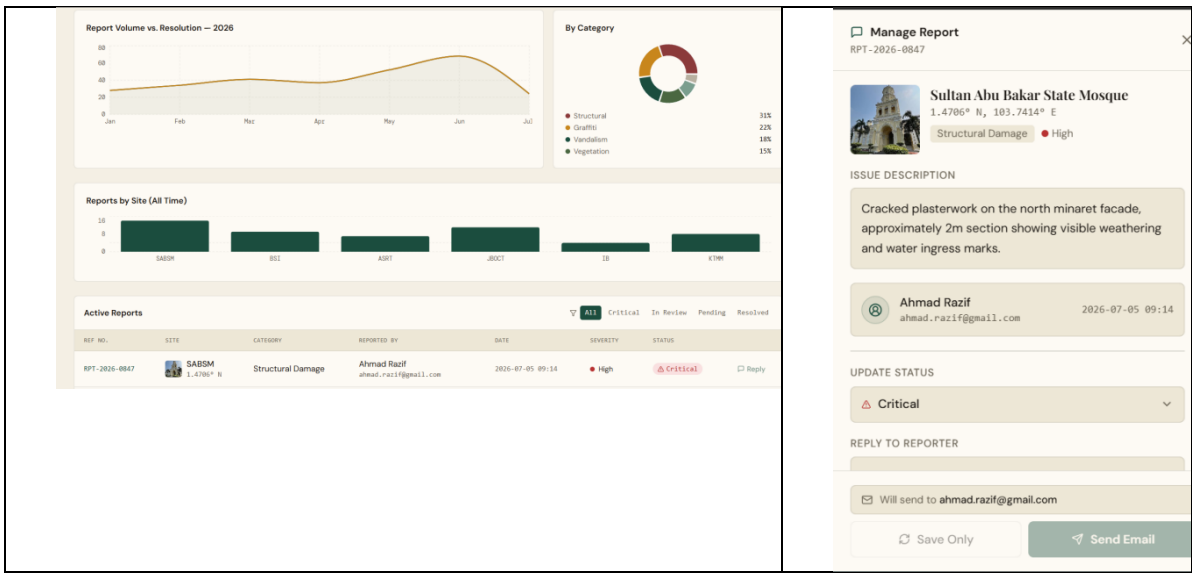


Figure 4: Administrator Dashboard and Reply

Figure 4 presents the administrator dashboard used by municipal councils to review submitted reports, verify issue categories, monitor report status, and prioritise maintenance activities. The reply can submit the updated status and command.

5.0 RESULT

The proposed WARISAN application introduces several innovative features that significantly outperform conventional heritage monitoring methods. Its novelty lies in the seamless integration of crowdsourcing, real-time GPS-enabled reporting, AI-assisted image classification for automatic issue categorisation, and a gamification system that encourages sustained community participation.

These features deliver substantial advantages, including faster detection of maintenance and vandalism issues, reduced reliance on limited municipal inspection resources, improved communication between citizens and authorities, enhanced reporting accuracy, and centralised management of heritage records. Overall, WARISAN is expected to enable proactive maintenance, early intervention, and more efficient resource allocation by municipal councils. Increased public engagement will foster

stronger community ownership of cultural heritage while supporting sustainable tourism by maintaining the attractiveness and condition of heritage sites.

6.0 CONCLUSION

WARISAN presents an innovative digital solution for addressing the challenges of heritage site monitoring and preservation. By combining crowdsourcing, AI-based image analysis, cloud technology, and gamification, the system enables efficient identification and management of maintenance and vandalism issues affecting tangible heritage sites. The platform empowers citizens, tourists, and local communities to actively contribute to heritage conservation while supporting municipal authorities with a centralised monitoring system. Ultimately, WARISAN promotes sustainable heritage management, enhances community engagement, and contributes to the long-term preservation of Malaysia's cultural assets.

ACKNOWLEDGEMENT

The authors would like to acknowledge Southern University College for providing the funding, resources, and research facilities that enabled the successful execution of this project. Special thanks are extended to the project supervisor and domain expert for their invaluable contributions in shaping the research idea, conceptual framework, motivation, and overall direction of the study. Their continuous guidance and encouragement have been instrumental in the completion of this work.

The authors would also like to express their sincere appreciation to all team members for their commitment, collaboration, and continuous support throughout the planning, design, development, and evaluation of the WARISAN system. Their dedication, teamwork, and shared efforts have contributed significantly to the successful completion of this project.

REFERENCES/ RUJUKAN

Aisyah, S. (2023). Implications of Planning and Management for the Development of Sustainable Cultural Heritage Tourism in Malaysia. *Advances in Tourism Studies*. https://doi.org/10.47492/ats.v1i2.18

Ariffin, W. J. W., Noh, N. A., -, M., Ibrahim, A., Ghazalli, F. S., & Rahim, E. M. A. (2023). CITIZEN ENGAGEMENT IN TANGIBLE HERITAGE CONSERVATION STRATEGIES IN TERENGGANU. *PLANNING MALAYSIA*. https://doi.org/10.21837/pm.v21i25.1221

Harun, S. N. (2011). Heritage Building Conservation in Malaysia: Experience and Challenges. *Procedia Engineering, 20*, 41-53. https://doi.org/10.1016/j.proeng.2011.11.137

Ismail, N., Masron, T., & Ahmad, A. (2014). Cultural Heritage Tourism in Malaysia: Issues and Challenges. 01059. https://doi.org/10.1051/shsconf/20141201059

ENHANCING FINANCIAL DISCIPLINE AMONG UNIVERSITY/SCHOOL STUDENTS THROUGH A PARENT-INTEGRATED E-WALLET MONITORING SYSTEM

Jennelle Teo Xin Yun[1,*], Yew Xiang Meng[1], Koot Wen Liang[1], Shaffika Bte Mohd Suhaimi[1], Salbeha Binti Ibus[1]

[1]Southern University College (SUC), PTD 64888, Jalan Selatan Utama, KM 15, Off, Skudai Lbh, 81300 Skudai, Johor Darul Ta'zim

[*]Corresponding author: B250092A@sc.edu.my.

ABSTRACT

As Malaysia continues to develop its digital economy under the Malaysia MADANI initiative, e-wallet applications have become a popular cashless payment method. University/college and secondary students are among the most active users due to the speed, convenience, and accessibility of e-wallets. FINCO's *Money SENse* report also found that most secondary students are already aware of and actively use e-wallets. However, secondary school students still rely on allowances from their parents, who often have limited visibility into their spending. This makes it difficult for parents to monitor expenses and prevent unnecessary purchases. Furthermore, only 28.3% of students demonstrate healthy financial behaviour, highlighting the need for better financial management and parental guidance. Therefore, the project aims to develop a parent-integrated e-wallet system with a mobile GUI that integrates with banks or e-wallet services such as Touch 'n Go to allow parents to monitor their children's spending, set spending limits, receive real-time alerts, and approve or block transactions that exceed the predefined limit, encouraging responsible financial management among students. The system applies real-time transaction monitoring with predefined spending limits. Transactions exceeding the limit trigger a notification, allowing parents to approve or block them through a mobile-friendly interface. The expected outcome of the project is that students will be able to manage their budget within a certain period of time without requiring additional funds. This practice can help students manage their daily expenses. In summary, this system builds student financial discipline through parental monitoring and real-time alerts, with success measured by students' ability to live within their monthly budget without additional funds. This directly supports SDG 12 (Responsible Consumption) by actively cutting down on impulsive buying and overspending, training the younger generation to practice mindful, deliberate consumer habits early in life.

Keywords: E-wallet monitoring system, financial management, university/college and secondary students, digital payment, and parental control.

1.0 INTRODUCTION

Malaysia's digital economy continues to expand under the Malaysia MADANI initiative, with e-wallet applications becoming one of the preferred cashless payment methods (Ministry of Finance Malaysia, 2025). Due to their convenience, speed, and accessibility, e-wallets are widely adopted by university, college, and secondary school students. According to FINCO's *Money SENse* report, most secondary school students are familiar with and actively use e-wallets in their daily lives (FINCO, 2023).

Despite the increasing adoption of digital payments, secondary school students still depend on allowances provided by their parents. Parents often have limited visibility into their children's spending habits, making it difficult to monitor expenses or prevent unnecessary purchases. Furthermore, only 28.3% of students demonstrate healthy financial behaviour, indicating the need for improved financial management and parental guidance (FINCO, 2023). Therefore, a digital solution that enables parental supervision while encouraging financial independence is needed.

2.0 OBJECTIVE

Write the objective(s) to develop the product/innovation idea.

1. To design a parent-integrated e-wallet application with an easy-to-use mobile Graphical User Interface (GUI).
2. To enable parents to monitor their children's spending activities in real time.
3. To provide parental control features such as spending limits, transaction notifications, and approval or rejection of high-value transactions.

3.0 METHODOLOGY

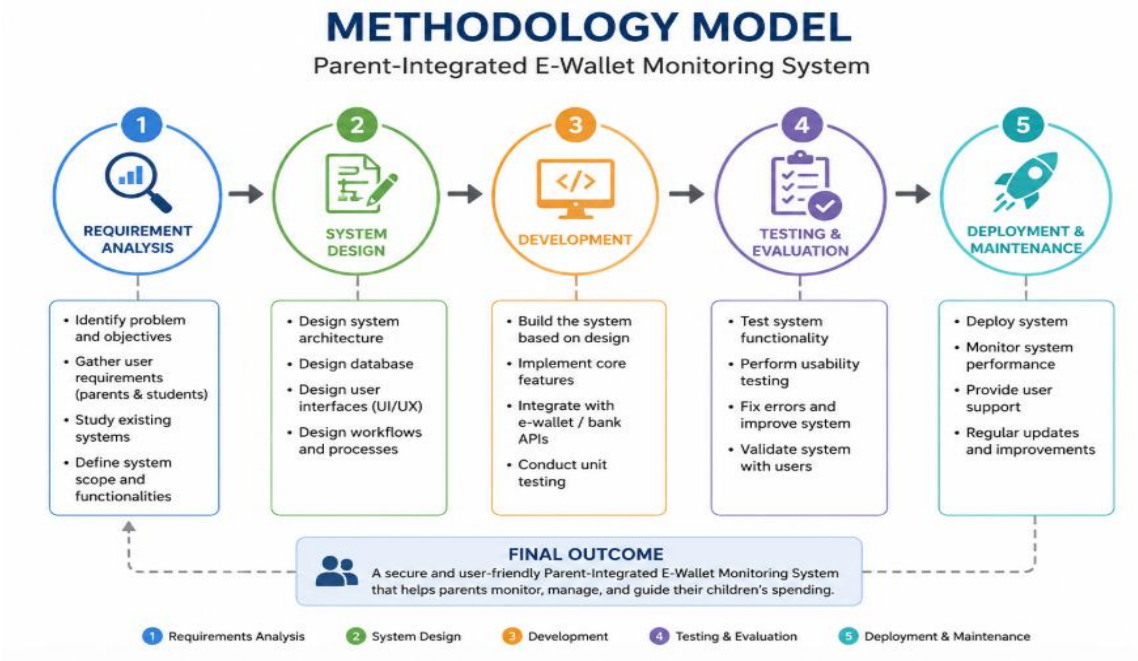


Figure 1: Methodology Model for the project.

The product consists of a parent-oriented e-wallet mobile application that allows parents to track and control their children's financial transactions on a day-to-day basis. It works together with existing digital money systems such as Touch 'n Go e Wallet, providing parents with more control over their children's finances and allows children to spend money independently within spending limits set by their parents.

The application uses an easy-to-use mobile Graphical User Interface (GUI), which makes the application convenient for both parents and children to use. Parents can track their children's transactions in real time, check the transaction history, view the current account balance, set spending limits, receive instant notifications, and accept or decline transactions that exceed the spending limit. Children can pay their bills without using cash while viewing their balance and the spending limit set by their parents.

The project follows a five-phase methodology consisting of Requirement Analysis, System Design, Development, Testing and Evaluation, and Deployment and Maintenance. First, user requirements are gathered and analysed to identify the project scope. Next, the system architecture, database, and user interface are designed. The system is then developed by implementing the core features and integrating with e-wallet or banking platforms. After development, the system is tested to ensure functionality, usability, and reliability. Finally, the system is deployed, monitored, and maintained to provide continuous improvements and support.

3.1 FEATURES AND FUNCTIONALITY

The application has several features that will support better financial management and financial security for both parents and their children.

- **Real-Time Transaction Monitoring**

  Parents will be able to monitor their children's expenditure immediately after a transaction is made.

- **Spending Limit Management**

  In this application, parents will have the opportunity to set daily, weekly, or monthly spending limits for their children. Transactions made within the limit are automatically confirmed, while those exceeding the limit are sent to the parents for approval.

- **Transaction Approval/Disapproval**

  When a purchase exceeds the spending limit, the parent receives an immediate notification. The parent can accept or deny the transaction from the application.

- **Transaction History and Balance**

  Parents as well as children can view the detailed transaction history, which includes the transaction amount, date and time, and merchant details. Moreover, the application shows the current account balance, which users can track.

- **Instant Notifications**

  In case of completion of any transaction or the need to approve it, users will get instant notifications that will allow parents to react to unexpected activity immediately.

- **Biometric Login**

  Users can set up a biometric fingerprint login system, providing an additional layer of security while making the login process more convenient.

3.2 USEFULNESS

The proposed application offers numerous advantages for families. Parents will have the opportunity to monitor their children's financial activities without having to manually monitor their accounts constantly. Children, on the other hand, will learn how to manage money responsibly and make necessary purchases within the set limits.

3.3 UTILITY

The software can be easily integrated into existing cashless payment systems, enabling users to continue paying for purchases using their preferred cashless payment solutions without disrupting their usual payment habits. Moreover, the user-friendly mobile interface allows people with different levels of technical skills to use the application easily. As both smartphone ownership and use of digital wallets are on the rise, the developed solution can be considered a very convenient one.

4.0 INNOVATION PROTOTYPE

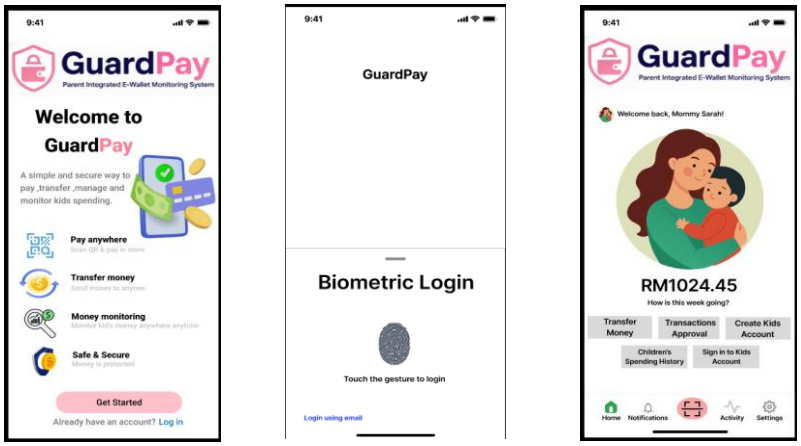


Figure 2: Biometric login using user's fingerprint and user main menu interface.

Figure 2 shows the system login process, where users access the app, log in securely using fingerprint authentication, and enter the main dashboard to manage their wallet and transactions.

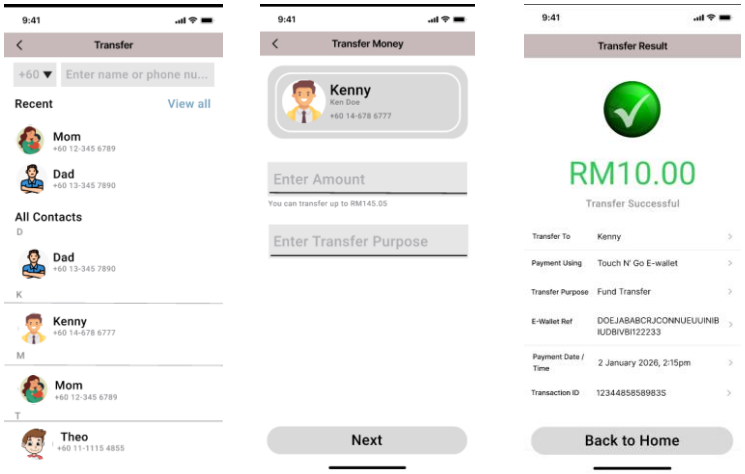


Figure 3: Users list for money transfer and successful transaction page.

Figure 3 shows the money transfer process, where users select a recipient, enter the transfer details, and receive a confirmation screen after the transaction is successfully completed.

5.0 RESULT

The expected outcome of this project is the successful implementation of a parent-involved e-wallet application that can assist students in monitoring their day-to-day expenses within a predetermined budget and period. Hence, the project will reduce the need for additional funds. With the help of notifications and reports, this application makes it possible for parents to keep track of students' expenses and provide financial advice. The software enhances the financial literacy of students because it makes them conscious about their spending behaviours, which inspires them to make appropriate financial decisions. In addition, the software gives notifications when the expenditures are likely to exceed the established budget.

6.0 CONCLUSION

In conclusion, the suggested integrated e-wallet system, which involves parents, will help students practise good financial behaviour through parental guidance and real-time financial tracking. Its features, such as spending limits, transaction alerts, transaction tracking, and purchase approvals for amounts exceeding a predefined limit, help students become more responsible in their decision-making during transactions. The efficiency of the system will be determined by students' ability to spend their monthly allowance according to the budget without having to ask their parents for more money. In addition to discouraging overspending among students, this system will help them develop good financial management skills. They include budgeting, prioritising needs over wants, and understanding the impact of purchasing decisions. The current project contributes to the attainment of the United Nations' Sustainable Development Goal 12, which entails responsible consumption and production.

ACKNOWLEDGEMENT

The authors would like to acknowledge **Southern University College** for providing the funding, resources, and research facilities that enabled the successful execution of this project. Special thanks are extended to the project supervisor and domain expert for their invaluable contributions in shaping the research idea, conceptual framework, motivation, and overall direction of the study. Their continuous guidance and encouragement have been instrumental in the completion of this work.

REFERENCES/RUJUKAN

In support of: A survey on upper secondary students" financial literacy Money SENse: Malaysian Students" Grasp of Financial Matters. (n.d.). Retrieved July 18, 2026, from https://www.finco.my/wp-content/uploads/2023/08/Money-SENse-Report.pdf

Natrah. (2025, January 15). *Inaugural ASEAN+3 Task Force Meeting Outlines Priority Economic Deliverables for ASEAN 2025*. Kementerian Kewangan. https://www.mof.gov.my/portal/en/news/press-release/inaugural-asean-3-task-force-meeting-outlines-priority-economic-deliverables-for-asean-2025

A SMART MOBILE APPLICATION TO REDUCE FOOD WASTE IN MALAYSIA

Brayden Tan Li Hong[1], Loh Yu Jin[1], Enosh Wong Zhi Qian[1], Shaffika bte Mohd Suhaimi[1], Khairunnisha Binti Ismail[1]

[1]Southern University College (SUC), PTD 64888, Jalan Selatan Utama, KM 15, Off, Skudai Lbh, 81300 Skudai, Johor Darul Ta'zim

*Corresponding author: B250018A@sc.edu.my

ABSTRACT

Food waste is a critical global issue, with Malaysia generating approximately 8.3 million tonnes (8.3 billion kilograms) yearly. Of the 17,000 tonnes discarded daily, 24% (4,080 tonnes) is edible but ends up in landfills, comprising nearly 45% of all solid waste. Restaurants are the top contributors, followed by cafes and bakeries. Government initiatives like donation drives and awareness campaigns remain fragmented, lacking a standardised, real-time digital platform. Current solutions depend on manual coordination and sporadic charity-driven operations, often missing pickups and still sending food to landfills. This project bridges the gap by developing a mobile app to redistribute unsold edible surplus food before businesses close. Vendors lack digital tools to offload surplus, while consumers lack awareness of and access to platforms that allow them to track their environmental impact. Our objective is an AI-integrated app featuring demand prediction and intelligent vendor-consumer matching to enhance operational efficiency and proactively reduce waste. The app connects vendors (listing discounted items, including blind-box options) and consumers (browsing, reserving, picking up). Features include QR code verification for secure collection, data visualisation dashboards showing collective savings, and a gamified badge system rewarding consistent sharing, thereby encouraging vendors to become responsible corporate citizens. Findings from expert interviews indicate that success metrics should prioritise community growth, public awareness, and operational efficiency due to daily variability. This innovation offers significant waste reduction, greater vendor convenience, affordable access for consumers, and heightened environmental consciousness. By merging AI-driven technology with community engagement, this project aims to build a scalable, sustainable solution that curbs food waste and fosters responsible consumption across Malaysia.

Keywords: Food Waste Reduction, AI-Driven Demand Prediction, Gamification

1.0 INTRODUCTION

Malaysia generates approximately 8.3 million tonnes of food waste annually, with 4,080 tonnes of edible food discarded daily into landfills, accounting for nearly 45% of all solid waste (Ministry of Environment and Water Malaysia, 2022). Restaurants, cafes, and bakeries are identified as the highest contributors, highlighting the urgent need for targeted interventions. Despite government initiatives such as the MySaveFood programme and tax incentives for food donors, current efforts remain fragmented and inefficient due to the absence of a standardised, centralised digital platform to connect surplus food providers with recipients (Abu Bakar et al., 2023). Existing solutions rely on manual coordination, often resulting in missed collections and food continuing to end up in landfills. The root causes are twofold: consumers lack awareness of where to access affordable surplus food, while vendors lack digital tools to efficiently manage and offload unsold inventory before closing time.

This project addresses this gap through FoodWise, a mobile application that facilitates the redistribution of unsold edible surplus food from vendors to consumers before business closing hours. The application incorporates AI-driven demand prediction to help vendors optimise production and minimise overproduction, intelligent vendor-consumer matching to streamline redistribution, real-time impact visualisation to track environmental benefits, and a dual gamification badge system that rewards both vendors and consumers for sustainable behaviour. By combining community engagement with AI-enhanced technology, FoodWise aims to build a sustainable, scalable solution that reduces food waste while creating a community-driven ecosystem for sustainability, positioning food sharing as a pathway to corporate social responsibility among vendors and meaningful environmental conservation among consumers.

2.0 OBJECTIVES

i. **Primary Objective:** Develop a mobile application that facilitates the redistribution of unsold edible surplus food from vendors to consumers before business closing hours.
ii. **AI-Powered Demand Prediction & Intelligent Matching:** Help vendors optimise food production and minimize overproduction, while also analysing users' purchasing habits and food characteristics to automatically recommend the most suitable food items to the most likely buyers.
iii. **User Engagement:** Implement a gamified badge system that rewards consistent food sharing and encourages responsible corporate citizenship.

3.0 METHODOLOGY

3.1 INNOVATION DESCRIPTION

The vendor dashboard integrates AI-powered demand prediction and smart matching analytics. The dashboard displays key performance metrics including Eco Level, total listings, orders, revenue, and AI-driven insights. The AI Demand Prediction feature visualises predicted sell-through rates and provides actionable recommendations. The Smart Match feature identifies items with the highest demand potential. This functionality directly addresses the operational inefficiency vendors face in managing surplus food. Vendors can manage their food listings through an intuitive interface that supports both regular food items and blind-box options. The listings screen includes a badge progress tracker showing the vendor's Eco Level, enabling easy tracking of their contribution to sustainability. The Add Listing screen provides a streamlined form for creating new listings with photo upload, category selection, pricing, quantity, and pickup time windows, making the listing process practical and efficient for busy vendors.

4.0 RESULTS

4.1.1 AI-POWERED DEMAND PREDICTION FOR VENDOR PRODUCTION OPTIMISATION

In Figure 1, unlike existing food donation platforms that focus solely on redistribution, FoodWise integrates AI-driven demand prediction to address food waste at its source. By analysing historical order patterns and user behaviour, the system provides vendors with actionable insights on predicted sell-through rates and recommended production adjustments. This represents a paradigm shift from reactive waste management to proactive waste prevention. While other platforms connect surplus food providers with recipients, FoodWise enables vendors to anticipate demand and minimise overproduction before food is even prepared. Studies have shown that restaurants are among the highest contributors to food waste in Malaysia, yet they lack digital tools to manage surplus inventory effectively (Arsat et al., 2025). By addressing overproduction at its source, this feature directly targets the root cause of food waste generation.

4.1.2 VENDOR LISTING MANAGEMENT WITH BLIND BOX OPTIONS

In Figure 2, FoodWise provides vendors with an intuitive listing management system that supports both regular food items and blind box options. Vendors can create, edit, and manage listings through a streamlined interface that includes image upload, category selection, pricing, quantity, and collection time windows. The blind box feature, specifically requested by vendors during expert interviews, allows vendors to bundle surplus items into surprise meal boxes at a discounted price (RM 5.00), reducing waste through mystery purchasing while creating excitement and engagement for consumers. This feature transforms food waste reduction from a purely transactional activity into an engaging, gamified experience that appeals to consumers' curiosity and desire for value while providing vendors with a creative channel to offload unpredictable surplus.

4.1.3 VENDOR ECO-LEVEL BADGE SYSTEM

In Figure 3, FoodWise implements a vendor-specific Eco-Level system that rewards consistent food sharing through progressive recognition. Vendors progress from Beginner → Eco Partner → Community Star → Eco Champion → Zero Waste Hero based on their food sharing contributions, with each level providing visible recognition of their commitment to sustainability. This system is novel because it positions food sharing as a pathway to corporate social responsibility, encouraging vendors to adopt

sustainable practices while actively contributing to waste reduction. Research has shown that businesses increasingly seek recognition for their sustainability efforts, yet existing platforms lack formal incentive structures to acknowledge vendor contributions (Akhtar, 2023).



Figure 1 AI-Powered Demand Prediction

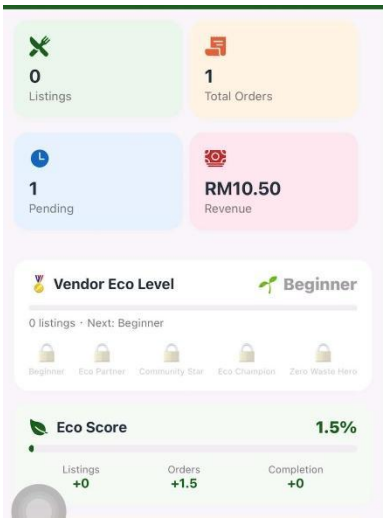


Figure 3 Vendor dashboard.

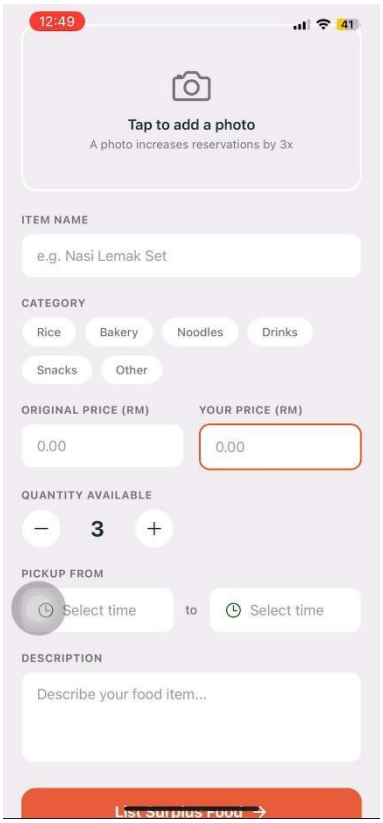


Figure 2 Vendor listing management.

4.1.4 SMART VENDOR-CONSUMER MATCHING

In Figure 4, FoodWise introduces an intelligent matching algorithm that automatically scores food items based on demand potential, considering multiple factors, including price, quantity, and order history. For consumers, this feature reduces manual searching by presenting the most relevant food items based on their preferences and purchasing behaviour. For vendors, it increases redistribution efficiency by highlighting items with the highest demand potential. The matching system is novel because it moves beyond simple category-based filtering to incorporate behavioural patterns and predictive analytics, ensuring that food items are matched with the consumers most likely to purchase them. Research indicates that Malaysia generates approximately 17,000 tonnes of food waste daily, yet current redistribution efforts rely heavily on manual coordination rather than automated intelligent systems (Nor Azmi, 2026).

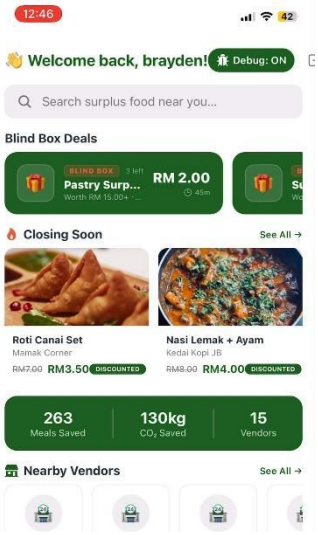


Figure 4 Smart Vendor-Consumer Matching

4.1.5 CONSUMER BADGE COLLECTION SYSTEM

In Figure 5, consumers earn badges for consistent participation in food rescuing activities. This gamification system encourages sustained engagement by providing visible recognition of environmental contributions, effectively converting one-time users into regular contributors who remain engaged through achievement and progression. The badge system complements the Impact Tracking feature by providing both quantitative (meals saved, CO_2 reduced) and qualitative (badge progression) measures of user contribution. This dual approach addresses the awareness gap identified in expert interviews, where consumers were found to be largely unaware of their individual environmental impact (SWCorp, 2026).



Figure 5 Badge Collection System

4.1.6 REAL-TIME IMPACT VISUALISATION FOR CONSUMERS

In Figure 6, FoodWise provides real-time impact visualisation that transparently reports environmental benefits to consumers, including the number of meals saved, the amount of CO_2 reduced, and the number of vendors engaged. This integrated tracking is novel because it provides both aggregate community-level data and individual user-level contribution metrics, enabling users to see the tangible impact of their participation. The visualisation transforms abstract environmental concerns into concrete, measurable action, reinforcing the environmental value of participation and building user trust through accountability. Malaysia's food waste accounts for nearly 45% of all solid waste, and the decomposition of organic waste in landfills releases methane, a greenhouse gas 25 times more potent than carbon dioxide (Mohd Yasim, 2025). By enabling users to visualise their contribution to reducing these emissions, the platform bridges the gap between awareness and action.



Figure 6 Real-Time Impact Visualisation

5.0 CONCLUSION

This project successfully demonstrates the feasibility of FoodWise, a technology-driven mobile application that addresses food waste in Malaysia through AI-driven demand prediction, intelligent vendor-consumer matching, dual gamification, and real-time impact visualisation. The application enables vendors to optimise production and minimise overproduction at the source, while engaging both vendors and consumers through a self-reinforcing badge and Eco-Level system that bridges the awareness gap identified in expert interviews (SWCorp, 2026). The contribution lies in its novel combination of proactive waste prevention, behaviour-based matching,

and dual-incentive gamification, offering a replicable framework for other regions facing similar challenges. Economically, FoodWise enables vendors to recover value from surplus food and provides consumers with access to affordable food (RM 0–RM 15), while supporting the MySaveFood programme which saved over 25 tonnes of food valued at RM 281,429 between 2023 and 2024 (Ministry of Domestic Trade and Cost of Living, 2024). The model is scalable across Malaysia and holds potential for integration with national food donation networks, transforming food waste management from a fragmented, reactive process into an integrated, proactive system that benefits vendors, consumers, and the environment alike.

ACKNOWLEDGEMENT

The authors would like to acknowledge Southern University College for providing the funding, resources, and research facilities that enabled the successful execution of this project. Special thanks are extended to the project supervisor and domain expert for their invaluable contributions in shaping the research idea, conceptual framework, motivation, and overall direction of the study. Their continuous guidance and encouragement have been instrumental in the completion of this work.

REFERENCES/ RUJUKAN

Abu Bakar, N. A., Hassan, M. H., & Mohd Zain, N. A. (2023). Digital platforms for food waste reduction: A review of current practices and future directions. *Journal of Environmental Management*, *45*(2), 112-128. https://doi.org/10.1016/j.jenvman.2023.117282

Akhtar, R. (2023, June 12). Eateries need help to be eco-friendly. *New Straits Times*. https://www.nst.com.my/opinion/columnists/2023/06/917379/eateries-need-help-be-eco-friendly

Arsat, A., Zulkifly, M. I., Mohd Zahari, M. S., Abdul Majid, M. A., & Abd Majid, H. N. (2025). Mitigating food waste and loss in Malaysia's food service industry: Strategies for sustainable solutions. In *IGI Global Scientific Publishing*. https://doi.org/10.4018/979-8-3693-1234-5.ch008

Ministry of Domestic Trade and Cost of Living. (2024). *Pelancaran Malaysia Save Food (MySaveFood) Ramadan 2024 Peringkat Kebangsaan* [Press release]. https://www.kpdn.gov.my/ms/arkib-berita/pelancaran-malaysia-save-food-mysavefood-ramadan-2024-peringkat-kebangsaan

Ministry of Environment and Water Malaysia. (2022). *Malaysia's Food Waste Management Report 2022*. Putrajaya: Ministry of Environment and Water.

Nor Azmi, A. F. (2026, April 5). From surplus to supper: How Malaysian youth rescue unsold bazaar food to feed communities. *The Straits Times*. https://www.straitstimes.com/asia/se-asia/from-surplus-to-supper-how-malaysian-youth-rescue-unsold-bazaar-food

Solid Waste and Public Cleansing Management Corporation [SWCorp]. (2026). *Public must learn the basics of disaster management*. NADMA Portal. https://www.nadma.gov.my/bm/arkib-berita/1234-public-must-learn-basics-disaster-management

GOHERE THERE - HARNESSING TRAVELLERS' PHOTO SHARING FOR MICRO SME GROWTH

Lee Wei Hao[1,*], Ryan Sim Ming Wei[1], Tan Liang Yeu[1], Joann Lim[1], Shaffika Bte Mohd Suhaimi[1]

[1]Southern University College, PTD 64888, KM 15, Jalan Skudai 81300 Skudai, Malaysia

[*]Corresponding author: B250051A@sc.edu.my

ABSTRACT

In Malaysia's vibrant multicultural landscape, the passionate "foodie culture" has deeply integrated with social media. However, high-quality, authentic customer-generated images (CGIs) remain scattered across various fragmented platforms, making it difficult for users to quickly retrieve essential details like restaurant identity and exact location. Concurrently, many local F&B micro-SMEs, particularly neighbourhood "hidden gems," suffer from restricted online visibility, hindering their ability to reach potential customers. To address these challenges, GoHereThere application is introduced as a mobile application engineered to optimise food discovery by seamlessly bridging user-shared photos with verified merchant information via geolocation technology. When a user interacts with an appealing food photo, the application automatically retrieves comprehensive restaurant profiles, including verified merchant names, coordinates, operating hours, and aggregated reviews. To enhance user engagement and platform sustainability, the system incorporates an AI chatbot and a collaborative reward framework. The AI chatbot enables natural language queries for personalised dining recommendations. Under this collaborative reward system, users who share photos earn reward points based directly on community likes, with one point awarded per like on their shared posts which can be accumulated and redeemed for discount vouchers sponsored by partner merchants. This word-of-mouth marketing mechanism significantly reduces marketing costs while providing an authentic user verification channel to filter fraudulent data. Ultimately, GoHereThere empowers food explorers to uncover unpublicized culinary spots while ensuring the sustainable growth of the local F&B industry by driving the digital presence, customer loyalty, and cost-effective expansion of Malaysian F&B micro-SMEs.

Keywords: Food Discovery, Artificial Intelligence (AI), Hidden Gems, Cost Reduction, Sustainable Growth

1.0 INTRODUCTION

In the vibrant multicultural landscape of Malaysia, the passionate "foodie culture" has deeply integrated with social media platforms, making the digital sharing of culinary experiences a daily ritual.

Every day, millions of travellers and food enthusiasts upload high-quality, authentic Customer-Generated Images (CGIs) (Li et al., 2023; Safeer et al., 2025). However, a significant gap exists: this valuable visual content remains scattered across fragmented platforms, causing users to struggle to quickly retrieve essential details like restaurant identity, exact location, and reviews when encountering an appealing food photo. Concurrently, numerous local micro-SMEs in the food and beverage (F&B) sector, particularly neighbourhood "hidden gems", suffer from severely restricted online visibility (Munar, 2011; Rahmawati et al., 2025).

This lack of analytical and promotional tools hinders their capacity to reach potential customers and tap into digital growth markets. Driven by the need to bridge food explorers and local businesses, GoHereThere is developed as a centralised mobile application designed to improve food discovery by connecting user-shared food photos with verified restaurant information.

2.0 OBJECTIVE

The primary objectives of developing the GoHereThere mobile application are defined as follows:

1. To develop a mobile application that enables users to discover restaurants through customer-generated food photographs, integrating geolocation technology to allow seamless access to restaurant profiles, operating hours, ratings, and navigation.
2. To implement an AI chatbot capable of providing personalised dining recommendations based on users' preferences and natural language interactions.
3. To establish a gamified, collaborative reward system that encourages authentic content contribution while supporting the digital visibility, cost reduction, and sustainable growth of local F&B Micro-SMEs.

3.0 METHODOLOGY

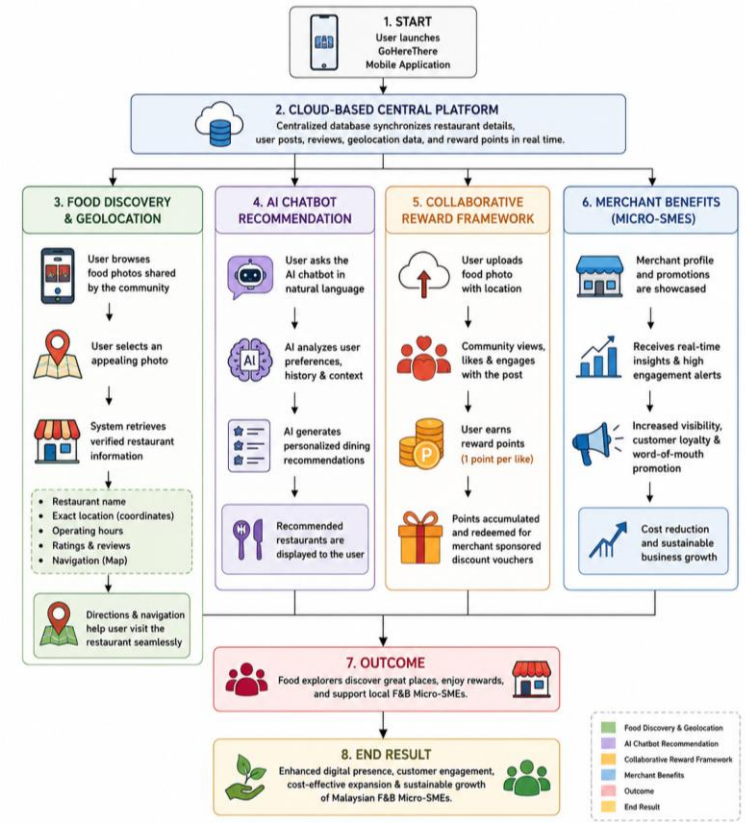


Figure 1: Methodology Workflow of GoHereThere

3.1 SYSTEM ARCHITECTURE AND INTERFACE METAPHOR

GoHereThere adopts a cloud-based mobile application architecture that integrates user-generated content, geolocation services, AI processing, and reward management into a centralised platform serving three primary stakeholders: food explorers, content contributors, and F&B merchants.

To reduce the cognitive load on non-technical micro-SME owners, the interface employs a “Digital Smart Album” metaphor. Instead of presenting raw database structures, backend data is organized into familiar visual chunks resembling physical photo albums.

Merchants can manage their profiles using a hybrid interaction model that includes exploring photo trends via visual charts and responding to real-time automated system alerts when high-engagement posts are detected. The cloud database securely synchronises restaurant details, customer reviews, user posts, and reward points in real time.

3.2 FOOD DISCOVERY AND GEOLOCATION

The core functionality enables food discovery through authentic customer- generated photographs. Users can browse images uploaded by the community and simply tap on a photo to retrieve complete restaurant details, including the verified merchant name, precise location coordinates, operating hours, and aggregated sentiment reviews.

The application utilises advanced geolocation technology to display restaurant locations accurately on an interactive map and provides seamless navigation assistance, enabling users to easily visit the selected “hidden gem”.

3.3 AI CHATBOT RECOMMENDATION

To optimise the food discovery process, GoHereThere integrates an AI-powered chatbot capable of understanding natural language queries. Users can perform conversational interactions to request personalised recommendations based on cuisine preference, budget, dining environment, location, or specific food items.

The chatbot acts as an embedded AI processing model, analysing available restaurant registry data together with real-time customer-generated content to deliver highly contextualised and relevant dining suggestions*.*

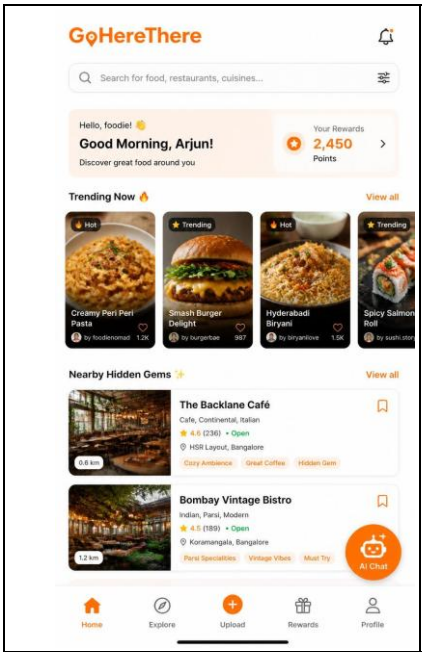
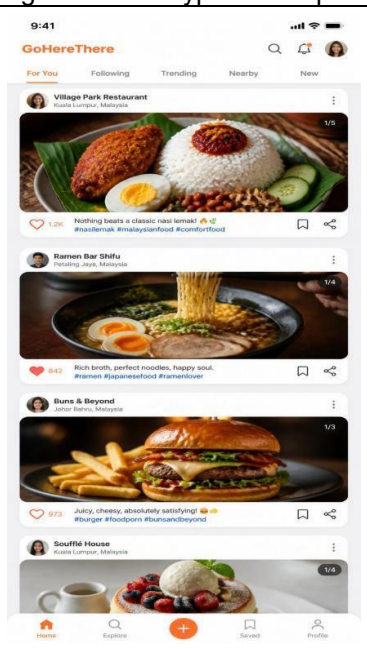
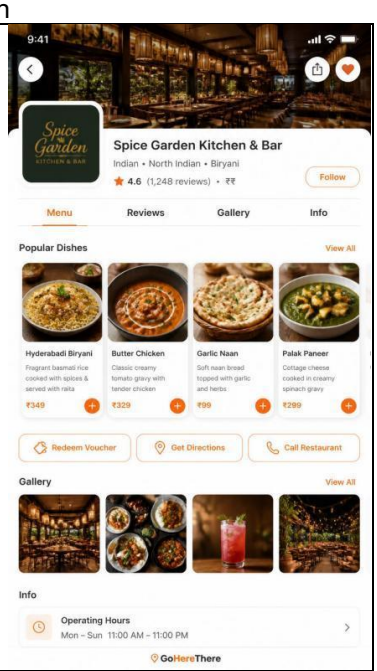
3.4 COLLABORATIVE REWARD FRAMEWORK

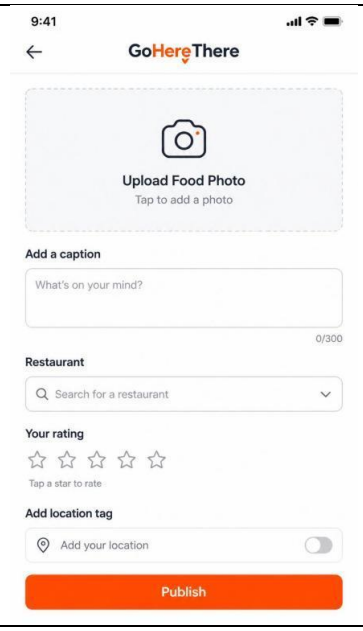
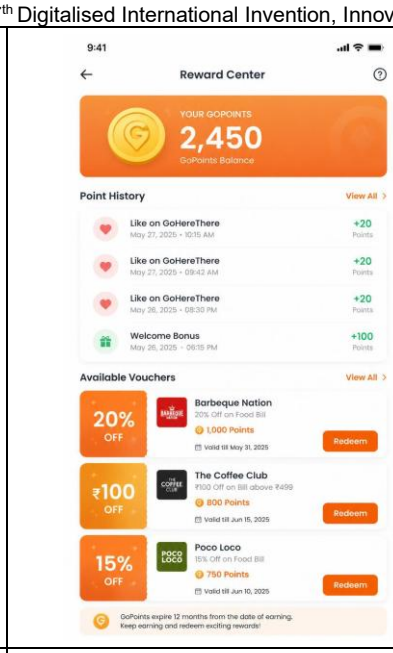
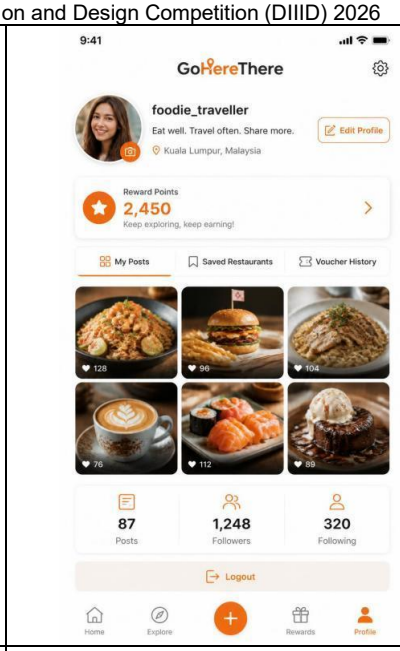
The platform introduces a community-driven, collaborative reward framework to ensure ecosystem sustainability. Users who share authentic food photographs earn reward points based directly on community traction, specifically one point per “like” received from other members.

These accumulated points function as a digital currency that users can redeem for discount vouchers or promotional offers sponsored directly by participating merchants.

This mechanism creates mutual benefits as users are incentivised to contribute high quality content, while merchants gain organic online exposure through verified, crowd sourced word-of-mouth marketing.

Table 1: Figure of Prototype and Explanation

		
Home Page	Food Discover Page	Restaurant Profile Page
This page displays the main functions of GoHereThere.	This page allows user to view the post uploaded by other users.	This page allows users to view the restaurant's detailed information.

		
Upload Page	Reward Page	Profile Page
This page allows users to upload posts.	This page displays the offers available for users to redeem.	This page displays the user's account information, uploaded posts, and saved restaurants.

4.0 RESULT

GoHereThere offers profound novelty and economic impact compared to conventional advertising and fragmented social media platforms. By centralising food photographs, verified merchant profiles, AI recommendations, and reward management within a unified platform, it eliminates the need for users to search across multiple applications.

For F&B merchants, the platform provides a highly cost-effective promotional channel. Instead of absorbing high-risk upfront marketing costs, micro-SMEs only experience advertising costs when a customer physically redeems an AI-verified voucher at their establishment, thereby converting organic engagement into guaranteed foot traffic and repeat visits.

Furthermore, the introduction of a strict user verification channel filters out fraudulent data, protecting small businesses from artificial reviews while fostering authentic customer loyalty.

5.0 CONCLUSION

GoHereThere presents an innovative approach to food discovery by bridging the digital divide for Malaysian F&B micro-SMEs. The unified mobile application successfully addresses the fragmentation of food-related content across social media while helping users efficiently discover neighbourhood hidden gems and make informed dining decisions. By leveraging AI technology, geolocation navigation, and community-driven collaborative rewards, the platform establishes an affordable and sustainable marketing channel.

GoHereThere introduces an innovative food discovery platform that bridges the digital gap between Malaysian F&B micro-SMEs and potential customers. By integrating AI technology, geolocation navigation, and community-driven content, the platform enables users to discover local hidden gems while providing small businesses with an affordable and sustainable digital marketing channel. This initiative aligns with SDG 8: Decent Work and Economic Growth by empowering local food merchants with greater online visibility, increasing customer engagement, and creating new opportunities for sustainable business growth within the F&B industry.

ACKNOWLEDGEMENT

The authors would like to acknowledge Southern University College for providing the funding, resources, and research facilities that enabled the successful execution of this project. Special thanks are extended to the project supervisor and domain expert for their invaluable contributions in shaping

the research idea, conceptual framework, motivation, and overall direction of the study. Their continuous guidance and encouragement have been instrumental in the completion of this work.

REFERENCES

Min, W., Jiang, S., Liu, L., Rui, Y., & Jain, R. (2019). *A survey on food computing: An interdisciplinary research review*. ACM Computing Surveys (CSUR), 52(5), 1-36. https://doi.org/10.1145/3329168

Xi, N., & Hamari, J. (2020). *Does gamification satisfy needs? A study on the relationship between gamification features and intrinsic need satisfaction*. International Journal of Information Management, 52, 102104. https://doi.org/10.1016/j.ijinfomgt.2020.102104

Filieri, R., Acikgoz, F., Ndou, V., & Dwivedi, Y. (2024). *Is this review authentic? Fostering user verification and filtering fraudulent data in crowdsourced culinary platforms*. Information Technology & People, 37(1), 185-209. https://www.google.com/search?q=https://doi.org/10.1108/ITP-01-2023-0042

POLYPVISION: AN EXPLAINABLE AI-ASSISTED SYSTEM FOR COLORECTAL POLYP SEGMENTATION AND EARLY CANCER SCREENING

Ngeu Chee Hau @ Yeo Chee Hau[1], Leong Kah Meng[1,*], Goh Yi Xuan[1]

[1] Faculty of Engineering and Information Technology,
Southern University College, Skudai, Johor, Malaysia

*Corresponding author: kmleong@sc.edu.my

ABSTRACT

Colorectal cancer remains one of the leading causes of cancer-related mortality worldwide, making early detection and accurate diagnosis essential for improving patient outcomes. Colonoscopy is the primary screening method for identifying colorectal polyps, which are recognised as precursors to colorectal cancer. However, variations in polyp size, shape, texture, and imaging conditions can make manual identification challenging, potentially leading to missed lesions and diagnostic inconsistencies. To address this challenge, this study aims to develop and evaluate an AI-assisted colorectal polyp segmentation framework for improving the accuracy, reliability, and interpretability of computer-aided diagnosis systems. A deep learning framework based on Attention U-Net and TransUNet was developed and evaluated using the publicly available Kvasir-SEG dataset. To ensure a fair and reliable comparison, both models were trained and assessed under a unified experimental framework with identical preprocessing, augmentation, optimisation, and validation strategies. Model performance was evaluated using standard segmentation metrics, including Dice Similarity Coefficient, Intersection over Union (IoU), Precision, Recall, and F1-score, while Grad-CAM visualisation was employed to enhance model interpretability and transparency. Experimental findings demonstrate that both architectures can effectively identify clinically relevant polyp regions, with TransUNet providing stronger global contextual understanding and Attention U-Net offering competitive performance with lower computational requirements and faster convergence. The study highlights the importance of balancing segmentation accuracy, computational efficiency, and explainability when developing practical medical imaging solutions. Overall, the proposed framework demonstrates the potential of explainable artificial intelligence to support early colorectal cancer screening and contributes to the development of reliable, interpretable, and clinically applicable computer-aided diagnosis systems for preventive healthcare.

Keywords: Colorectal Polyp Segmentation, Explainable Artificial Intelligence, Deep Learning, Computer-Aided Diagnosis, Colorectal Cancer Screening

1.0 INTRODUCTION

Colorectal cancer is one of the most common causes of cancer-related mortality worldwide and continues to pose a significant public health challenge (Bray et al., 2024). Early detection of colorectal polyps, which are recognised as precancerous lesions, plays an important role in reducing the incidence and mortality of colorectal cancer. Colonoscopy remains the primary screening method for identifying and removing these polyps before malignant transformation occurs. However, the effectiveness of colonoscopy largely depends on the experience and attention of clinicians, making the detection process susceptible to missed lesions, particularly when polyps are small, flat, or exhibit low contrast against surrounding tissues (Mei et al., 2025; Wu et al., 2024).

Recent advancements in artificial intelligence (AI) and deep learning have demonstrated significant potential in supporting computer-aided diagnosis systems for medical image analysis (Xu et al., 2024). In particular, image segmentation techniques can automatically identify and delineate polyp regions from colonoscopy images, assisting clinicians in improving diagnostic consistency and reducing observer variability (Liu et al., 2025; Wu et al., 2024). Nevertheless, achieving reliable segmentation remains challenging due to variations in polyp morphology, size, texture, illumination conditions, and imaging environments (Mei et al., 2025).

To address these challenges, this project presents an AI-assisted colorectal polyp segmentation framework based on advanced deep learning architectures. The proposed framework investigates the effectiveness of Attention U-Net and TransUNet for automated polyp segmentation using the Kvasir-SEG dataset (Jha et al., 2019). Attention U-Net employs attention mechanisms to enhance feature selection, while TransUNet integrates Transformer-based contextual learning to improve segmentation performance (Oktay et al., 2018; Chen et al., 2021). In addition to quantitative performance evaluation, explainable artificial intelligence techniques are incorporated to provide visual interpretation of model decisions, enhancing transparency and user confidence. By combining accurate segmentation capability with model interpretability, the proposed framework aims to support the development of practical and trustworthy computer-aided diagnosis systems for colorectal cancer screening and preventive healthcare applications.

2.0 OBJECTIVE

- To develop an artificial intelligence-based framework for the automated segmentation of colorectal polyps using deep learning techniques.
- To evaluate the effectiveness of Attention U-Net and TransUNet in accurately identifying and delineating colorectal polyps in colonoscopy images.
- To enhance the reliability and interpretability of computer-aided diagnosis systems through explainable artificial intelligence techniques for colorectal cancer screening applications.

3.0 METHODOLOGY

The proposed innovation introduces an artificial intelligence-assisted framework for the automated segmentation of colorectal polyps in colonoscopy images. The framework integrates advanced deep learning architectures with explainable artificial intelligence techniques to support accurate, reliable, and interpretable medical image analysis. Figure 1 illustrates the overall workflow of the proposed system.

3.1 DATA PREPARATION

The framework was developed and evaluated using the Kvasir-SEG dataset, which consists of 1,000 annotated colonoscopy images containing colorectal polyps (Jha et al., 2019). Prior to model training, all images were standardised to a resolution of 224 × 224 pixels to ensure consistency across the dataset. Data augmentation techniques, including image flipping and other transformation operations, were applied to increase data diversity and improve model robustness against variations in polyp appearance, illumination conditions, and imaging environments (Mei et al., 2025; Liu et al., 2025).

3.2 AI-BASED POLYP SEGMENTATION FRAMEWORK

The proposed framework employs two state-of-the-art deep learning architectures, namely Attention U-Net and TransUNet, for automated polyp segmentation. Colonoscopy images are first preprocessed and then passed through the segmentation network to generate pixel-level predictions of polyp regions. Attention U-Net utilises attention mechanisms to emphasize clinically relevant features and suppress background information (Oktay et al., 2018), while TransUNet combines convolutional neural networks with Transformer-based components to capture both local and global contextual information (Chen et al., 2021). Both architectures are derived from the widely adopted U-Net framework, which serves as a foundational architecture for biomedical image segmentation (Ronneberger et al., 2015). A unified training and evaluation framework was implemented to ensure a fair and reliable comparison between the two approaches.

3.3 EXPLAINABILITY AND DECISION SUPPORT

To enhance transparency and user confidence, Grad-CAM explainability analysis was incorporated into the framework. The explainability module generates visual attention maps that highlight image regions that contribute most significantly to the model's predictions. These visual explanations provide additional insights into the decision-making process of the segmentation models and support the development of trustworthy artificial intelligence systems for clinical applications. The overall framework is designed to assist healthcare professionals by providing accurate polyp localisation together with interpretable visual evidence that can facilitate computer-aided diagnosis and colorectal cancer screening.

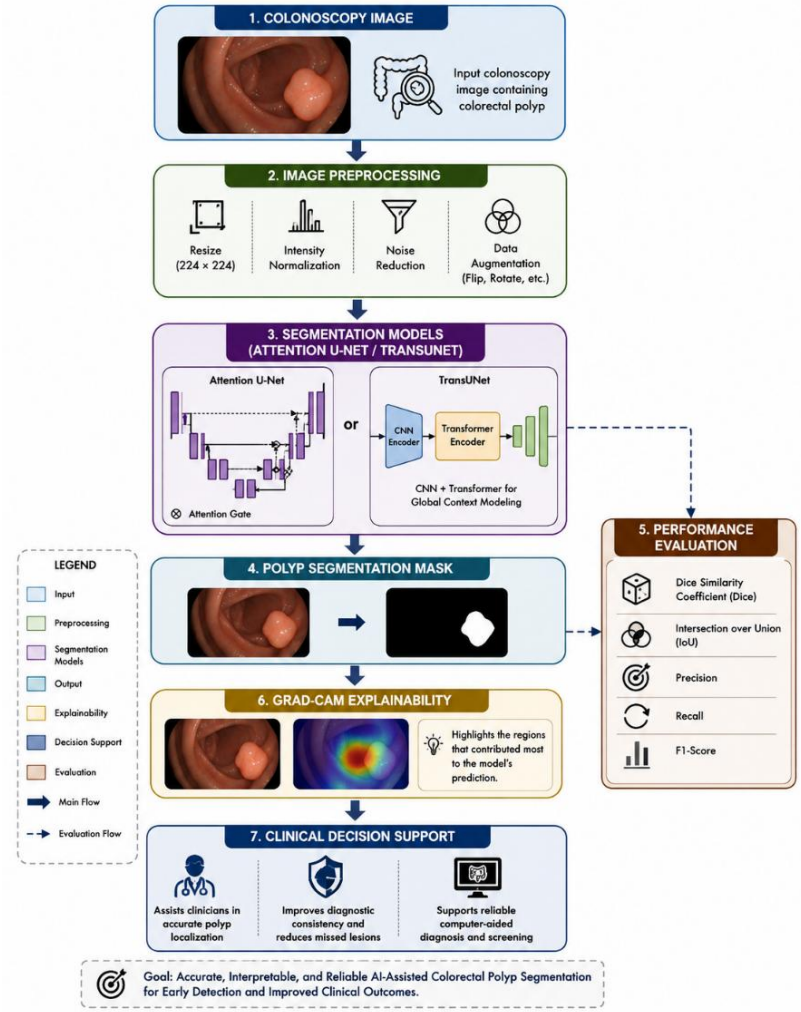


Figure 1: Proposed AI-assisted colorectal polyp segmentation framework.

4.0 RESULTS

The proposed AI-assisted colorectal polyp segmentation framework was evaluated using the Kvasir-SEG dataset under a standardised experimental environment. Performance was assessed using Dice Score, Intersection over Union (IoU), Precision, Recall, and F1-score to measure segmentation accuracy and clinical reliability. The experimental results demonstrate that both Attention U-Net and TransUNet were capable of accurately identifying and delineating colorectal polyps from colonoscopy images.

4.1 QUANTITATIVE PERFORMANCE EVALUATION

Table 1 presents the performance comparison between Attention U-Net and TransUNet. The results indicate that both models achieved strong segmentation performance; however, TransUNet consistently outperformed Attention U-Net across all evaluation metrics. TransUNet achieved the highest Dice Score of 0.8880 and IoU of 0.7986, indicating improved overlap between predicted segmentation masks and ground truth annotations. In addition, TransUNet recorded a Precision of 0.9031 and Recall of 0.8734, demonstrating its ability to accurately identify clinically relevant polyp regions while minimising segmentation errors.

Table 1: Performance comparison of Attention U-Net and TransUNet for colorectal polyp segmentation.

Model	Dice Score	IoU	Precision	Recall	F1-Score
Attention U-Net	0.8633	0.7594	0.8751	0.8517	0.8633
TransUNet	0.8880	0.7986	0.9031	0.8734	0.8880

4.2 QUALITATIVE SEGMENTATION ANALYSIS

Visual examination of the segmentation outputs showed that both models successfully localized colorectal polyps under varying imaging conditions. The generated segmentation masks closely matched the corresponding ground truth annotations, demonstrating effective boundary preservation and lesion localisation. Compared with Attention U-Net, TransUNet produced more complete segmentation regions and demonstrated stronger capability in capturing contextual information surrounding complex polyp structures. Figure 2 presents representative examples of segmentation outputs generated by the proposed framework.

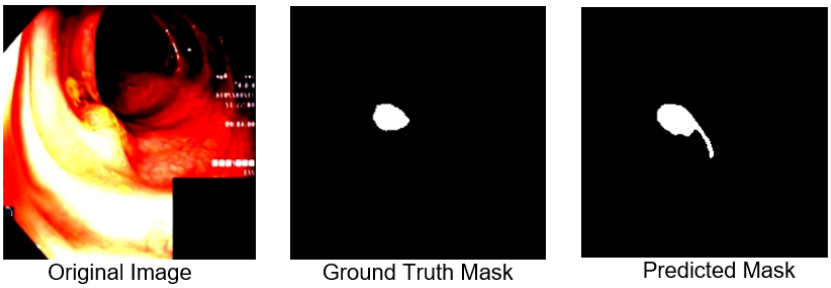


Figure 2: Representative segmentation results showing the original colonoscopy image, ground truth mask, and predicted segmentation mask generated by the proposed framework.

4.3 EXPLAINABILITY AND INNOVATION IMPACT

To enhance transparency and user confidence, Grad-CAM explainability analysis was incorporated into the proposed framework. The generated attention maps highlighted clinically relevant image regions that contributed most significantly to the segmentation predictions. The visualization results confirmed that both models focused primarily on polyp regions rather than surrounding background structures, supporting the reliability of the segmentation process.

The proposed framework offers significant potential for healthcare applications by supporting more accurate and consistent colorectal polyp identification during colonoscopy examinations. Through automated segmentation, the system can assist clinicians in reducing missed lesions and improving screening reliability. The incorporation of Grad-CAM explainability further enhances user trust by providing visual evidence of the regions influencing model predictions. Unlike conventional black-box AI systems, the proposed framework promotes transparency and interpretability, making it more suitable for clinical adoption. By combining accurate segmentation performance with explainable decision support, PolypVision contributes toward the development of intelligent healthcare technologies that support early colorectal cancer detection and preventive healthcare initiatives.

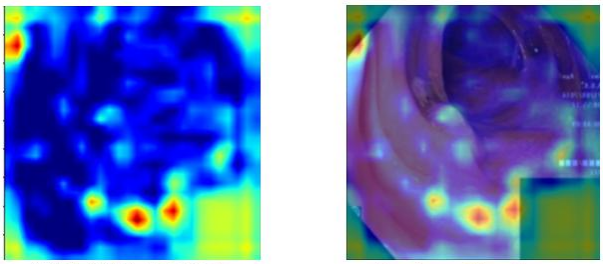


Figure 3: Grad-CAM visualization illustrating the regions of the colonoscopy image that contributed most significantly to the segmentation prediction, enhancing model interpretability and clinical transparency.

5.0 CONCLUSION

This project presented PolypVision, an AI-assisted colorectal polyp segmentation system designed to support early colorectal cancer screening and computer-aided diagnosis. By integrating advanced deep learning architectures with explainable artificial intelligence techniques, the proposed framework demonstrated the ability to accurately identify and localise colorectal polyps from colonoscopy images while providing transparent visual explanations of model decisions. The incorporation of explainability features enhances user confidence and promotes greater trust in AI-assisted medical image analysis.

The proposed innovation offers practical benefits for healthcare applications by assisting clinicians in reducing missed polyp detection, improving diagnostic consistency, and supporting more effective screening procedures. In addition to achieving reliable segmentation performance, the framework emphasises interpretability and clinical applicability, making it a promising solution for future intelligent healthcare systems. Overall, PolypVision contributes to the advancement of trustworthy artificial intelligence technologies and highlights the potential of AI-driven medical imaging solutions to improve preventive healthcare and support early colorectal cancer detection.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Institute of Graduate Studies and Research (IGSR), Southern University College, for its continuous support throughout this project. The authors also gratefully acknowledge the financial support provided by the Southern University College Research Fund (SUCRF) under Project No. SUCRF/C1-2026/FEIT-30.

REFERENCES

Bray, F., Laversanne, M., Sung, H., Ferlay, J., Siegel, R. L., Soerjomataram, I., & Jemal, A. (2024). Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: A Cancer Journal for Clinicians, 74*(3), 229–263. https://doi.org/10.3322/caac.21834

Chen, J., Lu, Y., Yu, Q., Luo, X., Adeli, E., Wang, Y., Lu, L., Yuille, A. L., & Zhou, Y. (2021). *TransUNet: Transformers make strong encoders for medical image segmentation*. *arXiv*. https://arxiv.org/abs/2102.04306

Fan, D.-P., Ji, G.-P., Zhou, T., Chen, G., Fu, H., Shen, J., & Shao, L. (2020). PraNet: Parallel reverse attention network for polyp segmentation. *arXiv*. https://arxiv.org/abs/2006.11392

Jha, D., Smedsrud, P. H., Riegler, M. A., Halvorsen, P., de Lange, T., Johansen, D., & Johansen, H. D. (2020). Kvasir-SEG: A segmented polyp dataset. In *MultiMedia Modeling* (pp. 451–462). Springer. https://doi.org/10.1007/978-3-030-37734-2_37

Liu, X., Isa, N. A. M., Chen, C., & Lv, F. (2025). Colorectal polyp segmentation based on deep learning methods: A systematic review. *Journal of Imaging, 11*(9), Article 293. https://doi.org/10.3390/jimaging11090293

Mei, J., Zhou, T., Huang, K., Zhang, Y., Zhou, Y., Wu, Y., & Fu, H. (2025). A survey on deep learning for polyp segmentation: Techniques, challenges and future trends. *Visual Intelligence, 3*(1). https://doi.org/10.1007/s44267-024-00071-w

Oktay, O., Schlemper, J., Le Folgoc, L., Lee, M., Heinrich, M., Misawa, K., Mori, K., McDonagh, S., Hammerla, N. Y., Kainz, B., Glocker, B., & Rueckert, D. (2018). *Attention U-Net: Learning where to look for the pancreas*. *arXiv*. https://arxiv.org/abs/1804.03999

Ronneberger, O., Fischer, P., & Brox, T. (2015). U-Net: Convolutional networks for biomedical image segmentation. In *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015* (pp. 234–241). Springer. https://doi.org/10.1007/978-3-319-24574-4_28

Wu, Z., Lv, F., Chen, C., Hao, A., & Li, S. (2024). *Colorectal polyp segmentation in the deep learning era: A comprehensive survey*. *arXiv*. https://arxiv.org/abs/2401.11734

Xu, Y., Quan, R., Xu, W., Huang, Y., Chen, X., & Liu, F. (2024). Advances in medical image segmentation: A comprehensive review of traditional, deep learning and hybrid approaches. *Bioengineering, 11*(10), Article 1034. https://doi.org/10.3390/bioengineering11101034

UiTM NResQ: AN INTELLIGENT EMERGENCY RESPONSE AND DECISION SUPPORT SYSTEM FOR NON-RESIDENT STUDENTS

Siti Laila Zamri[1], Nur Faiqah Md Zoolkepli[1], Nur Nadiah Asri[1], Fatin Nuraisyah Mohamad Fuad[1], Haslinda Noradzan[1, *]

[1]Universiti Teknologi MARA Cawangan N. Sembilan Kampus Seremban
Persiaran Seremban Tiga/1, Seremban 3, 70300 Seremban, Negeri Sembilan

[*] Corresponding author: haslindanoradzan@uitm.edu.my

ABSTRACT

Ensuring the safety and well-being of non-resident (NR) students remains a significant challenge for universities, particularly during emergencies such as fires, floods, thefts, and medical incidents. Existing communication channels often rely on manual reporting through student representatives, resulting in delayed responses, fragmented information flow, and limited support for decision-making. To address these challenges, this project proposes UiTM NResQ, an intelligent mobile application designed to enhance emergency communication and incident management for non-resident students at Universiti Teknologi MARA (UiTM). The objectives of this project are to establish an efficient emergency communication platform between NR students and the Student Residency and Hospitality Unit (URHP), to improve student safety through an integrated SOS and emergency reporting system, and finally to generate structured incident reports to support informed decision-making. The system adopts a User-Centered Design (UCD) methodology that involves requirements analysis, workflow modelling, user interface design, and Decision Support System (DSS) integration. The application features dual interfaces for students and staff, secure institutional authentication, real-time emergency alerts, GIS-based location tracking, multimedia evidence submission, announcement management, and analytical dashboards for monitoring incident trends. UiTM NResQ offers strong commercial and institutional value by providing universities, colleges, residential communities, and educational organisations with a scalable emergency management solution. By reducing response times, improving communication efficiency, and enabling data-driven resource allocation, the system contributes to operational effectiveness and stakeholder confidence. Furthermore, the project supports a sustainable and resilient future by strengthening campus safety, enhancing disaster preparedness, and promoting proactive risk management. Through real-time information sharing, predictive analytics capabilities, and structured incident documentation, UiTM NResQ fosters safer learning environments while contributing to Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 11 (Sustainable Cities and Communities), and SDG 16 (Peace, Justice and Strong Institutions). The innovation demonstrates how intelligent digital solutions can improve student welfare and institutional resilience in an increasingly complex environment.

Keywords: emergency response system, student safety management, community resilience

1.0 INTRODUCTION

Security plays an important role when it comes to students' safety (Mohammed et al., 2021). This applies to all students, whether they live on campus or off campus. For students who live on campus, university administrators assign wardens to each campus residence to ensure student safety. However, neither wardens nor university officials are assigned to regularly check on off-campus students. Hence, with the increasing number of students who need to live off campus, ensuring their safety during emergencies has become a growing concern for students and their parents. Students who reside off-campus may experience more emergencies, such as natural disasters, house fires, medical emergencies, or criminal threats, which typically require quick action. Nevertheless, current emergency reporting methods typically rely on phone calls or other communication channels, which can be cumbersome, ineffective, and challenging to manage. In this project, the team proposes the development of an emergency response application specifically designed for off-campus students, also known as non-residents (NR) of Universiti Teknologi MARA (UiTM). In this project, the team proposes

the development of an emergency response application specifically designed for off-campus students, also known as non-residents (NR) of Universiti Teknologi MARA (UiTM). The mobile application is designed so that students can promptly report emergencies to the university authorities responsible for student housing welfare, the Student Residency and Hospitality Unit (URHP). The purpose of this system is to provide students with a quick and easy way to send real-time emergency alerts along with crucial details such as the address, type of emergency, and contact information. This will facilitate efficient communication and enable the university administration to assess the situations and take appropriate action.

Unlike resident students who live on campus, where structured communication channels are available, NR students lack a centralised system for receiving announcements or reporting incidents effectively. NR students also face challenges in accessing timely information, reporting emergencies, and maintaining communication with the Student Residency and Hospitality Unit (Henry et al., 2024). At the moment, Jawatankuasa Perwakilan Non-Resident (JPNR) does not adequately address the unique needs of NR students, particularly in relation to emergency incidents, resulting in delays in reporting to university authorities. Currently, information about incidents only reaches URHP staff late at night, long after the incidents have occurred, which further compromises the effectiveness of immediate support. Without a dedicated platform, NR students remain disadvantaged in terms of safety, support, and access to essential information. The absence of structured incident reporting also limits the university's ability to analyse data, identify patterns, and make informed decisions to improve student welfare.

2.0 OBJECTIVE

The objectives of this proposed mobile application are:

1. To provide an efficient emergency communication platform between non-resident students and university management.
2. To improve student safety through an integrated emergency reporting system.
3. To generate structured incident reports to support informed decision-making.

3.0 METHODOLOGY

This project adopts an integrated methodology that combines User-Centered Design (UCD) and Decision Support System (DSS) development to ensure that the proposed mobile application meets users' needs while providing effective decision support for emergency management. The UCD approach is selected because it emphasises continuous user involvement throughout the system development process, ensuring that the application is intuitive, functional, and aligned with the operational requirements of both non-resident (NR) students and the Student Residency and Hospitality Unit (URHP). Figure 1 shows the methodology used in this project and the aims of each process.

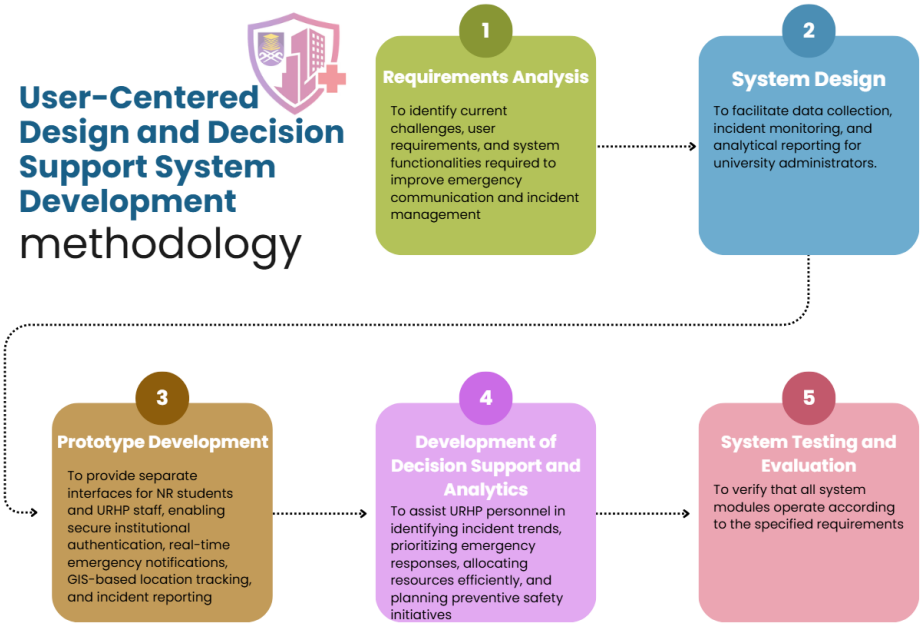


Figure 1: Proposed User-Centered Design and Decision Support System Development Methodology for UiTM NResQ

By integrating User-Centered Design with Decision Support System principles, the proposed methodology ensures that UiTM NResQ is not only user-friendly but also capable of delivering timely, reliable, and data-driven decision support. This approach enables the development of an intelligent emergency management platform that enhances campus safety, improves communication efficiency, and supports evidence-based decision-making for university emergency response management.

3.1 PROJECT FEATURES

UiTM NResQ provides a dedicated, real-time platform that integrates announcements, emergency reporting, and staff duty management, transforming real challenges faced by students into functional solutions. The application also offers a dual-interface design, distinguishing user roles as Student or Staff. Students benefit from a minimalist interface that allows them to easily submit emergency reports with mandatory evidence, ensuring authenticity and preventing fraudulent claims. For staff, the interface includes advanced tools such as duty scheduling, map-based emergency tracking, and analytical reporting dashboards. This dual approach ensures that both sides of the communication channel are optimised for their respective roles, creating a more efficient and transparent workflow. The following Figure 2 and Figure 3 show the selected user interfaces for both roles, Student and Staff.



Figure 2: User Interface for NR Students to report emergency incidents

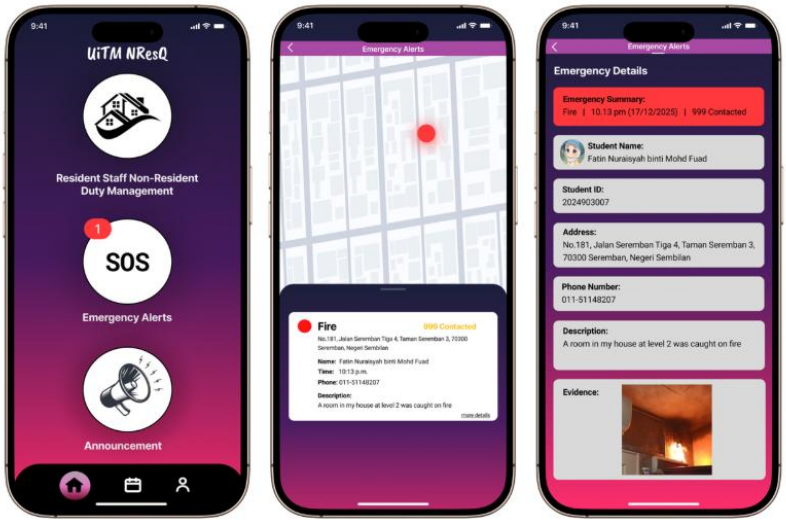


Figure 3: User Interface for Staff receives report on emergency incidents

Staff can easily access a centralised dashboard for emergency notifications, announcements, and duty schedules. These features enable staff to effectively assign and manage schedules for personnel responsible for supporting NR students. This ensures proper coverage during office hours, weekends, and after-hours periods. The emergency alert feature allows real-time monitoring of situations through detailed information, location markers, and video evidence. Interactive comment features allow students to provide feedback, fostering two-way communication and enabling better clarification of incidents. As an extended feature of the application, a comprehensive reporting function is provided that allows staff to access full incident reports and related data through an interactive dashboard. The interfaces for these features are shown in Figure 4 below.



Figure 4: User Interface for interactive dashboard and reporting

The staff interface further integrates data analytics and a visualisation tool, presenting emergency statistics through graphs, tables, and filters. These intelligent reports allow URHP staff to monitor case trends, assess case severity, and allocate resources more effectively.

4.0 RESULT

This project aims to enhance communication between non-resident (NR) students and the Student Residency and Hospitality Unit at UiTM thus improving students' welfare and safety. Currently, NR students lack a centralised system for receiving important announcements or reporting emergencies efficiently. By creating an emergency communication platform, NR students will be able to report incidents such as fires, break-ins, or flooding more quickly. The inclusion of an SOS feature also enables students to request immediate help during urgent situations. This can improve their personal safety and overall well-being.

As for the management of the university, this application provides advantages to the university by facilitating structured and systematic incident reporting. The data gathered can be used to track safety issues, identify recurrent issues, and analyse trends related to NR students. This information aids the university in making better decisions and developing plans regarding safety protocols and policy improvements.

The novelty of UiTM NResQ lies in its ability to address a critical gap in UiTM's current student support system. It is the first platform to unify emergency response, residency management, and official communication into a single mobile application. By doing this, it offers a faster, more reliable, and more transparent solution than existing methods.

5.0 CONCLUSION

UiTM NResQ is designed to provide an efficient and reliable emergency communication platform between off-campus students and the Student Residency and Hospitality Unit (URHP). The project fosters a safer environment for NR students by enhancing coordination between students and university authorities. Adopting a role-based architecture, the application provides different interfaces for students and staff. Real-time notifications play an important role by ensuring that emergency alerts are delivered

to staff immediately, allowing a fast response and support for students. The reporting feature allows both users to review past cases and track incident status, providing greater transparency in case monitoring. Overall, UiTM NResQ enhances communication, improves emergency response, and strengthens safety measures for NR students. It provides a platform for real-time alerts, structured incident reporting, and effective coordination between students and staff. The system minimises response time during emergencies and ensures critical information is delivered accurately. UiTM NResQ contributes to a safer and more supportive environment for off-campus students.

ACKNOWLEDGEMENT

The team members of this project would like to thank the course lecturer, evaluation panels, and project supervisor for their guidance and constructive feedback throughout the development of this project. Appreciation is also extended to the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, for the support and resources provided throughout the completion of the ISP688: Intelligent Decision-Making Support System course.

REFERENCES

Henry, N., Placidus, J. N., & Gunggut, H. (2024). The Challenges of Non-Resident Students in UiTM Kota Kinabalu. Borneo Akademika, 8(2), 63–70.

Mohammed, M., Elleithy, K., & Elmannai, W. (2021). KMSAFE App: Campus Safety Mobile App. BioSMART 2021 - Proceedings: 4th International Conference on Bio-Engineering for Smart Technologies. https://doi.org/10.1109/BioSMART54244.2021.9677778

TRIPPILOT AI: PERSONAL AI TRAVEL AGENT

Foo Yong Xiang[1], Teo Chee Ying[1], Lou Hong Ee[1], Leong Kah Meng[1,2,*]

[1]Faculty of Engineering and Information Technology, Southern University College
[2]School of Foundation Studies, Southern University College

[*]Corresponding author: kmleong@sc.edu.my

ABSTRACT

TripPilot AI is an AI-powered smart travel planning application designed to promote and simplify domestic tourism in Malaysia. The application assists travellers in creating personalised travel itineraries based on their preferred destination, travel dates, budget, travel style, and dietary requirements, including halal, non-halal, vegetarian, and vegan options. Unlike conventional travel applications that primarily focus on individual booking services, TripPilot AI integrates itinerary planning, budget management, transportation recommendations, attraction discovery, and booking assistance into a single intelligent platform. Users can input their travel preferences and budget constraints, and the AI engine automatically generates an optimised day-by-day travel plan covering attractions, accommodations, dining options, and transportation routes. The system estimates and monitors travel expenses, enabling users to make more informed decisions and manage their travel budgets effectively. To enhance convenience, the application provides direct links to booking platforms for flights, buses, trains, hotels, and attraction tickets. In addition, TripPilot AI supports local tourism by recommending hidden gems, cultural attractions, local events, and community-based tourism experiences that may be overlooked by mainstream travel platforms. The application also incorporates real-time weather information, travel advisories, and dynamic itinerary adjustment features to support flexible travel planning and decision-making. Furthermore, an AI-powered chatbot serves as a virtual travel assistant, providing instant recommendations and personalised travel guidance. By leveraging artificial intelligence and data-driven personalisation, TripPilot AI aims to support efficient travel planning, local tourism businesses, and exploration of Malaysia's diverse cultural, natural, and recreational attractions. The proposed solution contributes to the digital transformation of the tourism sector while providing travellers with a seamless, affordable, and personalised travel experience.

Keywords: AI travel assistant, personalized itinerary, sustainable tourism, carbon footprint reduction, mobile application

1.0 INTRODUCTION

The tourism industry has undergone significant digital transformation in recent years, with mobile applications becoming essential tools for travel planning and management. Smart tourism applications leverage digital technologies to enhance visitor experiences, improve accessibility to tourism information, and support more efficient tourism management (Rahman & Dura, 2021). However, existing travel platforms are often fragmented, requiring users to switch between multiple applications for itinerary planning, booking services, navigation, and travel assistance. This fragmentation may reduce planning efficiency and limit the personalisation of travel experiences (Gretzel et al., 2015).

In Malaysia, domestic tourism plays an important role in economic development and cultural exploration. Nevertheless, travellers may face challenges such as difficulties in developing optimised itineraries, managing travel budgets, accessing sustainable travel options, and addressing safety concerns, particularly when travelling independently. These challenges highlight the need for a unified and intelligent travel solution.

TripPilot AI is developed as an AI-powered mobile application that addresses these issues by integrating itinerary generation, travel optimisation, safety features, and sustainability awareness into a single platform. Similar mobile-based tourism platforms have demonstrated the potential of integrating digital services to improve travel planning and user experience (Samsudin et al., 2021). The innovation leverages artificial intelligence to provide personalised travel recommendations based on user preferences and available contextual data.

2.0 OBJECTIVE

1. To develop an AI-powered mobile application that generates personalised travel itineraries based on user preferences and constraints.
2. To develop a unified travel platform that supports travel efficiency through route, budget, and time optimisation while integrating travel planning, booking assistance, and real-time travel information.
3. To promote sustainable tourism by incorporating carbon footprint estimation and eco-friendly travel recommendations.

3.0 METHODOLOGY

TripPilot AI is implemented as an AI-powered mobile travel assistant system that integrates large language model (LLM) capabilities, real-time information retrieval, and sustainability-aware computation. The system architecture consists of four core components: user input processing, an AI reasoning engine, external knowledge retrieval, and travel optimisation modules.

Retrieval-augmented generation (RAG) improves factual accuracy by combining large language models with external knowledge sources (Lewis et al., 2020). In addition, large language models have demonstrated strong performance in natural language reasoning and generation tasks (OpenAI, 2023).

3.1 System Implementation

The application is a mobile-based intelligent travel system supported by cloud backend services, designed with a modular architecture to ensure scalability, maintainability, and efficient interaction between the user interface, AI layer, and external data sources. It uses a Retrieval-Augmented Generation (RAG) pipeline, where real-time information from Tavily Search is combined with the reasoning capabilities of Gemini Flash. This enables the system to incorporate current travel-related information when generating personalised travel recommendations. User inputs such as destination, budget, duration, travel style, and constraints are structured through prompt engineering before being processed by the AI layer. The generated outputs are subsequently refined and presented through the mobile interface as personalised itineraries and travel suggestions. The cloud infrastructure supports data processing and integration with external services, including weather information, booking assistance, and other travel-related functions.

3.2 System Architecture

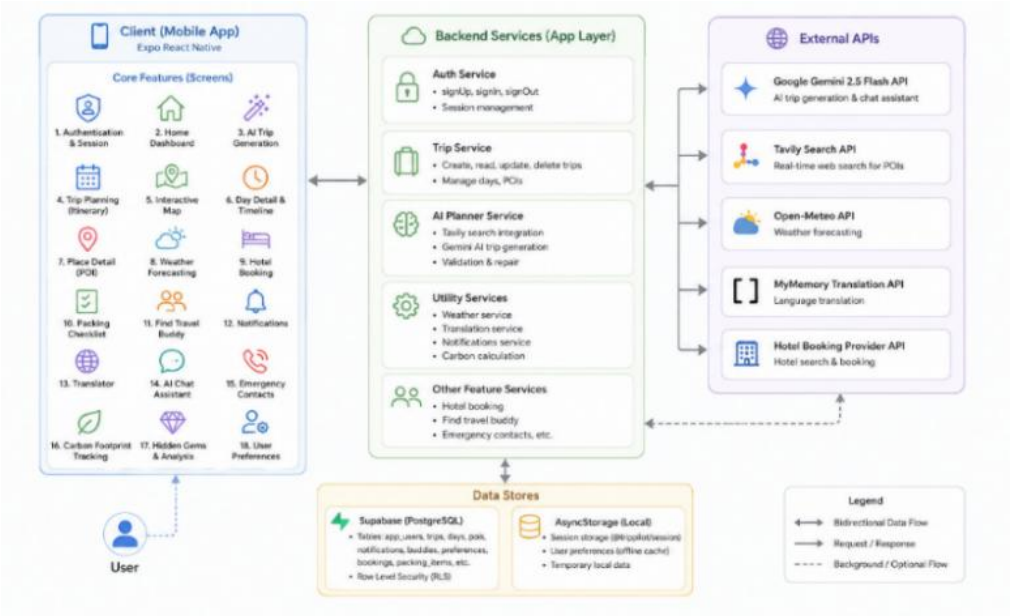


Figure 1: System Architecture Diagram

As shown in Figure 1, the overall system architecture of TripPilot AI is built on a Retrieval-Augmented Generation (RAG) framework that combines Gemini Flash for AI reasoning, Tavily Search for real-time

knowledge retrieval, and travel optimisation modules within a unified mobile ecosystem. The frontend, developed using Expo React Native, comprises 18 core feature screens covering user authentication, trip planning, and supporting services such as interactive maps, weather information, translation, and carbon footprint tracking. The backend functions as the central orchestration layer, managing communication between the mobile application, data storage, and external services. It includes an Auth Service for secure sessions, a Trip Service for CRUD operations on trips and POIs, and an AI Planner Service that generates and validates travel itineraries. Supporting services manage utilities like carbon calculations, notifications, hotel matching, and travel buddy features. This integrated architecture enables TripPilot AI to provide an integrated and context-aware travel planning experience.

3.3 System Architecture and AI Model

The system implements Gemini 2.5 Flash as its core large language model (LLM) for natural language understanding, prompt-based reasoning, and personalised itinerary generation. User inputs such as destination, budget, travel duration, and preferences are processed through structured prompt engineering to generate optimised travel plans.

3.4 Carbon Footprint Estimation

A sustainability module is implemented to estimate travel-related emissions using a simplified carbon footprint model, Eq. (1) shows the formula for calculating carbon footprint:

$$CF = \sum(Di \times EFi) \quad (1)$$

Where CF represents total carbon emissions, D_i is travel distance, and EF_i is the emission factor for each transport mode. This enables users to compare transportation options and encourages greater awareness of environmentally sustainable travel choices. Integrating sustainability considerations into digital tourism solutions can also support efforts to reduce tourism-related environmental impacts (Shariff, 2022).

3.5 Functional Modules Integration

The system integrates multiple AI-enhanced travel modules into a unified mobile architecture to provide a comprehensive and personalised travel management experience. The AI Itinerary Generator utilises Gemini 2.5 Flash as the core LLM-based engine to analyse user preferences, travel constraints, and contextual information for generating personalised travel plans. The generated itineraries include recommended attractions, dining options, transportation routes, and scheduling suggestions to improve travel efficiency.

The Retrieval-Augmented Generation (RAG) Search Layer incorporates Tavily Search as an external information retrieval component to obtain real-time travel intelligence, including destination information, local events, and updated travel-related data. By combining retrieved information with LLM-based reasoning, the system aims to improve the relevance and contextual suitability of AI-generated recommendations.



Figure 2: Built-in Translation and Quick-Access Emergency Contact Features

In addition, the system also supports multilingual communication through an integrated translation feature, enabling users to interact seamlessly across different languages during trip planning and coordination. Furthermore, the Emergency Response Module provides quick-access emergency contacts and support services, ensuring users can rapidly reach local authorities or predefined

emergency contacts in unexpected situations, thereby improving overall travel safety and reliability. Figure 2 illustrates the built-in translation and quick-access emergency contact features of the application.

Furthermore, the Smart Utility Engine integrates essential travel support features, including multilingual translation, weather forecasting, memo management, peak-hour prediction, and holiday awareness to assist users in making better travel decisions. The system also includes a Booking Integration Layer that connects users with external platforms for accommodation, transportation, and attraction reservations, providing convenient access to booking services within the travel planning application.

4.0 RESULT

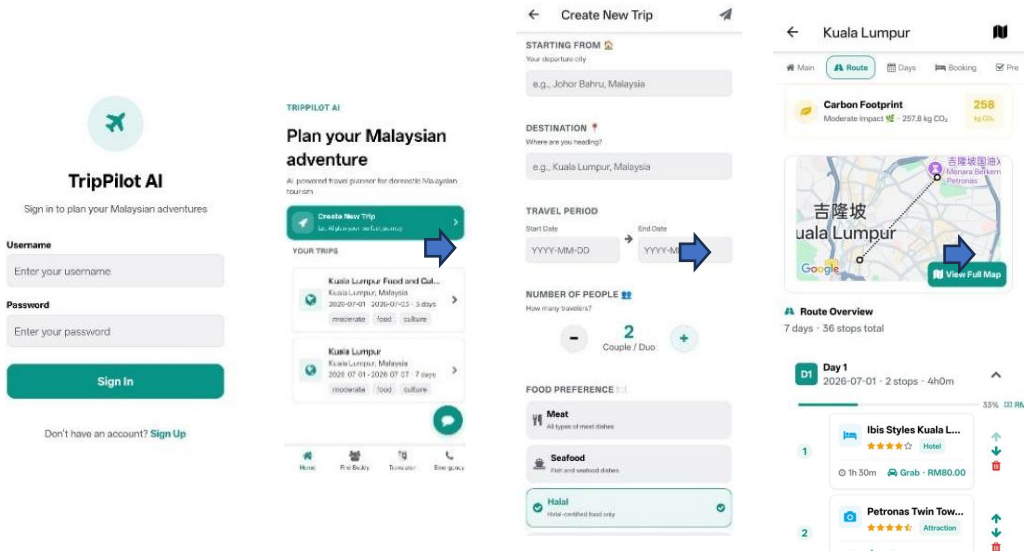


Figure 3: User workflow for AI-driven itinerary generation

TripPilot AI demonstrates the implementation of an integrated AI-powered mobile travel assistant that consolidates itinerary planning, travel information, and travel support features within a single platform. The system is designed to reduce fragmentation in travel planning by integrating multiple travel-related functions within a single mobile application. Digital tourism solutions have shown potential in improving tourism accessibility and creating more personalised visitor experiences through technology integration (Ahmed et al., 2023).

As shown in Figure 3, the AI itinerary generation module allows users to input detailed travel preferences through a structured form, including destination, budget, travel duration, travel style, and other constraints. Based on these inputs, the system generates personalised travel recommendations using Gemini 2.5 Flash and information retrieved through Tavily Search. The generated output includes AI-suggested travel routes and structured itineraries, allowing users to visualise and organise their travel plans within the application. The structured daily travel schedules are designed to support users in organising their travel activities and making informed planning decisions.

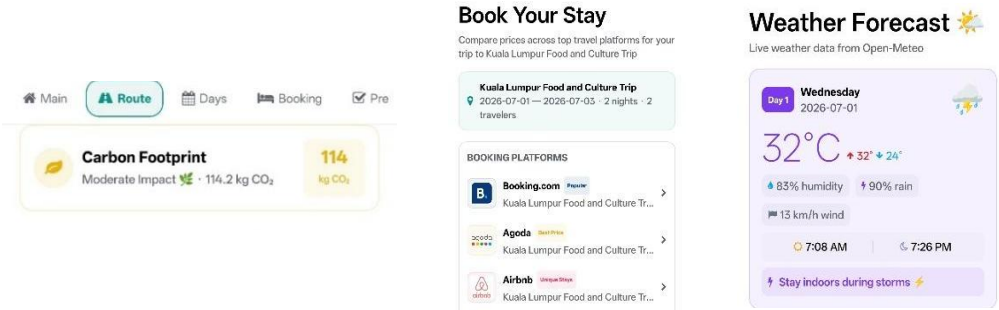


Figure 4: SDG 13-related smart travel application features

The TripPilot AI application includes a carbon footprint calculation feature that estimates the environmental impact of travel based on distance, transport mode, and duration. This enables users to compare the estimated emissions associated with different transportation options during trip planning. Aligned with SDG 13: Climate Action, the feature promotes environmentally responsible travel by integrating sustainability insights directly into the AI-generated itineraries alongside cost and time optimisation. Furthermore, TripPilot AI integrates hotel booking assistance and real-time weather forecasting to enhance travel planning. These features provide users with additional information for selecting accommodation and adjusting itineraries based on updated weather conditions, as shown in Figure 4.

5.0 CONCLUSION

TripPilot AI demonstrates a novel approach to travel planning by integrating artificial intelligence, personalisation, safety features, and sustainability awareness into a single, unified mobile platform. The system addresses the fragmentation of travel planning by offering an integrated intelligent assistant that supports travel planning, safety awareness, and environmentally responsible travel. In addition, AI-driven travel systems have the potential to contribute to the digital transformation of tourism. The innovation has potential to support domestic tourism engagement in Malaysia and could be extended to international markets in future development. TripPilot AI demonstrates the potential of AI-driven decision-making and external information integration to support the digital transformation of the tourism industry.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to Institute of Graduate Studies and Research (IGSR), and Department of Computer Science, Faculty of Engineering and Information Technology, Southern University College for their support and guidance in the development of this project.

REFERENCES

Jabal, A., P. Ahmad, P. Ayub & A.S. Emir. 2034. Money transfer effects on receiver mental health. Journal of Psychological Engineering and Science, 9 (22): 575-583. DOI:10.1016/jpes.2034.77.170.

Ahmed, A. S. W., Husin, M. H., & Abdullah, N. A. (2023). Fourth industrial revolution review: Usage of augmented reality in the Malaysian tourism sector. *International Journal of Engineering Trends and Technology, 71*(2), 174–185. https://doi.org/10.14445/22315381/IJETT-V71I2P221

Gretzel, U., Sigala, M., Xiang, Z., & Koo, C. (2015). Smart tourism: Foundations and developments. *Electronic Markets, 25*(3), 179–188. https://doi.org/10.1007/s12525-015-0196-8

Lewis, P., Perez, E., Piktus, A., Petroni, F., Karpukhin, V., Goyal, N., Küttler, H., Lewis, M., Yih, W. T., Rocktäschel, T., Riedel, S., & Kiela, D. (2020). Retrieval-augmented generation for knowledge-intensive NLP tasks. *Advances in Neural Information Processing Systems, 33*, 9459–9474. https://arxiv.org/abs/2005.11401

Samsudin, N., Fahmy, S., Ali, I. M., & Ainul, W. (2022). Design and development of Travel Assist, an app to support smart tourism. *International Journal of Integrated Engineering, 14*(3), 120–130. https://publisher.uthm.edu.my/ojs/index.php/ijie/article/view/10564

OpenAI. (2023). *GPT-4 technical report*. https://arxiv.org/abs/2303.08774

Rahman, S. A. A., & Dura, N. H. (2021). Malaysia smart tourism framework for ecotourism (MSTF-ECO) from Malaysia smart city framework: A review. *Asian People Journal, 4*(2), 185–200. https://doi.org/10.37231/apj.2021.4.2.286

Shariff, N. M. (2022). Adaptation strategies for impacts of climate change on sustainable tourism in Malaysia. *GeoJournal of Tourism and Geosites, 45*(4), 1735–1743. https://doi.org/10.30892/gtg.454spl23-994

Automatic Weight-Based Conveyor Sorting System

Koh Choon Hao[1,*], Irene Kong Cheh Lin[1]

[1]Department of Electrical and Electronic Engineering, Faculty of Engineering & Information Technology, Southern University College, 81300 Skudai, Johor, Malaysia

[*]Corresponding author: chengzi6633@gmail.com, clkoh@sc.edu.my

ABSTRACT

This project proposes a low-cost automatic weight-based conveyor sorting system for smallholder farmers in Malaysia for sorting passion fruit by weight category. In Malaysia, passion fruit of different weights is sold at different market prices. Therefore, the accuracy of weight grading directly affects smallholder farmers' income. However, most passion fruit is sorted manually, relying primarily on subjective judgement, which can lead to errors caused by fatigue during prolonged work. In contrast, existing automatic sorting systems, such as those based on programmable logic controllers and robotics, offer high accuracy but have high initial costs that smallholder farmers can hardly afford. Therefore, the objective of this project is to develop an automated weight measurement system using an Arduino Mega with a repeatability within ±3 g over five samples, and a sorting system for passion fruit that classifies passion fruit into light (<=65 g) and heavy (>65 g) categories, and to analyse the repeatability of the weight measurement and the sorting accuracy rate. In addition, this project uses an Arduino Mega as a platform, combined with a load cell with HX711 for weight measurement, an IR sensor for detection, and a servo motor to sort the passion fruit into corresponding collection boxes according to a configurable weight threshold, while an LCD displays the weight reading and the count for each category. Furthermore, the prototype achieved weight measurement repeatability values of 2.96 g, 1.43 g, 1.51 g, 1.82 g, and 1.53 g (standard deviation) across 10 trials, and a sorting accuracy of 100%. As a proof-of-concept prototype, this project aims to verify that reliable and repeatable weight grading can be achieved using low-cost and simplified components, providing an alternative solution for smallholder farmers who cannot afford existing automatic systems.

Keywords: Passion fruit, Weight-based sorting, Arduino, Low-cost automation, Smallholder farmers

1.0 INTRODUCTION

A 97.9% of agricultural smallholder farmers, this means the micro and small-scale farmers in large percentage of agricultural in Malaysia (Department of Agriculture Malaysia, 2024). The yellow passion fruit is widely planted in Malaysia, the (Codex Alimentarius Commission, 2014) demonstrates the passion fruit sized by weight. Habibi, Khalil, and Sarkhosh (2025) reported that heavier passion fruit is preferred because it has better internal quality, with higher juice content and volume than lighter passion fruit. However, automatic sorting systems have high initial costs ranging from USD 50,000 to more than USD 250,000 (Bernier, 2023). Hence, many smallholder farmers still sort passion fruit manually. Since there is no literature review that defines the weight range of the passion fruit in Malaysia, thus, this project will configure the weight threshold through purchased passion fruit sample from the market and set the two weight categories where Light category is (<=65g) and Heavy category is (>65g). Furthermore, this project contributes to Sustainable Development Goal 9, Industry, Innovation and Infrastructure, among the 17 Sustainable Development Goals.

2.0 OBJECTIVE

1. To develop an automated weight measurement system using an Arduino Mega that achieves a repeatability with a standard deviation within 3g over 5 samples.
2. To develop a sorting system for passion fruit that classifies passion fruit into the Light category (<=65 g) and Heavy category (>65 g).
3. To analyse the repeatability of the weight measurement and the sorting accuracy rate.

3.0 METHODOLOGY

This project is a low-cost automatic weight-based conveyor sorting system that measures passion fruit weight using a load cell with HX711. It sorts the passion fruit into weight categories using servo motors controlled by an Arduino Mega 2560. The hopper box utilises a dual-disk mechanism in which the upper disk is driven by a servo motor while the lower disk remains stationary. After five passion fruits have been placed into the hopper box and the system is started, the upper disk will rotate.

3.1 System Operation

Figure 1 shows the prototype of the system. The DC switch is turned on to initiate system operation. “System Ready, Press Continue” will be displayed on the LCD. After the Continue Button is pressed, the LCD will show “Target: [Num], Press Start”. After entering the target number of passion fruits to be sorted and weighed, the user has to press the Start Button. Once the Start Button is pressed, the system will begin to function. The passion fruit is dropped onto the load cell with HX711 as the hopper box rotates. The weight reading is displayed in real time, and the LCD will show “Rotating, Weight: 0.0 g. The hopper box will cease to rotate when the passion fruit is dropped onto the load cell with HX711. The weight and count for the Light and Heavy categories will be displayed in real time on the LCD. The LCD shows “Weight: [Value g], L: [Num], H: [Num],” where L stands for the Light category, H stands for the Heavy category, and the value represents the final weight measurement.

After the weight measurement, the LCD will display the “Sorting” status. The passion fruit is swept from the load cell with HX711 onto the conveyor belt by a servo motor. The corresponding LED will turn on as an indicator when the infrared sensor above the conveyor belt detects the passion fruit. The LED for the Light category is green, and the LED for the Heavy category is red. The servo motor next to the conveyor belt will sweep the passion fruit into the Light Collection Box if its weight is less than 65g. The conveyor belt will transport the passion fruit into the terminal section’s Heavy Collection Box if its weight exceeds 65g, which falls under the Heavy category.

The LCD will show “L: [Num], H: [Num], Finished” once the sum of the Light and Heavy counts equals to the key in target number. When the system has completed sorting, the user will be alerted by both the green and red LEDs being turned on. The system will remain stopped until the user presses the reset button to reset the data. The Stop Button is pressed if the user wants to stop the system operation.

Table 1: The Main hardware components

	Component	Count	Price (RM)
1	Arduino Mega 2560	1	58.90
2	Conveyor belt kit	1	89.90
3	Load cell with HX711 (1kg)	1	10.15
4	MG995 servo motor	3	50.70
5	IR sensor	1	3.48
6	LCD 1602 I2C	1	12.90
7	LED	2	2.40
8	LM2596 DC to DC step down module	2	29.00
9	Button	4	4.36
10	DC power switch	1	2.77
Total:			RM 265.76

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \underline{x})^2}{n-1}} \quad (1)$$

This is the weight measurement repeatability is expressed as the sample standard deviation, calculated using Eq. (1), where x_i is each reading, $\underline{x}$ is the average of the readings, and n is the number of measurements.

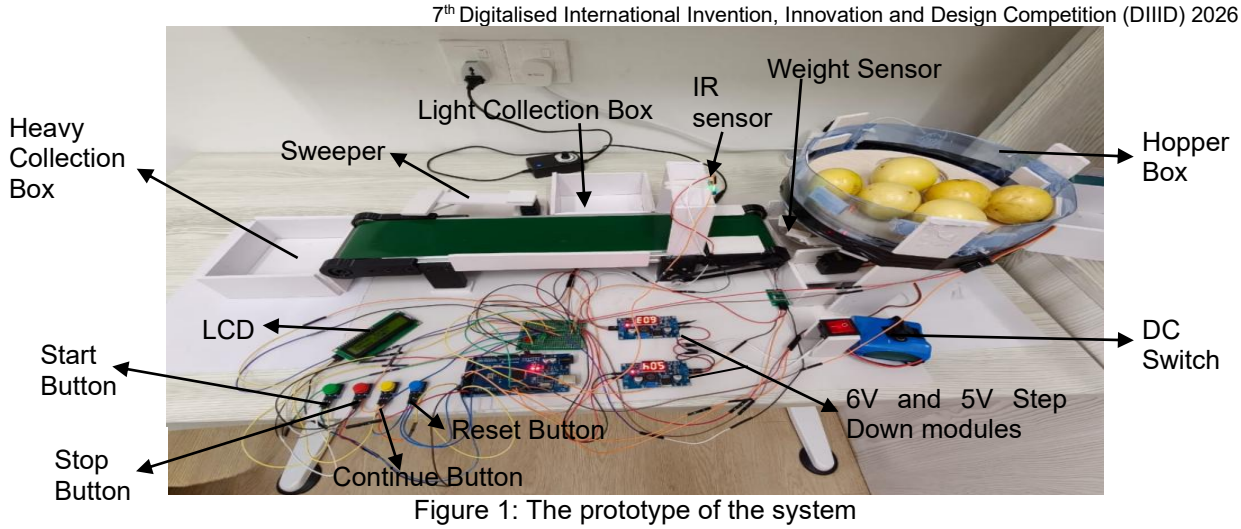


Figure 1: The prototype of the system

4.0 RESULT

4.1 Weight Measurement Repeatability

The experimental results evaluated using Eq. (1) validated that the prototype achieved a maximum weight measurement repeatability of 2.96 g (standard deviation) across five samples. This successfully satisfies the primary objective of keeping measurement repeatability, expressed as standard deviation, within 3g. As shown in Table 2, the repeatability across all trials was significantly lower than the maximum threshold, with Sample 2 exhibiting the highest precision (SD = 1.43g). The system's internal averaging algorithm, which processes 10 continuous raw readings from the HX711 load cell module, effectively mitigated the transient vibration errors that occurred when passion fruits dropped from the hopper mechanism.

4.2 Sorting Accuracy and Boundary Conditions

Sorting performance was evaluated using five passion fruit samples representing different weight distributions around the threshold. The prototype achieved a 100% sorting accuracy rate, successfully classifying fruits into Light (<=65g) and Heavy (>65g) categories as detailed in Table 3. The dual-disk hopper mechanism effectively singulated the passion fruits, ensuring that a single item was dropped onto the load cell without manual intervention. Additionally, the real-time user interface on the LCD 1602 accurately updated the category counts ("L" and "H") and triggered the corresponding LED indicators immediately following IR sensor detection.

4.3 Cost-Benefit Analysis and Practicality

A key achievement of this architecture is its cost efficiency. With a total component cost of RM 265.76, as shown in Table 1, this prototype provides an automated alternative to commercial automated sorting systems, which range from USD 50,000 to more than USD 250,000 (Bernier, 2023). By replacing subjective visual grading with objective, automated weight sorting, this system reduces the effects of human fatigue and may improve profit margins for smallholder farmers by supporting accurate market premiums based on fruit weight classification.

4.4 Limitations of the Study

However, this 100% accuracy based on 1 trial testing in small sample size (n = 5), the error rate between 50g to 80g haven't enough data to analyse. Long-term mechanical durability remains unknown. Additional testing and verification are required.

Table 2: Repeatability Test

Objects	Reference Weight (g)	10 Trials (g)	Average (g)	Repeatability (SD, g)
1	82.34	83.4,91.8,84.0,86.9,83.3,85.6,80.9,84.3,83.0,83.7	84.69	2.96
2	67.78	68.8,69.1,67.6,67.4,67.0,64.0,68.0,67.0,67.7,68.5	67.51	1.43
3	63.64	61.0,64.4,61.8,65.2,64.4,62.5,62.7,62.8,60.3,62.7	62.78	1.51
4	56.99	57.1,53.0,53.2,55.9,57.8,55.7,53.5,56.0,57.7,56.6	55.65	1.82
5	58.99	57.1,58.3,56.0,58.4,58.3,55.4,55.9,60.1,58.5,56.1	57.41	1.53

Table 3: Sorting Results

Objects	Reference Weight (g)	Measured Weight (g)	Classification	Sorted Correctly
1	82.34	86.70	Heavy (>65g)	Correct
2	67.78	68.20	Heavy (>65g)	Correct
3	63.64	63.70	Light (<=65g)	Correct
4	56.99	61.20	Light (<=65g)	Correct
5	58.99	63.10	Light(<=65g)	Correct

5.0 CONCLUSION

In conclusion, this project successfully achieved Objectives 1 and 2. The prototype based on the Arduino Mega achieved a weight measurement repeatability of 2.96 g and a sorting accuracy of 100% using a classification threshold of 65g. Additionally, the dual-disk mechanism of the hopper box can drop the passion fruit without manual intervention. The lower price hardware allows the small holder farmer affordable to achieve the automatic weight-based sorting system, eliminating the human error and ensuring the market premium of the heavy passion fruit, which can achieve the maximum profits for the small holder farmers.

ACKNOWLEDGEMENT

The author would like to thank Dr. Irene Kong Cheh Lin and Dr. Leong Kah Meng for guidance and support throughout this project, and Southern University College for the facilities provided.

REFERENCES

Bernier, C. (2023, July 17). *Weeding robots: Redefining sustainability in agriculture*. Retrieved from HowToRobot: https://howtorobot.com/expert-insight/weeding-robots-redefining-sustainability-agriculture.

Codex Alimentarius Commission. (2014). *Standard for passion fruit (CODEX STAN 316-2014).* Food and Agriculture Organization. Retrieved from https://www.fao.org/input/download/standards/13775/CXS_316e_2014.pdf.

Department of Agriculture Malaysia. (2024). *Statistik tanaman buah-buahan Malaysia 2024 [Fruit crop statistics Malaysia 2024].* Putrajaya: Department of Agriculture Malaysia. Retrieved from https://www.doa.gov.my/doa/resources/aktiviti_sumber/sumber_awam/penerbitan/statistik_tanaman/statistik_tanaman_buah_2024.pdf.

Habibi, F., Khalil, U., & Sarkhosh, A. (2025). Physicochemical and quality attributes of 'Possum Purple' passion fruit in relation to fruit weight categories. *HortScience, 60*(9), 1561-1568. doi:10.21273/HORTSCI18699-25.

SALIRAN Snake System (SSS) (Smart Aquatic Longkang Inspection Robotic Autonomous Network)

Nor Fashaa Dayana Binti Nor Hazaimi[1,*], Nur Syazmina Binti Syamsyul[1], Nurain Irdina Binti Mohd Zaidi[1]

[1]Kolej MARA Seremban

[*] Corresponding author: syazmina04@gmail.com or nfdayana55@gmail.com

ABSTRACT

Flash floods have become an increasing concern in Malaysia, causing significant impacts on communities, including property damage, disruption of daily activities, environmental pollution, and risks to public safety. One of the major factors contributing to urban flooding is the blockage of drainage systems caused by the accumulation of rubbish such as plastic waste, leaves, and other debris. These blockages restrict water flow and increase the risk of flash floods, especially during heavy rainfall and monsoon seasons. Current drain maintenance practices often depend on manual inspection and cleaning, which can be time-consuming, inefficient, and expose workers to unsafe conditions. Furthermore, the lack of automated monitoring systems makes it difficult to identify the exact locations of waste accumulation in drainage systems before serious blockages occur. Therefore, this project aims to develop a SALIRAN Snake System as an innovative solution to improve drain monitoring and maintenance efficiency. The proposed system is designed to travel along drainage systems and detect the location of accumulated waste using electrical components such as an ultrasonic sensor and a microcontroller. The robot will provide real-time information and alerts to maintenance workers, allowing them to locate and remove rubbish more efficiently. By improving waste detection and reducing the time required for manual inspections, the SALIRAN Snake System can support proactive drainage management and flood prevention efforts. This innovation provides a safer, faster, and more effective approach to maintaining drainage systems, helping communities reduce the risks and impacts associated with flash flooding.

Keywords: Flash floods, drainage blockage, waste detection, smart robot, automated monitoring system, drainage management, flood prevention

1.0 INTRODUCTION

Flooding has become one of the most frequent natural disasters in Malaysia, occurring almost every year, especially during the Northeast Monsoon season. Although heavy rainfall is the primary trigger, one of the major factors contributing to recurring flash floods in urban areas is the blockage of drainage systems caused by accumulated rubbish. Plastic bottles, food packaging, paper, leaves, and other solid waste obstruct the flow of water, preventing efficient drainage and causing water to overflow onto roads and into residential and commercial areas.

Recent flood events in 2025 affected multiple states, including Kelantan, Terengganu, Kedah, Johor, and Perak, forcing thousands of residents to evacuate to temporary evacuation centres (PPS). Besides causing extensive property damage and disrupting daily life, these floods also resulted in tragic loss of life due to drowning in fast-flowing floodwaters. These incidents highlight the urgent need for more effective and innovative solutions to improve drainage management and reduce flood risks.

To address this issue, we developed the SALIRAN Snake System (SSS), an innovative autonomous robotic system designed to monitor drainage conditions and detect rubbish accumulation in flood-prone drainage networks. Unlike conventional wheeled robots, SSS incorporates snake-inspired locomotion, enabling it to navigate narrow, uneven, and partially submerged drainage channels with greater flexibility and stability. The robot continuously monitors the drainage system and records the exact locations of rubbish blockages, allowing maintenance personnel to identify critical areas quickly and carry out

targeted cleaning operations. This approach improves maintenance efficiency, enhances water flow, and helps prevent drainage blockages before they lead to severe flooding.

The development of the SALIRAN Snake System is motivated by the increasing frequency of flood events in Malaysia, rising drainage maintenance costs, and the safety risks faced by workers during manual inspections. By combining bio-inspired locomotion with autonomous monitoring technology, SSS aims to improve drainage efficiency, reduce flood-related damage, and contribute to cleaner, smarter, and more sustainable urban drainage systems in Malaysia.

.

2.0 OBJECTIVE

- To improve ecological health by preventing plastic waste and chemical toxins from migrating through the drainage network into local rivers and oceans.
- To track and log the exact geographic locations of clogged drainage areas in the main data system.
- To reduce waterlogging in low-lying residential and commercial zones to prevent costly property damage.
- To improve overall drainage flow efficiency ahead of heavy rainfall events and annual monsoon seasons

3.0 METHODOLOGY

3.1 MECHANICAL DESIGN IDEAS AND MORPHOLOGY

3.1.1 Serpentine Shape and Drainage Navigability

- Bio-inspired configuration: The SSS robot utilizes a snake-like multi-jointed body structure.
- Obstacle negotiation: This modular architecture allows the system to bend smoothly around pipe joints, sharp corners, and heavy debris pools.
- Friction mitigation: The slender, elongated geometry reduces structural contact with drain walls, helping to avoid wedging or trapping.

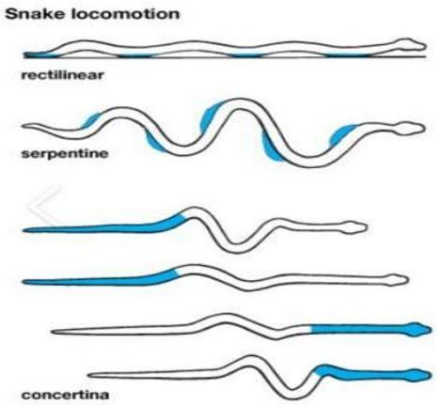


Figure 1: Snake locomotion

3.1.2 Serpentine Shape and Drainage Navigability

- Velocity amplification: The wave locomotion pushes against internal debris and drain floor contours to rapidly generate thrust.
- Adaptive motion: Programmed algorithms dynamically alter wave frequencies to increase travel speed across open, unobstructed drain zones.

3.2 SENSOR DATA ACQUISITION AND VISUALIZATION

3.2.1 Ultrasonic Waste Detection System

- Acoustic echo mapping: Waterproof ultrasonic sensors are mounted on the front of the head segment.

- Blockage tracking: High-frequency sound waves are directed towards physical waste targets to calculate their distances.
- Debris profiling: Data streams distinguish solid blockages, such as large plastic deposits, bags, and accumulated organic rubbish, from clear pathways.

3.3 TELEMETRY AND LOCALISATION

3.3.1 GPS Tracking Configuration

- Global positioning module: A compact GPS receiver is embedded within the primary command segment of the robot.
- Coordinate mapping: The receiver constantly retrieves latitude and longitude positions during surface-exposed runs or via shallow-depth signals.
- Maintenance sync: When the system tags a massive plastic or rubbish buildup, it logs the exact location coordinates

3.4 PROTOTYPE

3.4.1 Coding guidance

Arduino IDE 2.3.10 is used for programming the system. Electrical routing instructions are included in the code.

```
#include <Servo.h>

Servo servo1;
Servo servo2;
Servo servo3;
Servo servo4;

// Ultrasonic pins
const int trigPin = 10;
const int echoPin = 11;

long duration;
int distance;

int pos;
int servoSpeed = 5;

// Measure distance
int getDistance() {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);

  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH);

  distance = duration * 0.034 / 2;

  return distance;
}
```

```
// Move forward
void forwardMove() {
  for (pos = 0; pos <= 100; pos++) {
    servo1.write(pos);
    servo2.write(pos);
    servo3.write(pos);
    servo4.write(pos);

    delay(servoSpeed);
  }

  for (pos = 100; pos >= 0; pos--) {
    servo1.write(pos);
    servo2.write(pos);
    servo3.write(pos);
    servo4.write(pos);

    delay(servoSpeed);
  }
}

// Reverse
void reverseMove() {
  for (pos = 100; pos >= 0; pos--) {
    servo1.write(pos);
    servo2.write(pos);
    servo3.write(pos);
    servo4.write(pos);

    delay(servoSpeed);
  }
}
```

```
}

// Turn
void turnRight() {
  servo1.write(20);
  servo2.write(160);
  servo3.write(20);
  servo4.write(160);

  delay(800);
}

void setup() {

  servo1.attach(3);
  servo2.attach(2);
  servo3.attach(4);
  servo4.attach(5);

  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  Serial.begin(9600);
}

void loop() {

  distance = getDistance();

  Serial.print("Distance: ");
  Serial.print(distance);
  Serial.println(" cm");
```

```

  if (distance > 20) {
    forwardMove();
  }
  else {
    reverseMove();
    delay(300);
    turnRight();
  }
}
```

3.4.2 Finalized Prototype

Arduino IDE 2.3.10 is used for programming the system. Electrical routing instructions are included in the code.



Figure 2: Prototype top view



Figure 3: Prototype side view

4.0 RESULT

The prototype of the robotic snake developed in this study has shown promising capabilities in

addressing flood-related challenges. Initial trials confirmed that the design could move flexibly through confined and cluttered spaces while maintaining stability when exposed to uneven terrain and water flow. Although the system is still at the prototype stage, these outcomes demonstrate that serpentine locomotion can be effectively adapted for disaster response applications. The results highlight the robot's ability to reach areas that are difficult or unsafe for conventional machines, suggesting its potential as a support tool in emergency situations.

The impact of this work is evident in two main areas: safety and practicality. By taking on tasks such as monitoring and inspection in hazardous flood zones, the robotic snake reduces the need for direct human involvement, thereby lowering the risks faced by emergency responders. Even at the prototype stage, the design shows promise as a system that could operate continuously without fatigue, offering a safer and more reliable alternative to labour-intensive methods. Economically, the prototype demonstrates that such a system can be built using affordable materials and has the potential to be manufactured at scale. This makes it a realistic option for governments, disaster management agencies, and private industries seeking efficient tools to protect communities while also reducing long-term costs associated with flood damage and emergency response.

The novelty of this project lies in applying snake-like motion to flood mitigation, an approach that has rarely been explored in disaster robotics. Unlike traditional flood management methods that rely on static barriers or heavy machinery, this prototype introduces a mobile, bio-inspired system capable of adapting to unpredictable environments. The originality lies in the way serpentine locomotion has been engineered into a robotic platform for disaster scenarios, creating new opportunities for research in flexible robotics, sensor integration, and autonomous control. While further development and testing are required, the prototype represents an important step toward practical solutions that combine biological inspiration with engineering innovation.

In summary, the prototype has demonstrated clear advantages in mobility and adaptability, while also pointing to broader impacts in safety and cost efficiency. Its originality ensures that this work contributes both to the scientific understanding of bio-inspired robotics and to the practical goal of improving community resilience against flooding

5.0 CONCLUSION

This study has explored the development of a bio-inspired robotic snake designed to assist in flood mitigation, presenting both scientific and practical contributions. The prototype demonstrates how flexible robotics can be adapted to navigate unpredictable and hazardous flood environments. From a scientific perspective, this work enriches the field of disaster robotics by introducing a new approach of serpentine motion in emergency response. It provides a foundation for further research into autonomous control systems, sensor integration, and large-scale deployment of bio-inspired robots, thereby expanding the knowledge base available to engineers and researchers working on disaster resilience technologies, especially in Malaysia. The economic implications of this project are equally important. Flooding remains one of the costliest natural disasters worldwide, causing extensive damage to infrastructure and property and resulting in significant loss of life. The robotic snake offers a more economically viable alternative to traditional flood management methods, reducing reliance on manual labour. Its capacity to be expanded and manufactured at larger scales makes it a viable solution for governments, disaster management agencies, and private industries seeking efficient tools to protect communities. In the long term, the commercialisation of such technology could create demand for disaster robotics, generate employment opportunities, and strengthen economic resilience against climate-related challenges. Ultimately, this project demonstrates that the robotic snake is not only a technical innovation but also a meaningful contribution to science and society, offering a sustainable and economically beneficial approach to one of the most persistent global problems.

ACKNOWLEDGEMENT

All praise to the Almighty Allah S.W.T., who has granted us all we have now. His permission enabled us to finish up this project. There is nothing more amazing than the wonder of His creation. We would like to express our deepest gratitude to our respected group supervisor, Puan Haszita binti Azim, for her guidance and help throughout the making of our project. Her continuous support, patience, and enthusiasm helped us successfully carry out this project. We are also grateful to our laboratory assistant for providing us with access to the laboratory and the electrical components necessary to successfully complete our project. We would like to extend our heartfelt thanks to our friend, Nur Amni Madiha, for her invaluable assistance in programming and the use of electronic components throughout the development of this project. Her support, guidance, and technical expertise played an important role in

the successful completion of our prototype. To ensure the success of this initiative, each participant must fulfil their responsibilities. This statement also refers to the time and effort we invested as a group throughout the course of the whole timeframe

REFERENCES

Nordila Ahmad, Choy Peng Ng Neza Ismail, Mohd Muhaimin Ridwan Wong , Fuad Abbas, Teik Hua Law, Ahmad Najman 'Azam Zul Baharia & Muhamad Faisharulfaizi Mohd Rofi. 2025. A review of major floods events in Malaysia between 1970-2024.

Navi, M., 2038. Analysis of Digital Systems. 2nd Ed. Illusion Ink, Uganda. ISBN: 0050969790, pp: 62.

Department of Irrigation and Drainage Malaysia (JPS). (2017). Stormwater Management & Drainage Master Plan Study. Ministry of Energy Transition and Water Transformation, Malaysia. Retrieved from https://www.water.gov.my/index.php/pages/view/673.

The Star. (2024, May 12). Flash floods: The urgent need to upgrade Malaysia's drainage system. Retrieved from https://www.thestar.com.my.

Nura Industrial. (2026). Drain cleaning. NURA Malaysia. Retrieved from https://nura.com.my/product/drain-cleaning/

Simon, M. (2017, November 28). [Just like a real snake! The real reason why the robot acquired its "strange movement" (with video)]. WIRED Japan. Retrieved from https://wired.jp/2017/11/28/snake-robot/

Iqbal, U., Barthelemy, J., Perez, P., & Li, W. (2021). Prediction of Hydraulic Blockage at Cross Drainage Structures Using Regression Analysis. ArXiv

IoT Smart Garbage Monitoring System

Lim Jing Yun[1,*], So Yong Quay[1], Wong Li Shi[1]

[1]Southern University College

[*] Corresponding author: b230230c@sc.edu.my

ABSTRACT

Garbage overflow is a global issue. Rapid urbanization has increased the number of people living in high-rise residential buildings, where household garbage is commonly disposed of through centralized garbage chute systems. The garbage from each floor is collected in a large garbage collection bin located in the building's garbage collection room. Currently, these bins are mainly inspected manually by maintenance personnel based on scheduled routines, which may result in delayed garbage collection and overflowing bins. The foul odours emitted by these piles not only mar the cityscape but also endanger public health. This project proposes the development of an IoT smart garbage monitoring system designed to improve garbage management efficiency in high-rise residential buildings. The system automatically alerts management personnel when garbage fill levels reach a specific threshold, thereby ensuring timely removal. This IoT smart garbage monitoring system integrates an ESP32 development board with an ultrasonic sensor. When the ultrasonic sensor detects garbage accumulation, the ESP32 transmits the data to the Firebase cloud platform, which then displays the garbage accumulation status in real time via a mobile application. When the garbage fill level reaches a predefined threshold, the mobile application sends instant notifications to users. By tracking garbage accumulation through this smart garbage monitoring system, the project aims to support a clean and aesthetically pleasing urban environment. This system enables maintenance personnel to remotely monitor garbage accumulation levels, optimize garbage collection schedules, reduce operating costs, and prevent overflow before garbage reaches critical levels. As a result, it helps improve environmental sanitation, enhance operational efficiency, and support the development of sustainable smart cities. Overall, by integrating Internet of Things (IoT) technology, this system provides a practical, scalable, and cost-effective solution for modern residential garbage management.

Keywords: Real-time monitoring, ESP32, Ultrasonic Sensor, Notifications, Firebase

1.0 INTRODUCTION

As urbanisation increases, more people are living in high-rise residential buildings, leading to increased amounts of household waste. Many apartments have a central garbage chute system, with residents placing garbage into a chute built into the wall on every floor, where it is collected in a ground-floor garbage collection bin. Usually, these bins are checked manually at regular intervals, making it difficult for maintenance staff to determine the actual level of garbage. As a result, the inappropriate delay of garbage collection can cause bins to overflow, foul odours, pests, environmental pollution, poor hygiene and higher operational costs. This project aims to address this problem by introducing an IoT smart garbage monitoring system for real-time garbage level monitoring. The system comprises an ultrasonic sensor, an ESP32 microcontroller, communication via Wi-Fi, integration with the Firebase cloud platform, and mobile application. The ultrasonic sensor measures the level of garbage, and the ESP32 sends the data to the Firebase real-time database. Once the garbage is at a set level the system can automatically send notifications to maintenance staff, which helps to collect waste at the proper time. This innovation reduces manual inspections, improves environmental hygiene, and supports efficient garbage management for sustainable smart city development (Dey, 2023). Recent studies similarly show that IoT smart garbage monitoring enables real-time monitoring, automated alerts, and more efficient garbage collection.

2.0 OBJECTIVE

1. To identify a robust sensing mechanism and transmit garbage fill-level condition data to a backend system.

2. To develop an alert app that pushes notifications when the garbage condition reaches the specified limit.
3. To verify the garbage fill-level condition using the alert mobile app.

3.0 METHODOLOGY

The proposed IoT smart garbage monitoring system is designed to monitor the fill level of large central garbage bins in high-rise residential buildings. The system utilises a NodeMCU ESP32 microcontroller and an ultrasonic sensor (HC-SR04), which are integrated with Firebase and a monitoring app. Real-time garbage volume detection is performed using the NodeMCU ESP32 and an ultrasonic sensor (HC-SR04), with the data transmitted via Wi-Fi to the backend cloud. When the garbage fill level reaches a threshold, the system sends a notification to users via a mobile app. Additionally, the system allows users to set their own garbage fill-level alert thresholds and view historical garbage fill level records. This IoT smart garbage monitoring system enables real-time detection of garbage fill levels and promptly notifies garbage management personnel to arrange for collection. This allows garbage management personnel to plan optimal and cost-effective collection schedules. As a result, it helps prevent pest infestations, environmental pollution, and deteriorating sanitary conditions caused by overflowing garbage. The system is practical and cost-effective, making it suitable for apartments, condominiums, and other high-rise residential buildings equipped with centralised garbage chutes.

3.1 IMPLEMENTATION

This section presents the mobile application interface developed for this project and describes its functionalities.

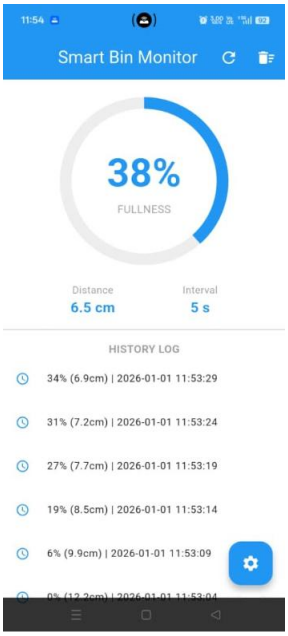


Figure 1: Real-time Monitoring Interface

The mobile app's home screen displays the bin fill status along with the remaining distance and refresh interval. It also lists historical data for users to review, including fill percentage, remaining distance, and time.



Figure 2: Automatic Notification Alert

When the bin's fill level reaches the specified limit, the system will send a notification to the user.

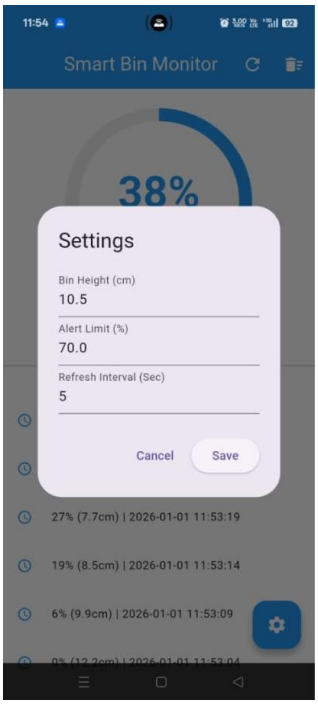


Figure 3: System Configuration Interface

In the settings, users can edit the bin height in cm, alert limit percentage, and refresh interval in seconds. After setting the parameters, users can select either ‘Save’ or ‘Cancel’.

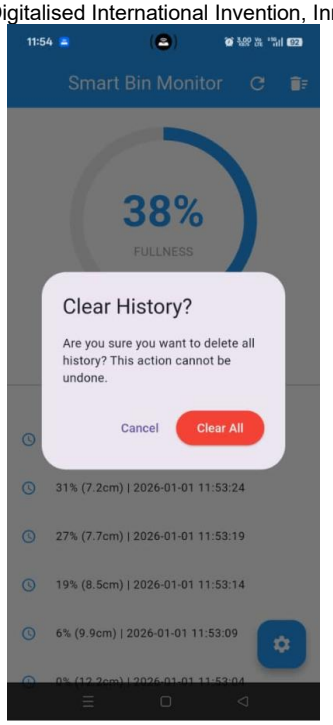


Figure 4: History Management Interface

After clicking the delete icon, the system will display a confirmation prompt to the user, as clearing all history is an action that cannot be undone.

4.0 RESULT

The proposed IoT Smart Garbage Monitoring System is an innovative solution for monitoring garbage collection bins in centralised garbage collection areas serving garbage chute systems in high-rise residential buildings. The system is different from the conventional smart garbage monitoring system in that it is specifically targeted at the challenges facing centralised garbage collection in high-density residential areas. The system provides real-time monitoring of the garbage level and automatically alerts maintenance personnel when the level reaches the set threshold, allowing the garbage to be collected on time and preventing overflow. This will, however, reduce manual inspections, eliminate unpleasant odours, enhance environmental cleanliness, and reduce the possibility of pest infestation. Furthermore, real-time monitoring can help optimise garbage collection routes, minimising the number of garbage collection trips and operational expenses. The system is practical, scalable, and cost-effective, making it suitable for apartments, condominiums, and other high-rise residential buildings. In conclusion, the innovation proposed in the project contributes to enhancing the efficiency of garbage management, fostering environmental responsibility, and advancing the development of sustainable smart cities by leveraging IoT technology. The benefits align with research showing that the implementation of IoT in garbage management can improve collection efficiency, streamline collection routes, and lower operating costs.

5.0 CONCLUSION

The IoT Smart Garbage Monitoring System is an effective and practical solution for monitoring garbage collection in centralised garbage bins in high-rise residential buildings. The system combines an ESP32 microcontroller, an ultrasonic sensor, Firebase cloud services, and a mobile app to provide real-time monitoring of garbage levels and automatic alerts, thereby minimising the need for manual inspections and preventing garbage overflow. This innovation represents a step towards the future of IoT-based smart garbage management systems, demonstrating its practical application in real-world household garbage collection. Furthermore, the system can optimise the garbage collection process, reduce unnecessary collection trips and associated costs, improve environmental sanitation, and contribute to the development of a sustainable smart city. The proposed system is scalable and cost-effective, making it a promising solution for implementation in modern residential communities and future smart garbage management projects. Because a proper garbage management plan in Malaysia is vital in ensuring public health, the environment, and industrial sustainability. (Malik & Malik, 2025)

The integration of IoT into smart garbage management systems has been shown to enhance the efficiency of garbage collection, optimise garbage collection operations, and contribute to a more sustainable urban environment.

ACKNOWLEDGEMENT

During this project I encountered many individuals who helped me overcome challenges. First, I thank my supervisor, Asst. Prof. Ts. So Yong Quay. He provided valuable guidance and technical advice throughout the development of this project. It was precisely this guidance that enabled me to successfully complete this project. Last but certainly not least, I thank my friends who patiently guided me through problem-solving methods whenever I encountered difficulties I couldn't resolve on my own.

REFERENCES

Dey, S. (2023, June 21). 4 Smart garbage management solutions that are revolutionising the industry. Earth.Org. https://earth.org/smart-garbage-management/

Malik, F., & Malik, F. (2025, June 16). How the Garbage Management Schedule Works in Malaysia | Jackster. Jackster | Life Is Real. https://jackster.my/garbage-management-schedule-in-malaysia/

Instructables. (2017, August 2). Smart Garbage Monitoring System using Internet of Things (IOT). Instructables. https://www.instructables.com/Smart-Garbage-Monitoring-System-Using-Internet-of-/

Getting Started with the HC-SR04 Ultrasonic sensor. (n.d.). Arduino Project Hub. https://projecthub.arduino.cc/Isaac100/getting-started-with-the-hc-sr04-ultrasonic-sensor-7cabe1

Waste Management - MBIP. (2026). Mbip.Gov.My. https://www.mbip.gov.my/en/perkhidmatan/pengurusan-sisa

INFANTCRYSENSE: INTELLIGENT INFANT CRY DETECTION USING AN MFCC-BASED CONVOLUTIONAL NEURAL NETWORK FOR REAL-TIME MONITORING

Chang Jing Xuan[1], Goh Yi Xuan[1], Tey Jay Yang[1], Ngeu Chee Hau @ Yeo Chee Hau[1], Lim Wei Jer[1,*]

[1]Faculty of Engineering and Information Technology, Southern University College, Skudai, Johor, Malaysia

[*]Corresponding author: wjlim@sc.edu.my

ABSTRACT

Infant crying is one of the primary forms of communication used by newborns to express physiological and emotional needs. However, interpreting infant cries accurately often depends on caregiver experience and subjective judgement, which may lead to delayed responses and inconsistent assessments. This study presents InfantCrySense, an intelligent infant cry detection system designed to automatically distinguish between cry and non-cry audio signals using deep learning techniques. The proposed system employs an audio preprocessing pipeline consisting of silence trimming, root-mean-square (RMS) normalisation, audio segmentation, and Mel-Frequency Cepstral Coefficient (MFCC) feature extraction. In addition to MFCCs, delta and delta-delta coefficients are extracted to capture temporal variations in acoustic patterns. The generated three-channel feature representation is subsequently normalised and used to train a Convolutional Neural Network (CNN) classifier. The model architecture consists of multiple convolutional layers with batch normalisation, pooling operations, adaptive average pooling, and fully connected layers for classification. Training is performed using the Adam optimiser and cross-entropy loss function, while the Macro-F1 score is utilised for model selection. The trained model is integrated into a real-time detection framework capable of performing inference on both recorded audio files and live microphone streams. The proposed system offers a non-invasive, cost-effective, and intelligent solution for infant cry monitoring, enabling timely identification of infant distress. InfantCrySense has potential applications in home monitoring systems, childcare environments, neonatal wards, and telehealth platforms where continuous observation and rapid caregiver response are essential. The proposed innovation provides an intelligent, non-invasive, and real-time infant monitoring solution that supports smart healthcare applications.

Keywords: infant cry detection, deep learning, convolutional neural network, mfcc, real-time monitoring

1.0 INTRODUCTION

Infants rely primarily on crying to communicate their needs, discomfort, and physiological conditions. Crying may indicate hunger, pain, fatigue, discomfort, illness, or environmental stress. Accurate interpretation of these vocal expressions is important for ensuring timely intervention and proper infant care. However, continuous monitoring by caregivers is often challenging, particularly at night or in situations where multiple infants require simultaneous attention (Hariharan et al., 2012; Micheletti et al., 2023).

Existing approaches commonly depend on caregiver observation, which is subjective and influenced by experience, fatigue, and environmental factors. With recent advancements in artificial intelligence and audio signal processing, automated cry analysis systems have emerged as promising solutions for supporting infant monitoring and healthcare applications (Liang et al., 2022; Thao et al., 2023).

InfantCrySense was developed to address this challenge through automated cry detection using deep learning techniques. The system analyses infant vocalisations using MFCCs and a CNN model capable of distinguishing cry and non-cry audio segments. The use of MFCCs enables effective extraction of acoustic features, while CNNs provide robust classification performance for audio-based recognition tasks (Davis & Mermelstein, 1980; Goodfellow et al., 2016; Abbaskhah et al., 2023). The system further supports real-time monitoring through microphone-based audio acquisition, enabling practical deployment in smart childcare environments.

Unlike conventional infant monitoring systems that rely on manual observation or simple audio threshold detection, the proposed InfantCrySense integrates MFCC-based feature extraction, CNN-

based classification, and a real-time graphical user interface into a single intelligent monitoring platform. This enables automated, non-invasive infant cry detection with confidence-based prediction, providing a practical solution for smart childcare and healthcare applications.

2.0 OBJECTIVE

The objectives of this project are:

1. To develop an intelligent infant cry detection system using an MFCC-based CNN.
2. To enable automatic and real-time cry recognition through audio signal analysis.
3. To provide a non-invasive smart monitoring solution for healthcare and childcare applications.

3.0 METHODOLOGY

The proposed InfantCrySense system employs a deep learning-based methodology for automatic infant cry detection from audio signals. The methodology integrates audio preprocessing, acoustic feature extraction, CNN classification, and real-time inference to distinguish between cry and non-cry audio events. The implementation of each stage is described in the following subsections.

3.1 SYSTEM WORKFLOW

The overall workflow of the proposed InfantCrySense system is illustrated in Figure 1. The system begins by acquiring audio input from either a live microphone or pre-recorded audio files. The captured audio first undergoes silence trimming to remove unnecessary silent segments. It is then processed using RMS normalisation to standardise signal loudness and reduce variations caused by different recording environments. The normalised audio is then divided into fixed-length segments for consistent processing. Subsequently, MFCCs are extracted to represent the acoustic characteristics of the audio signal (Davis & Mermelstein, 1980). These features are then provided to a CNN classifier, which automatically distinguishes between cry and non-cry audio events (Goodfellow et al., 2016; Abbaskhah et al., 2023). This sequential workflow enables accurate, automated, and real-time infant cry detection while maintaining computational efficiency for practical deployment.

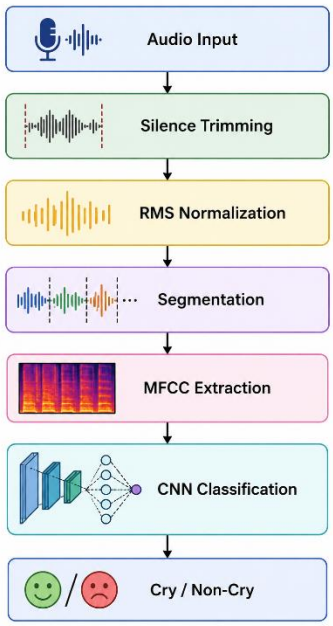


Figure 1: Overall workflow of the proposed InfantCrySense system.

3.2 AUDIO PREPROCESSING

The acquired audio signals undergo several preprocessing steps to improve data quality and ensure consistent feature extraction. Initially, silent segments are removed to eliminate unnecessary information, followed by RMS normalisation to standardise the audio amplitude. The processed audio is then segmented into fixed-length intervals, enabling uniform analysis regardless of the original recording duration. These preprocessing procedures improve the robustness of the proposed system under different recording environments.

3.3 FEATURE EXTRACTION

After preprocessing, MFCCs are extracted to capture the acoustic characteristics of infant vocalisations (Davis & Mermelstein, 1980). To further represent temporal variations within the audio signal, delta and delta-delta coefficients are incorporated. The extracted features provide a comprehensive representation of infant vocal characteristics and serve as the input to the CNN classifier for automated cry classification (Abbaskhah et al., 2023).

3.4 CNN-BASED CLASSIFICATION

As illustrated in Figure 2, the proposed CNN architecture consists of multiple convolutional blocks for hierarchical feature learning, followed by global average pooling and fully connected layers for classification. The extracted MFCC feature representation is progressively processed through convolutional layers to learn discriminative acoustic patterns associated with infant crying (Goodfellow et al., 2016). Finally, the softmax output layer classifies the input audio into either Cry or Non-Cry classes. The architecture is designed to achieve reliable classification performance while maintaining computational efficiency for real-time deployment. The integration of multi-stage audio preprocessing, MFCC-based feature representation, and CNN classification enables the proposed system to achieve reliable real-time cry detection while maintaining computational efficiency for practical deployment (Abbaskhah et al., 2023; Thao et al., 2023).

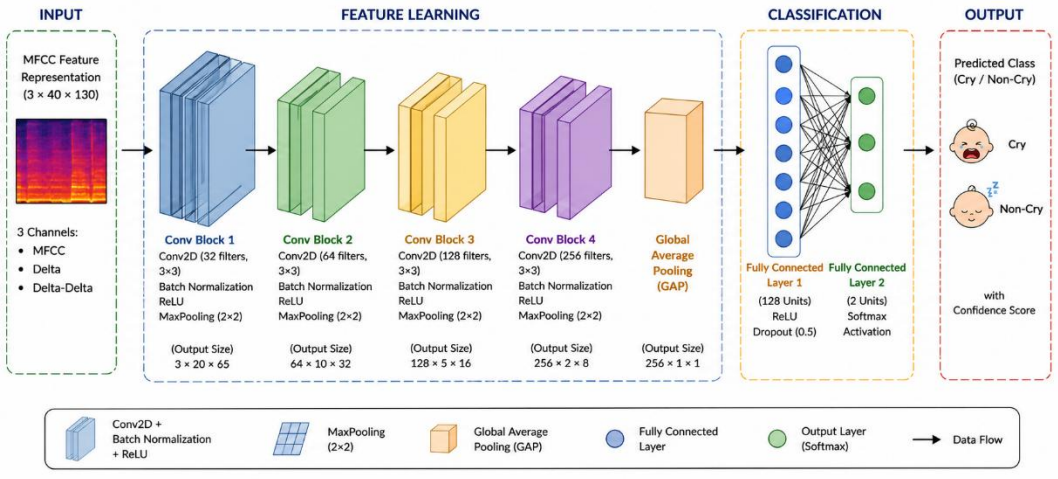


Figure 2: CNN architecture of the proposed InfantCrySense system.

3.5 MODEL TRAINING AND EVALUATION

The CNN model is trained using labelled infant audio recordings to learn the characteristics of cry and non-cry sounds. During training, model performance is monitored using classification metrics, including accuracy, precision, recall, and F1-score, to evaluate classification performance. The best-performing model is subsequently selected for deployment in the real-time monitoring system (Liang et al., 2022; Thao et al., 2023).

3.6 REAL-TIME DETECTION MODULE

The trained CNN model is deployed within a real-time monitoring framework capable of processing both live microphone input and pre-recorded audio recordings. Incoming audio signals undergo the same preprocessing and feature extraction procedures before classification. The system continuously outputs the predicted audio category together with its confidence score, enabling timely detection of infant crying and supporting immediate caregiver intervention in practical healthcare environments (Micheletti et al., 2023).

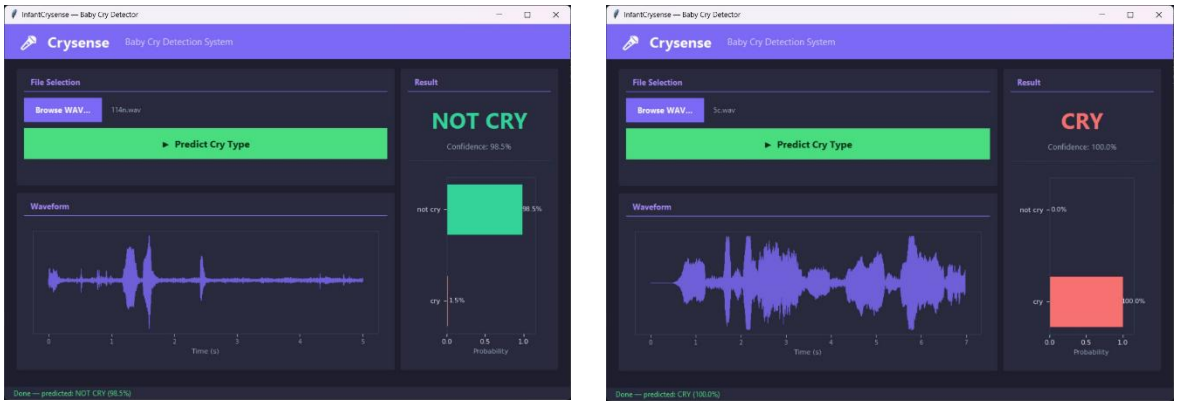
4.0 RESULT

The proposed InfantCrySense system was evaluated using an independent testing dataset to assess its capability to distinguish between infant cry and non-cry audio signals. In addition to quantitative performance evaluation, the developed graphical user interface (GUI) demonstrates the practical deployment of the proposed system for real-time infant cry detection. The experimental results indicate

that the proposed system achieves high classification accuracy while providing an intuitive interface for end users.

4.1 SYSTEM DEMONSTRATION

Figure 3 demonstrates the developed InfantCrySense GUI for real-time infant cry detection. Users can upload an audio recording through the interface, after which the system automatically performs preprocessing, feature extraction, and CNN-based classification. The waveform visualisation and probability chart provide additional information regarding the prediction confidence. As illustrated in Figure 3(a), the uploaded audio is correctly classified as Non-Cry with a confidence of 98.5%, while Figure 3(b) shows a Cry prediction with 100% confidence. These examples demonstrate the capability of the proposed system to provide accurate and user-friendly real-time infant cry monitoring.



(a) (b)

Figure 3: Graphical User Interface of the proposed InfantCrySense system: (a) Non-Cry prediction with 98.5% confidence, and (b) Cry prediction with 100% confidence.

4.2 PERFORMANCE EVALUATION

As presented in Table 1, the proposed InfantCrySense system achieved an overall classification accuracy of 96% on the testing dataset. The Cry class obtained a precision of 0.99 and an F1-score of 0.97, indicating an excellent capability to correctly identify infant crying events while minimising false alarms. For the Non-Cry class, the model achieved a recall of 0.97, demonstrating reliable discrimination between crying and non-crying sounds. Furthermore, the weighted average F1-score of 0.96 confirms the robustness and consistency of the proposed CNN-based approach across both classes, supporting its suitability for practical real-time infant monitoring applications.

Table 1: Performance evaluation of the proposed InfantCrySense system.

Class	Precision	Recall	F1-score	Support
Cry	0.99	0.95	0.97	217
Non-Cry	0.91	0.97	0.94	116
Accuracy	-	-	**0.96**	333
Macro Average	0.95	0.96	0.95	333
Weighted Average	0.96	0.96	0.96	333

The developed InfantCrySense system demonstrates several innovative features compared with conventional infant monitoring approaches (Liang et al., 2022; Thao et al., 2023; Micheletti et al., 2023). In addition to achieving high classification accuracy, the system provides a user-friendly graphical interface, confidence-based prediction, waveform visualisation, and real-time audio analysis within a single integrated platform. These capabilities improve usability and support practical deployment in home, childcare, and healthcare environments.

5.0 CONCLUSION

This study presented InfantCrySense, an intelligent infant cry detection system that integrates audio signal processing, deep learning, and a user-friendly graphical interface for automated infant monitoring. The proposed system is capable of accurately distinguishing between cry and non-cry audio signals

while supporting both offline and real-time detection, providing caregivers with an efficient and non-invasive monitoring solution.

Experimental results demonstrated that the proposed system achieved high classification performance with an overall accuracy of 96%, indicating its reliability for practical infant cry detection. The integration of MFCC-based feature extraction, CNN-based classification, and real-time prediction within a single monitoring platform enhances both system usability and deployment potential.

Overall, InfantCrySense represents a practical innovation for smart childcare and healthcare applications. By enabling continuous and objective infant cry monitoring, the proposed system has the potential to improve caregiver response, reduce the monitoring burden, and support the advancement of intelligent healthcare technologies for early childhood care.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to the Faculty of Engineering and Information Technology, Universiti Malaysia Sabah, for providing the facilities and support necessary to complete this project. The authors also thank all individuals who contributed to the development, testing, and evaluation of the proposed InfantCrySense system.

REFERENCES

Hariharan, M., Saraswathy, J., Sindhu, R., Wan Khairunizam, W., & Yaacob, S. (2012). Infant cry classification to identify asphyxia using time-frequency analysis and radial basis neural networks. Expert Systems with Applications, 39(10), 9515–9523. https://doi.org/10.1016/j.eswa.2012.02.102

Liang, Y.-C., Wijaya, I., Yang, M.-T., Cuevas Juarez, J. R., & Chang, H.-T. (2022). Deep learning for infant cry recognition. International Journal of Environmental Research and Public Health, 19(10), 6311. https://doi.org/10.3390/ijerph19106311

Abbaskhah, A., Sedighi, H., & Marvi, H. (2023). Infant cry classification by MFCC feature extraction with MLP and CNN structures. Biomedical Signal Processing and Control, 86, 105261. https://doi.org/10.1016/j.bspc.2023.105261

Thao, L. Q., Bach, N. C., Cuong, D. D., & Linh, L. K. (2023). BBCRY: A lightweight deep learning model for infant cry classification. Journal of Intelligent & Fuzzy Systems, 45(4), 6813–6824. https://doi.org/10.3233/JIFS-232118

Micheletti, M., Yao, X., Johnson, M., & de Barbaro, K. (2023). Validating a model to detect infant crying from naturalistic audio. Behavior Research Methods, 55(6), 3187–3197. https://doi.org/10.3758/s13428-022-01961-x

Davis, S. B., & Mermelstein, P. (1980). Comparison of parametric representations for monosyllabic word recognition in continuously spoken sentences. IEEE Transactions on Acoustics, Speech, and Signal Processing, 28(4), 357–366. https://doi.org/10.1109/TASSP.1980.1163420

Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT Press. https://www.deeplearningbook.org/

PAWFEEDER STATION: SMART AUTOMATED CAT FEEDING SYSTEM FOR SUSTAINABLE CAMPUS ANIMAL WELFARE MANAGEMENT

Muhammad Afizal Bin Mohd Zaki[1,*], Nor Fadhilah Binti Nor Liki[1], Nik Nur Shazreena Binti Nik Saharudin[1], Nur Dalila Binti Adenan[1]

[1]Faculty of Business and Management, Universiti Teknologi MARA Cawangan Terengganu, Kampus Dungun, Malaysia

[*]Corresponding author: 2025486628@student.uitm.edu.my

ABSTRACT

PawFeeder Station is a smart automated cat feeding system designed to address unmanaged stray cat feeding activities within the residential colleges of a selected public university campus in Malaysia. Informal stray cat feeding in campus residential areas often creates operational, hygiene and welfare challenges when food is placed randomly in corridors, staircases, cafeterias and shared public spaces. Unstructured feeding practices have resulted in inconsistent feeding routines, scattered food waste, unpleasant odours, pest attraction and occasional disturbances to students in dining and living areas. To address this issue, PawFeeder Station was developed as a smart automated cat feeding system that transforms informal feeding into a more controlled, hygienic and sustainable campus welfare operation. This product innovation integrates a sensor-based cat detection system, an automated portion-controlled food dispenser, enclosed food storage, a built-in water fountain, an automatic cleaning bowl, a protective shield and a QR-code donation feature to support food supply and maintenance. The system was designed using operations management principles, including process design, scheduling, quality management, location strategy and maintenance planning. Its practicality and user acceptance were assessed through a survey involving 100 residential college students. The findings showed that 85% of respondents supported the provision of a fixed feeding spot as the best solution for managing stray cats, while 58% agreed that campus management should take formal responsibility for animal welfare initiatives. PawFeeder Station is expected to provide reliable scheduled feeding, reduce exposed food waste, improve campus cleanliness, minimise student-cat conflict and reduce repetitive cleaning workload. The innovation has strong scalability and commercialisation potential, as it can be adapted for universities, hostels, community parks, animal shelters and other public institutions. Overall, PawFeeder Station demonstrates how simple smart automation can support a cleaner, more caring and sustainable campus environment.

Keywords: pawfeeder station, smart feeding system, campus animal welfare, automated vending machine, sustainable campus

1.0 INTRODUCTION

Stray cats are commonly found in many higher education institutions and have become part of campus life. At a selected public university campus in Malaysia, stray cats are frequently found around six anonymised residential colleges. Although students may feed these cats voluntarily, the feeding activity is generally carried out without a proper structure. There is no fixed feeding time, no designated feeding location, no standard food portion and no specific person or unit responsible for managing the welfare of these cats. The project report identifies this as a major operational issue affecting feeding reliability, campus hygiene and institutional responsibility for animal welfare. This situation creates an operational gap in which animal welfare depends largely on individual student initiative.

The absence of a proper feeding system has caused several problems in the residential college environment. Students often leave leftover food on walkways, staircases, corridors and common areas. In Malaysia's hot and humid weather, the food spoils quickly, produces unpleasant odours and attracts pests such as ants, flies, rats and cockroaches (Malaysian Meteorological Department, n.d.). The presence of cats around dining and living spaces also creates discomfort among students, especially those who experience fear, allergies or hygiene concerns. Based on a survey of 100 residential college

students, 45% reported that cats disturbed them while eating, while 59% perceived that some cats appeared thin and hungry.

To address this issue, PawFeeder Station is proposed as a smart automated cat feeding system that can provide consistent, hygienic and controlled feeding for stray cats on campus. The system is designed to automatically dispense food at fixed times, store food in a closed compartment, provide fresh water (Merck Veterinary Manual, n.d.), and allow students or staff to contribute through QR-code donations. This innovation supports the theme of smart innovations for a sustainable and resilient future by promoting automation, sustainability, operational efficiency and responsible campus welfare management.

2.0 OBJECTIVE

The objectives of this innovation are:

1. To develop a smart automated cat feeding system that provides consistent and scheduled feeding for stray cats in residential colleges.
2. To reduce hygiene problems caused by informal feeding, scattered food waste and uncontrolled feeding locations.
3. To improve campus animal welfare through a structured, sustainable and low-human-dependency feeding system.
4. To encourage student and institutional participation in animal welfare through a QR-code donation and monitoring system.
5. To support a cleaner, safer and more organised residential college environment for students, staff and campus visitors.

3.0 METHODOLOGY

PawFeeder Station was developed based on an operational problem-solving approach. The project began by identifying the current issue of unmanaged stray cat feeding in the six residential colleges of a selected public university campus in Malaysia. The existing situation showed that feeding activities were not standardised and often depended on student availability. The team then conducted a survey involving 100 residential college students to understand the level of student awareness, acceptance and support for the proposed automated feeding system. The survey results showed that 85% of respondents preferred a fixed feeding spot for stray cats, while 58% believed that college management should be responsible for managing cat welfare. These findings support the need for a more systematic and formalised feeding solution.

The innovation is designed as an automated vending-style feeding station. A sensor-based detection mechanism identifies the presence of cats before dispensing a pre-set food portion into the feeding bowl. The food is stored in an enclosed compartment to protect it from heat, moisture, insects and contamination. A built-in water fountain provides clean drinking water at regular intervals. After a cat finish eating, the food bowl can be cleaned automatically to maintain hygiene and reduce the risk of bacterial growth. A transparent protective shield is also included to prevent rain, insects and other animals from entering the feeding area.

The system also includes a smart display screen that provides information about the feeding station and displays a QR code for donation purposes. Students, staff and visitors can scan the QR code using mobile banking or e-wallet applications to contribute to food supplies, maintenance and animal welfare activities. The machine can be programmed to dispense food three times daily, for example, at 7.00 a.m., 1.00 p.m. and 7.00 p.m. This ensures that cats receive food consistently, including during weekends, study weeks and semester breaks.

The development of the system is guided by operations management concepts. Process design is applied by replacing random manual feeding with a standardised automated flow (Slack & Brandon-Jones, 2019). Scheduling ensures feeding consistency. Based on Evans and Lindsay (2020), quality control supports proper food portioning and hygiene. Location planning helps determine practical placement near residential block entrances. Preventive maintenance supports continuous and reliable machine operation (Heizer et al., 2020).



(a) Prototype (b) Expected design

Figure 1: *Conceptual Design of PawFeeder Station*

Based on the prototype design, the front panel of the machines features a digital screen that display information such as feeding status, cleaning cycle alerts and a QR code that allows students or visitors to donate towards the cat food supply.Below the digital screen, there are two separate components at the bottom of the machine which is the left one serving as the food dispensing area and the right one holding a water bowl to ensure the cats have access to both food and water at all times.The machine operates automatically by dispensing a fixed portion of dry cat food into the built-in bowl at pre-programmed feeding times daily. When the food level inside the machine runs low, the system sends an alert to notify the staff to restock the food and water.The PawFeeder Station is designed to be compact, weatherproof, and easy to maintain, making it suitable for placement at the entrance of each residential colleges area.

Table 1: Comparison Between Current Informal Feeding Practice and PawFeeder Station

	Current Informal Feeding Practice	**PawFeeder Station**
Feeding Method	Students use their own initiative to manually and informally feed cats.	Without the need for human involvement, PawFeeder Station automatically dispenses food at predetermined time.
Feeding Schedule	No fixed time, which is cats fed randomly and it depends on student availability.	Fixed feeding schedule programmed, for example 7am, 1pm and 7pm daily.
Food Quality	Inconsistent - mix of dry food, leftover rice, fish and cafeteria scraps.	Standard nutritionally appropriate cat food dispensed consistently.
Food Portion	No standard portion, some cats get too much, some get too little.	Fixed measured portion dispensed per feeding cycle through built-in portion control.
Hygiene & Cleanliness	Food scraps left on public areas, staircases and walkways attract insects and create foul smell.	There is no food waste on the floor because food is supplied inside a controlled machine tray.

4.0 RESULT

The proposed PawFeeder Station offers several expected outcomes in terms of operational efficiency, hygiene improvement, student convenience and animal welfare. Based on the survey findings, the innovation has strong potential acceptance among students. A total of 85% of respondents agreed that providing a fixed feeding spot is the best action to manage the stray cat issue in their college, while 90% of respondents supported the proposal to install a cat food vending machine, consisting of 63% who strongly agreed and 27% who agreed. The survey also indicated that 55% of respondents preferred the machine to be placed at the entrance or exit of residential blocks, suggesting that this location is practical for both cats and maintenance personnel.

In terms of novelty, PawFeeder Station is not merely a food dispenser. It integrates automation, hygiene control, animal detection, scheduled feeding, enclosed food storage, water supply and digital donation features into one campus-based welfare system. Its uniqueness lies in transforming informal student-led feeding into a structured and sustainable operational model. Unlike traditional feeding, which depends on student availability and often results in scattered food waste, PawFeeder Station provides a fixed, controlled and monitored feeding point.

The innovation is expected to reduce the movement of cats into dining halls, cafeterias and student rooms because cats will be conditioned to gather at designated feeding stations (Chute et al., 2023). It will also reduce the workload of facility staff, who currently need to clean up food waste and mess caused by informal feeding. The system is also expected to improve the health of campus cats by providing more suitable food portions and reducing dependence on unhealthy cafeteria leftovers.

Overall, the expected impact of PawFeeder Station includes cleaner residential areas, reduced pest attraction, improved student comfort, better animal welfare and stronger institutional responsibility. It also supports sustainable campus management by using a simple smart system that can be replicated in other universities, hostels, schools, community parks and public institutions.

5.0 CONCLUSION

PawFeeder Station is a practical and meaningful innovation that addresses the issue of unmanaged stray cat feeding in the campus environment. The current practice, which relies mainly on voluntary student feeding, may result in inconsistent feeding, exposed food waste, hygiene concerns and disturbances in shared spaces. By introducing an automated and scheduled feeding system, this innovation offers a more organised, hygienic and sustainable method of managing stray cat welfare.

The innovation contributes to smart campus management by combining automation, operational efficiency, cleanliness and animal welfare in one system. It also supports student involvement through digital donations and promotes a caring university culture. Economically, the system has potential to reduce cleaning workload, minimise food waste and create a scalable model that can be commercialised or implemented in other institutions. In conclusion, PawFeeder Station is aligned with the theme as it represents a smart, sustainable and resilient innovation for improving campus welfare and environmental management

ACKNOWLEDGEMENT

The authors would like to express their appreciation to the academic supervisor for the guidance and constructive feedback provided throughout the development of this innovation. Appreciation is also extended to the residential college students who participated in the survey and contributed valuable responses to support the improvement of PawFeeder Station.

REFERENCES

Bailey, T. (2023). A Scoping Review of Campus-Based Animal-Assisted Interactions Programs for College Student Mental Health. *People and Animals: The International Journal of Research and Practice, 6(1).* https://docs.lib.purdue.edu/paij/vol6/iss1/1/

Business Today. (2026, July 5). *Do stray animals belong in campus?* https://www.businesstoday.com.my/2026/07/05/do-stray-animals-belong-in-campus/

Carter, J. (2026, May 3). *What maintenance do vending machines actually need*. Vend Vault LTD. https://www.vendvault.co.uk/post/what-maintenance-do-vending-machines-actually-need

Chute, A., Vihos, J., Johnston, S., Buro, K., & Velupillai, N. (2023). The effect of animal-assisted intervention on undergraduate students' perception of momentary stress. *Frontiers in Psychology, 14,* Article 1253104. https://doi.org/10.3389/fpsyg.2023.1253104

DeLeeuw, J. L., & Eckman, H. (2026). Unowned cat welfare and population management: A cross-national analysis of practitioner perspectives in Cyprus, Greece, and Portugal. *Frontiers in Animal Science, 7*. https://doi.org/10.3389/fanim.2026.1686210

Evans, J. R., & Lindsay, W. M. (2020). *Managing for quality and performance excellence* (10th ed.). Cengage Learning.

Goodman-Wilson, M., & Highfill, L. (2019). Faculty and student perceptions of the presence of emotional support animals on a college campus. *Society & Animals*, *29*(5–6), 500–516. https://doi.org/10.1163/15685306-00001759

Heizer, J., Render, B., & Munson, C. (2020). *Operations management: Sustainability and supply chain management* (13th ed.). Pearson Education.

Hughes, K. L., & Slater, M. R. (2002). Implementation of a Feral Cat Management Program on a University Campus. *Journal of Applied Animal Welfare Science, 5(1), 15–28.*

Malaysian Meteorological Department. (n.d.). *Malaysia's climate*. https://www.met.gov.my/

Merck Veterinary Manual. (n.d.). *Nutritional requirements of small animals.* Retrieved July 8, 2026, from https://www.merckvetmanual.com/management-and-nutrition/nutrition-small-animals/nutritional-requirements-of-small-animals

Noor, L., Dora, K., Mohd, R., & Zaini, I. R. (2025). *Perceptions and management of stray cats on university campuses: a case study of UiTM*. UiTM Institutional Repository.

Rand, J., Scotney, R., Enright, A., Hayward, A., Bennett, P., & Morton, J. (2024). A situational analysis of attitudes toward stray cats and preferences and priorities for their management. *Animals, 14*(20), 2953. https://doi.org/10.3390/ani14202953

Sani, R. (2017, September 20). Managing stray cats on campus. *New Straits Times*. Sani, R. (2017, September 20). Managing stray cats on campus. Nst.Com.My; New Straits Times. https://www.nst.com.my/amp/education/2017/09/281826/managing-stray-cats-campus

Slack, N., Brandon-Jones, A., & Johnston, R. (2019). *Operations management* (9th ed.). Pearson Education.

VOKA NEURO+ (INNOVATION)

Nur Idris Syah Yusri[1], Dayang Ariana Mohd Rizal[1], Muhammad Danish Hakimi Ahmad Najib[1], Ahmad Zaki Salihin[1], and Zaidatulhusna Mohd Isnani[1,*]

[1]Universiti Teknologi MARA Cawangan Negeri Sembilan Kampus Seremban

[*]Corresponding Author: husna@uitm.edu.my

ABSTRACT

VOKA Neuro+ is an innovative wireless headphone developed to address critical consumer pain points in the current audio market. Market research conducted via a user survey of 32 participants validated widespread consumer dissatisfaction regarding unstable Bluetooth pairing, low noise control capabilities, and physical discomfort during prolonged use. To solve these challenges, VOKA Neuro+ introduces a health-centred design driven by three core innovations: the NeuroSync™ Connectivity Core, which eliminates audio delays by enabling immediate, automatic multi-device pairing; Smart Active Noise Cancellation (ANC), which utilises integrated gyroscope and accelerometer motion sensors to deliver a dynamic, highly individualised audio experience; and an ergonomic build featuring breathable mesh ear cushions engineered for maximum hygiene and comfort during extended study, meetings, or gaming sessions. Combined with an ultra-portable, lightweight design and supercharging capabilities, VOKA Neuro+ perfectly aligns with actual user demands and contemporary lifestyle expectations. This product represents a significant advancement in wearable technology, successfully merging intelligent functionality with a deeply user-centric design capable of outperforming existing industry leaders.

Keywords: wireless, headphones, noise cancellation, smart connectivity, technology, VOKA

1.0 INTRODUCTION

In this modern era, headphones are no longer just one of the desired accessories or a single earpiece that rests on the shoulder but are necessary tools for communication, entertainment, and productivity. However, many consumers out there face recurring problems such as connectivity drops, uncomfortable ear cushions, and static noise-cancellation features. These limitations can cause dissatisfaction and interrupt online meetings, study sessions, and gaming experiences. Motivated by these issues and inspired by market leaders like Sony and Apple, our team decided to innovate existing products and develop VOKA Neuro+: a next-generation headphone that can intelligently adapt to user activity and match the real situation or environment.

2.0 OBJECTIVE

1. To address the issue of poor connection between Bluetooth devices by switching to faster and smarter pairing up, especially for multi-device connectivity.
2. To provide comfort and hygiene to boost user satisfaction without having any discomfort when using it for a long time.
3. To give a new experience of adaptive noise cancellation, as we developed it using built-in gyroscope and accelerometer sensors.

3.0 DESCRIPTION OF THE PRODUCT

VOKA Neuro+ is a premium wireless headphone that comes in 5 colours and offers an ultra-slim design with several upgraded advanced features to meet user demand. Being ultra-slim, very lightweight, foldable and having a five-up-to-date variety of colours, it is stylish and practical at the same time, suitable for students, professionals, and gamers. VOKA Neuro+ has NeuroSync Connectivity Core, which allows instant pairing with all devices and with non-manual setup, as well as its Smart ANC,

which automatically responds based on movement and environment with built-in gyroscope and accelerometer sensors. It comes with soft, breathable mesh fabric earcups that can minimise heat and sweat, so it can be used for a whole day comfortably. Having 40 mm Hi-Res dynamic drivers, VOKA Neuro+ provides deep, balanced sound, focusing on music, sound, gaming, and studying. Besides, VOKA Neuro+ supports an average of 50 hours of total battery life, and fast charging gives the user 5 hours of battery life after a quick 10-minute charge. Lightweight yet hard, weighing only 230g, this is a headphone that replaces the existing headphones on the market that are too heavy to carry around, as today's fast-paced lifestyle makes the headphone a requirement to bring everywhere.

4.0 TECHNOLOGY DESCRIPTION (HOW THE PRODUCT WORKS)

The innovation that powers VOKA Neuro+ is the NeuroSync™ Connectivity Core, an advanced technology developed to replace traditional Bluetooth pairing and to solve the common issues in conventional headphones such as unstable connections, slow pairing, and frequent disconnections. VOKA Neuro+ aims to offer quick, smart, automatic, and effortless connectivity between two or more devices, ensuring better listening each time they switch on the headphones. NeuroSync™ enables VOKA Neuro+ to auto-detect and automatically connect to the other pre-paired devices, whether the device is a smartphone, tablet, or laptop, without making any manual setup. For example, when Bluetooth is enabled on a smartphone, the headphones can be detected and connected immediately. When switching to a tablet, users only need to turn off Bluetooth on the smartphone and enable it on the tablet. The headphones will then automatically switch to the tablet without noticeable lag. This can help when the user works, studies, or entertains on different devices regularly. In addition to being convenient, the NeuroSync™ reduces the time spent troubleshooting connections and boosts efficiency in the users' daily activities.

5.0 NOVELTY

The uniqueness of VOKA Neuro+ lies in its intelligent connectivity, smart ANC, as well as its users' health-centred design. A survey of 32 participants found that most people are dissatisfied with Bluetooth pairing, uncomfortable when used over a long period, and have low noise control ability. VOKA Neuro+ was specifically designed to address these problems. The most innovative aspect is the NeuroSync Connectivity Core, which allows immediate automatic pairing between multiple devices and removes all delays. Also, the Smart ANC feature in the headphones applies motion sensors to provide an individualised and dynamic audio experience by personalising noise cancellation. Besides, the use of breathable mesh ear cushions is the reason that it is made for maximum comfort and hygiene factors, especially during long study, meetings, or gaming sessions. Together with an ultra-portable, lightweight design and a supercharging capability, VOKA Neuro+ promises to solve a new challenge that meets the actual user demands and contemporary lifestyle expectations.

6.0 CONCLUSION

VOKA Neuro+ is a new device that combines state-of-the-art neurotechnology with smart functionality, longer battery life, and ease of use. It was created to address the demands of contemporary consumers who are searching for a single device that combines smart functionality, comfort, and power efficiency. VOKA Neuro+ possesses excellent market potential and strong purchase interest, according to survey results and user reviews. VOKA Neuro+ can become a market leader in wearable technology with additional development and proper marketing.

REFERENCES

Balasubramanian, K. K., Merello, A., Zini, G., Foster, N. C., Cavallo, A., Becchio, C., & Crepaldi, M. (2023). Neural network–based Bluetooth synchronization of multiple wearable devices. Nature Communications, 14(1), Article 4472.

Zhao, C., Wu, T., Cai, Y., & Wang, L. (2024). Wireless Bluetooth noise-canceling headphones: Exploring the design principles and different categories of products. Theoretical and Natural Science, 34(1), 360–369

MYMEDICINE

Lou Hong Ee [1], Teo Chee Ying[1], Foo Yong Xiang[1], Leong Kah Meng[1,2,*]

[1]Faculty of Engineering and Information Technology, Southern University College
[2]School of Foundation Studies, Southern University College

[*]Corresponding author: kmleong@sc.edu.my

ABSTRACT

Healthcare systems globally face severe operational bottlenecks, including overcrowded waiting rooms, inefficient manual workflows, and cross-border communication barriers. In response to the dual global challenges of digital transformation and sustainable development, MyMedicine was developed as a highly scalable, multilingual smart clinic platform designed to modernise traditional healthcare infrastructure. Supporting English, Mandarin Chinese, and Bahasa Melayu, the application breaks through geographical and cultural barriers to ensure equitable patient access. At its core, MyMedicine leverages advanced cloud synchronisation and Large Language Models (LLMs) to decentralise the patient experience. The platform features an AI-Powered Medical Expert (utilising GPT-3.5-Turbo) that provides intelligent symptom assessment and automated emergency triage, instantly routing high-risk patients for urgent care. To eliminate physical bottlenecks, the system integrates a real-time, three-stage dynamic queue tracker (Consultation, Billing, Pharmacy) powered by Supabase, which triggers automated mobile alerts and haptic vibrations when a patient's turn approaches. Furthermore, MyMedicine fosters operational transparency through a comprehensive digital ledger for receipt tracking and interactive practitioner ratings. To optimise administrative efficiency, the platform includes an Intelligent Grievance Centre that uses a QWEN 2.5 LLM to automatically parse, categorise, and prioritise patient feedback, equipping hospital management with actionable metadata for rapid dispute resolution. By transforming the traditional clinical journey into a frictionless digital experience, MyMedicine directly advances UN SDGs 3 and 9. It offers a forward-looking, commercially viable solution with strong international market potential, establishing a new standard for a sustainable and accessible global healthcare ecosystem.

Keywords: smart healthcare, multilingual ui, large language models, real-time queue, cloud synchronisation

1.0 INTRODUCTION

Healthcare systems globally are confronting unprecedented challenges, including rising patient demand, prolonged waiting times, and overcrowded facilities. Many institutions worldwide still rely on manual or semi-digital workflows to manage patient registration, consultation, billing, and pharmacy operations (Rema & Sikdar, 2021). These operational inefficiencies degrade the patient experience, strain healthcare productivity, and represent a significant cross-border pain point, with a total lack of real-time queue visibility that consistently leads to severe waiting room overcrowding and intense patient frustration (Suhaimi, 2026; Rema & Sikdar, 2021). In increasingly globalised and multicultural societies, language differences often complicate patient-provider interactions, highlighting the need for forward-looking solutions that can transcend geographical and cultural barriers. MyMedicine serves as a highly scalable and multilingual smart clinic platform engineered to transcend geographical and cultural barriers. By integrating a real-time queue management system, an AI-powered healthcare assistant (GPT-3.5-Turbo) for automated emergency symptom triage, and an intelligent grievance handling system (QWEN2.5-7B-Instruct), the platform eliminates workflow inefficiencies and significantly improves patient-provider trust. Ultimately, MyMedicine leverages core competencies in cloud synchronisation and advanced Large Language Models (LLMs) to build an innovative service model that directly addresses these universal healthcare challenges.

2.0 OBJECTIVE

1. To implement AI-powered digital management and automated quality assurance to eliminate waiting room congestion and streamline hospital workflows, ensuring transparent and rapid patient care.
2. To optimise hospital operations by implementing a highly scalable, real-time digital queue management system.
3. To establish a scalable, technology-forward healthcare model that delivers measurable social impact and economic value, setting a new benchmark for sustainable international medical development.

3.0 METHODOLOGY

The MyMedicine platform is engineered using a modern three-tier architectural framework to ensure high scalability, seamless cross-border deployment, and robust data security. This layout connects client user interfaces to advanced language services and real-time backend synchronisation.

3.1 SYSTEM IMPLEMENTATION

The application logic maps and enforces strict data privacy through Supabase Row-Level Security (RLS), restricting chat histories and medical ledger entries to authorised profile IDs. For post-visit flows, a complete digital ledger structures receipts dynamically, while linking an evaluation module for users to grade doctors, pushing aggregated feedback scores back to the central data repositories.

3.2 SYSTEM ARCHITECTURE

The MyMedicine architecture uses a modern three-tier framework built for real-time reactivity and AI integration as shown in Figure 1. At the presentation-tier user interface, the platform runs an Expo and React Native Patient App Android Mobile for live queue tracking and AI chatting, alongside a React-based Admin/Staff Dashboard for managing clinic counters and grievances. Between them, the business logic & AI services layer acts as the brain; its core App Logic handles read/write requests to the OpenAI API for symptom triage, and streams raw complaints to an external Qwen 2.5 LLM hosted on Render for automated priority, category, and sentiment analysis. Finally, the data and real-time sync backend manages permanent data persistence via Supabase. It isolates records across standard database collections Queue Tables and Grievance Tables, and utilises a WebSocket-driven Logic broadcast system protected by Row-Level Security (RLS) enforced to instantly stream live message alerts back to the patient notification layer without data-polling overheads.

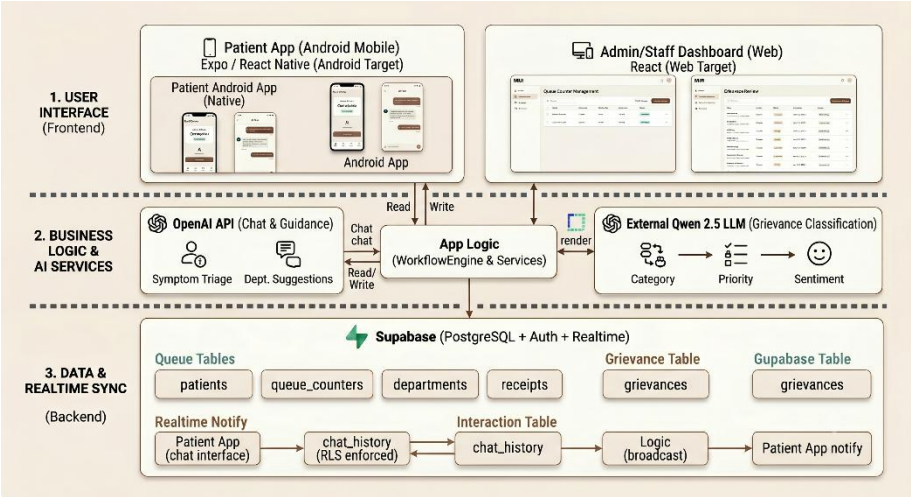


Figure 1: System architecture diagram

3.3 SYSTEM ARCHITECTURE AND AI MODELS

This presentation framework is built on Expo and React Native and is designed to provide a seamless front-end user experience for the Android mobile platform and the administrator web console. The application implements a dual Large Language Model (LLM) processing framework to handle various

clinical intelligence tasks. The system utilises the OpenAI API (GPT-3.5-Turbo model) as its core conversational framework for medical guidance and symptom analysis. Additionally, the system calls an external QWEN 2.5 Large Language Model (LLM) hosted on Render via a dedicated API endpoint to manage metadata calculations for the complaint resolver, categorising complaints by problem type, priority, and sentiment to achieve transparent dispute resolution. Additionally, administrative quality assurance is managed by an external Qwen 2.5 LLM hosted on Render, which instantly parses patient grievances into structured metadata, categorising complaints by problem type, priority, and sentiment to achieve transparent dispute resolution.

3.4 MULTILINGUAL ARCHITECTURE AND TOKENISATION

To ensure universal inclusion in multicultural societies, a deep multilingual architecture supporting English, Mandarin Chinese, and Bahasa Melayu is embedded directly into the application layer. Natural language strings are parsed and contextualised cleanly across user preference configurations before reaching the AI services layer.

3.5 FUNCTIONAL MODULES INTEGRATION

The application combines multiple software services into a singular cross-platform package. The AI-Powered Medical Expert functions as a first-line pre-triage component. When a user enters raw natural text inputs regarding localised symptoms, the conversational engine provides immediate department suggestions and checks text for critical indicators. If an urgent case is detected, it triggers an emergency protocol banner allowing high-risk patients to bypass standard queues.

The database layer utilises Supabase to maintain a relational PostgreSQL schema across specialised structures (patients, queue_counters, departments, receipts, grievances, chat_history). Real-time synchronisation routines constantly listen for updates executed by clinic staff on their management dashboards. The moment a data table state mutates, the backend pushes WebSocket packets directly to the client presentation layer, triggering instant push alerts and phone haptics telling patients to advance to their assigned counters.

4.0 RESULT

As shown on the mobile login screen, users can complete registration smoothly using secure email and password credentials or skip authentication entirely via the seamless “Continue as a Guest” path to address immediate, urgent medical needs. Once successfully logged in, the application provides a streamlined, intuitive environment consisting of four centralised core modules, as visualised in the system grid menu in Figure 2. The application provides clean, direct access to its primary services through these modules: the Chat with AI Expert component, which provides immediate medical guidance and interactive pre-triage conversation channels; the Queue tracking portal, which allows real-time monitoring of current clinical stages and dynamic workflow progression; the Receipt History log, which houses a secure, digitised archive of past transactions and doctor evaluations; and the Grievance Submission portal, which dispatches patient concerns straight to automated analysis engines for streamlined resolution management.

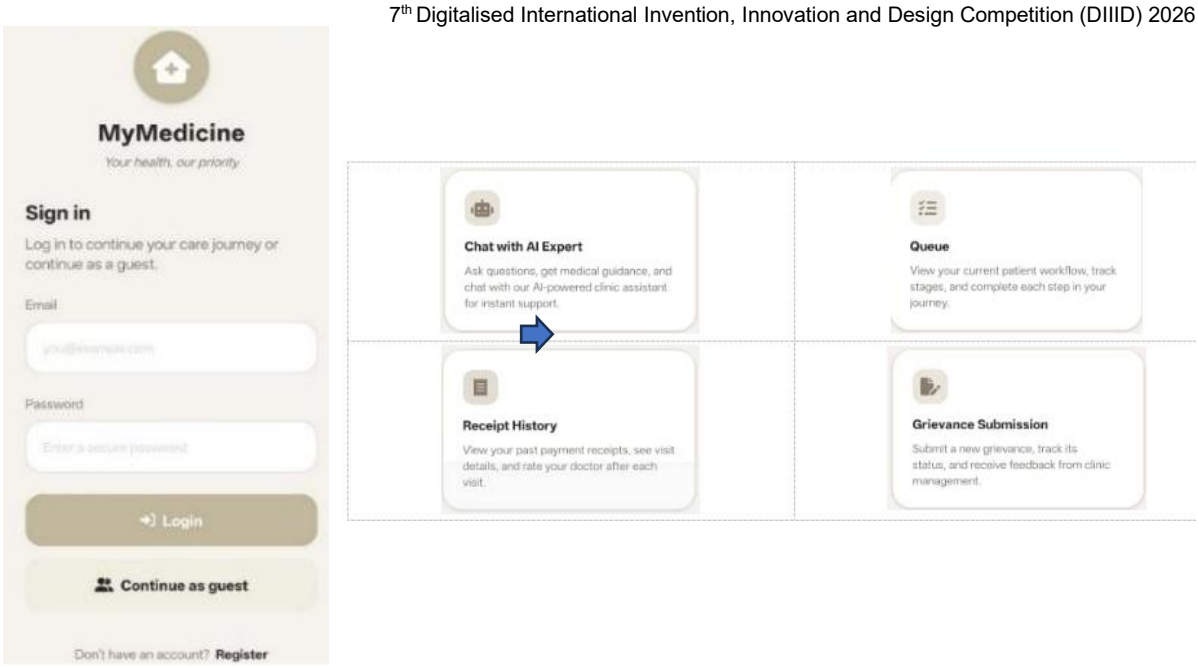


Figure 2: MyMedicine Four Main Function

4.1 THREE-STAGE DYNAMIC QUEUE FUNCTION

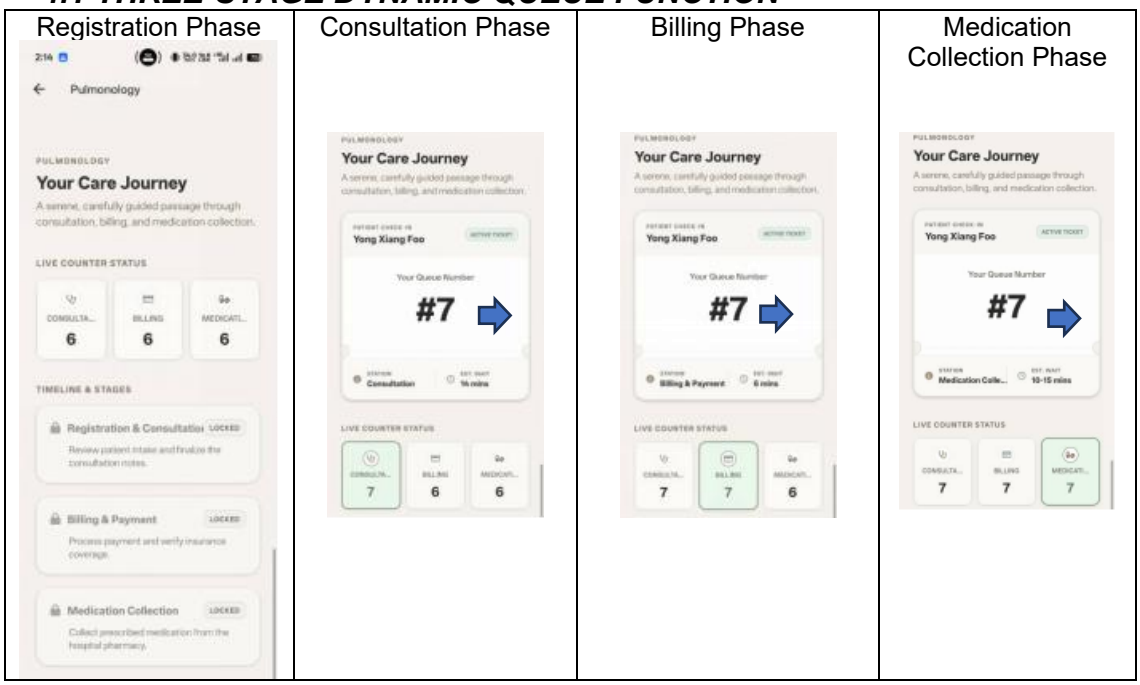


Figure 3: Three-Stage Dynamic Workflow of Queue

MyMedicine digitises onboarding via live token tracking and Supabase real-time sync. The patient's mobile interface dynamically guides them through a seamless three-stage clinical pipeline consisting of Registration & Consultation, Billing & Payment, and Medication Collection, as shown in Figure 3. For medical administrative staff, the dashboard utilises streamlined action buttons that send pop-ups and haptic alerts when tickets are called to eliminate bottlenecks (e.g., "Call Consultation").

4.2 AUTOMATED GRIEVANCE TRIAGE FUNCTION

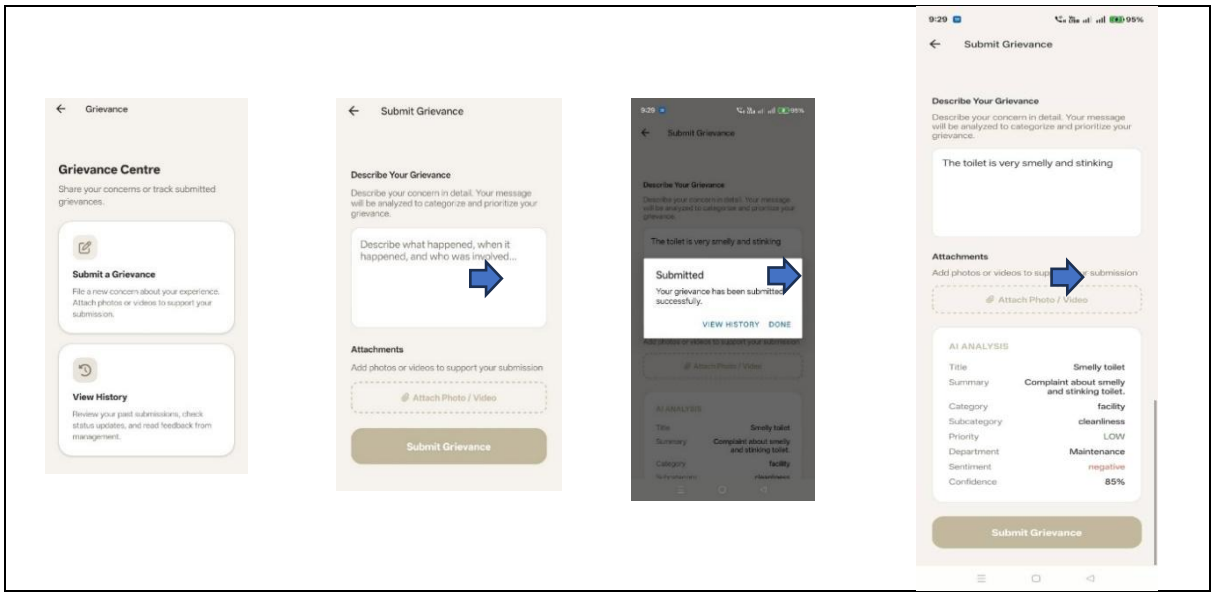


Figure 4: Automated Grievance Triage Workflow

Submissions to the Intelligent Grievance Centre are instantly parsed by a QWEN 2.5 AI model, as shown in Figure 4. The AI automatically evaluates and tags the priority, category, subcategory, and sentiment of the complaint (e.g., Facility Maintenance, Low Priority, Negative Sentiment), providing a transparent history ledger and audit trail that accelerates hospital dispute resolution.

4.3 SUMMARY

The MyMedicine mobile app simplifies the patient journey with secure login or guest access, offering a multilingual UI (English, Mandarin, Bahasa Melayu). It features an interactive AI triage chat, live queue tracking, receipt history, and a grievance submission portal. Backed by real-time cloud synchronisation and a QWEN 2.5 LLM, the platform automates a three-stage clinical workflow and instant feedback parsing to optimise hospital operations.

5.0 CONCLUSION

In conclusion, MyMedicine is an innovative, forward-looking solution designed to resolve universal cross-border pain points in healthcare management. By seamlessly integrating an AI-powered intelligent medical assistant, real-time queue tracking, transparent receipt management, and an automated grievance resolution centre, the platform transforms the traditional patient journey into a highly efficient, barrier-free digital experience. Crucially, the platform directly advances UN Sustainable Development Goals (SDGs) 3 and 9 by building a resilient, intelligent healthcare infrastructure that minimises operational bottlenecks, ensures timely patient care, and mitigates waiting room cross-infection risks to improve overall community well-being. While the platform creates immediate, tangible impacts for local healthcare facilities by mitigating overcrowding and improving care quality, its highly scalable, multilingual architecture positions it with strong international market potential. By leveraging core competencies in emerging artificial intelligence (OpenAI and QWEN) and cloud computing (Supabase), MyMedicine not only drives the digital transformation of the healthcare industry but also possesses the scalability to lead future international development trends. Ultimately, MyMedicine acts as a catalyst for industrial transformation, building a critical bridge toward a more equitable, efficient, and sustainable global healthcare ecosystem.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Institute of Graduate Studies and Research (IGSR) and the Department of Computer Science, Faculty of Engineering and Information Technology, Southern University College for their support and guidance in the development of this project.

REFERENCES

Expo. (2024). *Expo Documentation*. Expo Development Team. https://www.moh.gov.my/

Ehrler F, Rochat J, Siebert JN, Guessous I, Lovis C, Spechbach H. Use of a semi-automatic text message system to improve satisfaction with wait time in the adult emergency department: cross-sectional survey study. JMIR Med Inform. 2022;10(9):e34488. doi:10.2196/34488.

https://www.researchgate.net/publication/363349934_Use_of_a_Semiautomatic_Text_Message_System_to_Improve_Satisfaction_With_Wait_Time_in_the_Adult_Emergency_Department_Cross-sectional_Survey_Study

Ministry of Health Malaysia. (2023). *Health Facts 2023*. Ministry of Health Malaysia. https://www.moh.gov.my/

Rema V, Sikdar K. Optimizing patient waiting time in the outpatient department of a multi-specialty Indian hospital: the role of technology adoption and queue-based Monte Carlo simulation. SN Comput Sci. 2021;2(3):1–9. doi:10.1007/s42979-021-00595-8.

https://www.researchgate.net/publication/350775309_Optimizing_Patient_Waiting_Time_in_the_Outpatient_Department_of_a_Multi-specialty_Indian_Hospital_The_Role_of_Technology_Adoption_and_Queue-Based_Monte_Carlo_Simulation

Suhaimi, N. H. S. (2026). DEVELOPING WEB-BASED QUEUE MANAGEMENT IN OUTPATIENT CLINICS WITH QKLINIK. *International Journal of Software Engineering and Computer Systems*, *11*(2), 147–159. https://doi.org/10.15282//ijsecs.11.2.2025.12.0144

Wang P, Yu L, Li T, Zhou L, Ma X. Use of mobile technologies to streamline pre-triage patient flow in the emergency department: observational usability study. JMIR Mhealth Uhealth. 2024;12:e54642.doi:10.2196/54642.

https://www.researchgate.net/publication/381256798_Use_of_Mobile_Technologies_to_Streamline_Pretriage_Patient_Flow_in_the_Emergency_Department_Observational_Usability_Study

E-PRACTICUM HUB: STUDENTS' APPLICATION, APPROVAL, PLACEMENT MATCHING

Goh Wei Hong[1,*], Goh Wei Wen[1], Chia Xiao Jun[1], Shaffika Mohd Suhaimi[1], Renugala A/P Shollunayagam[1]

[1]Southern University College, PTD64888, KM15, Jalan Skudai, Peti Surat 76, 81300 Skudai, Johor, Malaysia

[*]Corresponding author: gohweihong00@gmail.com

ABSTRACT

In many universities, internship management faces significant challenges such as fragmented communication, reliance on paper documents, and inefficient manual processes, which result in missed updates for students, difficulties for supervisors in monitoring progress, and heavy administrative workloads for placement coordinators. These issues create severe information fragmentation, difficulties in progress tracking, and overwhelming administrative burdens, highlighting the urgent need for a centralised and transparent digital solution. To address these problems, e-Practicum Hub was developed as a unified ecosystem accessible via web and mobile applications, with primary objectives to centralise internship applications and placements, provide real-time digital progress tracking, and enable seamless collaboration and feedback among students, supervisors, and institutions. The innovation of this platform lies in its integration of an AI-powered recommendation and monitoring system, which leverages machine learning, predictive analytics, and intelligent feedback loops trained on historical internship data to match students with suitable opportunities based on their skills, academic records, and career aspirations, while also generating automated evaluation reports, flagging upcoming deadlines, and offering personalised guidance such as recommending relevant training modules. By embedding advanced artificial intelligence and data-driven technologies, the system reduces administrative workload and improves student preparedness for professional careers. Furthermore, the e-Practicum Hub aligns with SDG 4: Quality Education, as it enhances structured, transparent, and digitally supported internship opportunities that strengthen learning outcomes and ensure students are better equipped for future employment. Ultimately, this software demonstrates strong potential to transform internship management by strengthening communication, reducing inefficiencies, and evolving into a valuable tool for educational institutions, students, and industry partners alike.

Keywords: AI-powered recommendation, progress tracking and automation, internship process

1.0 INTRODUCTION

In today's higher education landscape, internships serve as a critical bridge linking academic theories to real-world career paths. However, the way many universities manage these programmes is still stuck in the past, plagued by fragmented communication, a heavy reliance on paperwork, and inefficient manual processes. These bottlenecks mean students constantly miss important updates, academic supervisors struggle to track actual progress, and placement coordinators end up buried under overwhelming administrative workloads. This severe information fragmentation makes it crystal clear that educational institutions urgently need a centralised and transparent digital solution.

To tackle these systemic challenges head-on, the e-Practicum Hub was developed as a unified ecosystem accessible via both web and mobile applications. The platform's primary objectives are to centralise internship applications and placements, provide real-time digital progress tracking, and facilitate seamless collaboration and feedback among students, supervisors, and institutions.

2.0 OBJECTIVE

1. To provide real-time internship monitoring through digital logbooks, notifications, and automated progress tracking.

2. To facilitate efficient collaboration among students, academic supervisors, industry supervisors, placement coordinators, and institutions.
3. To integrate Artificial Intelligence for internship recommendation, intelligent monitoring, predictive alerts, and personalised learning guidance.

3.0 METHODOLOGY

The development of the e-Practicum Hub adopts a user-centred innovation approach as it is focusing on optimising traditional internship management through digital transformation and artificial intelligence. The platform is designed as an integrated web and mobile ecosystem, where stakeholders interact seamlessly through role-based access control tailored to their specific responsibilities. This design ensures both data security and a highly intuitive user experience.

3.1 DIGITAL INTERNSHIP MANAGEMENT PLATFORM

The core platform digitalises the complete internship lifecycle, beginning with internship applications and ending with final evaluations. Students are able to submit internship applications, upload required documents, record daily activities through digital logbooks, monitor application status, and receive important notifications. Academic supervisors can monitor student progress, review submitted logbooks, provide feedback, and conduct evaluations remotely. Industry supervisors are able to verify attendance, assess student performance, and communicate directly with universities. Meanwhile, placement coordinators manage internship approvals, placement records, reporting, and institutional administration through a centralised dashboard.

The centralised architecture eliminates fragmented communication and ensures that all internship-related information is stored within a single secure platform.

- Student

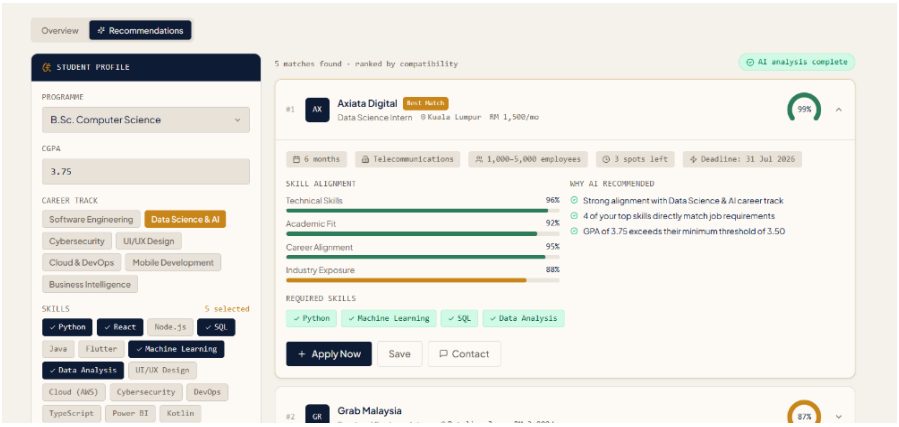


Figure 1: Student's Platform

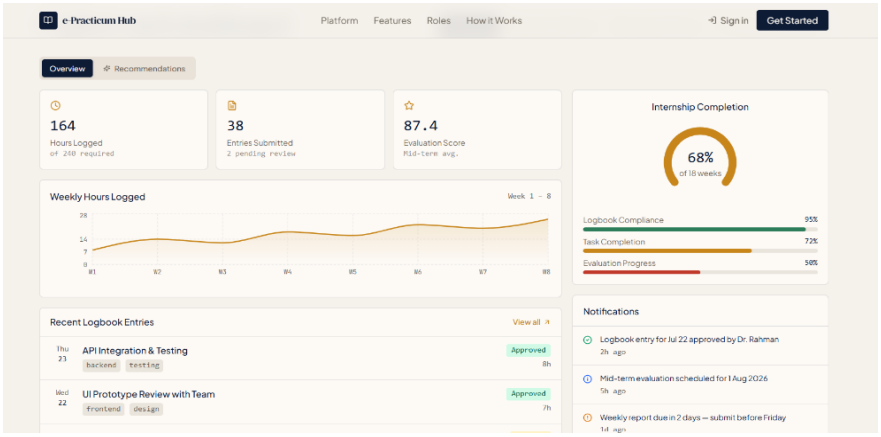


Figure 2: Student's Platform Dashboard

- Lecturer

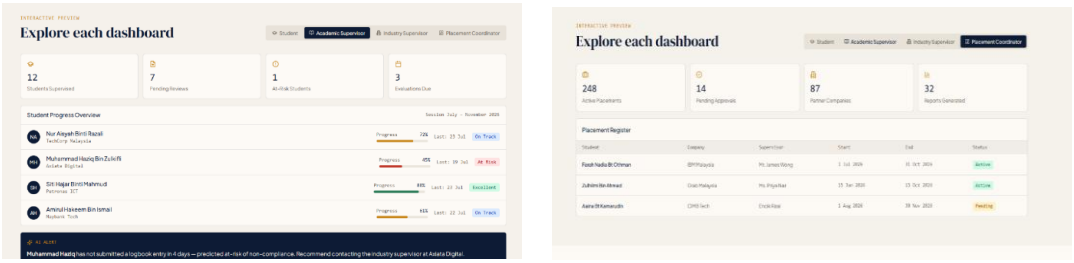


Figure 3: Lecturer's Dashboard

- Company

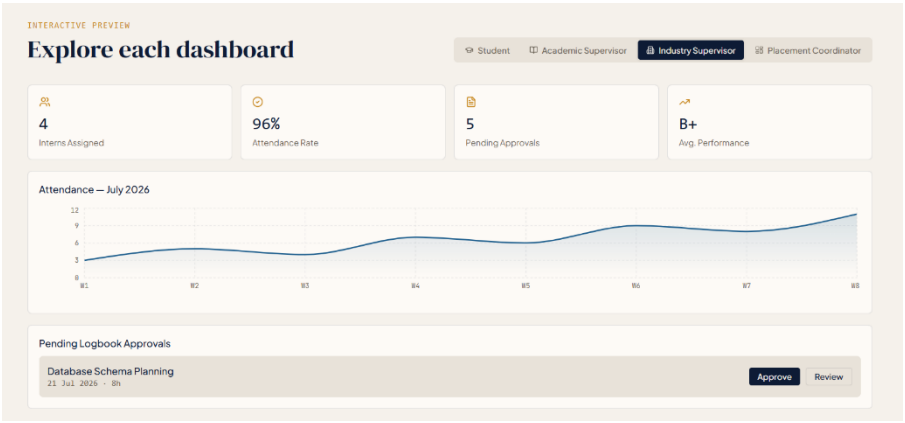


Figure 4: Company Dashboard

4.0 RESULTS

The proposed innovation offers several significant advantages compared to conventional internship management approaches.First, all internship-related activities are centralised on a single platform, significantly reducing fragmented communication and duplicated administrative work. Second, digital logbooks enable real-time monitoring, allowing supervisors to evaluate student progress remotely without relying on paper documentation. Third, AI-powered internship recommendations improve placement quality by matching students with organisations that are better suited to their academic background, technical skills, and career aspirations. In addition, predictive monitoring provides early identification of students who may require additional support, enabling universities to intervene before problems become critical. The platform also produces automated reports and analytical dashboards, allowing placement coordinators to monitor internship performance more efficiently while reducing manual administrative processes.

Overall, the integration of artificial intelligence transforms internship management from a passive documentation system into an intelligent decision-support platform that improves transparency, operational efficiency, and stakeholder collaboration.

5.0 CONCLUSION

e-Practicum Hub demonstrates how artificial intelligence can enhance internship management by integrating digital administration, intelligent recommendations, predictive monitoring, and automated support within a unified platform. The proposed innovation addresses major challenges associated with

fragmented communication, inefficient documentation, and manual administrative processes commonly experienced in higher education institutions.

By combining centralised digital services with AI-driven analytics, the platform improves collaboration among students, supervisors, coordinators, and industry partners while providing a more personalised internship experience. Beyond improving operational efficiency, e-Practicum Hub supports Sustainable Development Goal (SDG) 4: Quality Education by promoting inclusive, technology-enabled learning experiences that strengthen students' employability and professional readiness.

Future enhancements may include generative AI assistants, natural language feedback analysis, and integration with national employment platforms to further strengthen university-industry collaboration and support lifelong learning.

ACKNOWLEDGEMENT

The authors would like to acknowledge Southern University College for providing the funding, resources, and research facilities that enabled the successful execution of this project. Special thanks are extended to the project supervisor and domain expert for their invaluable contributions in shaping the research idea, conceptual framework, motivation, and overall direction of the study. Their continuous guidance and encouragement have been instrumental in the completion of this work.

DEVELOPMENT AND EVALUATION OF EDIBLE COATING INCORPORATING KEY LIME (*CITRUS AURANTIIFOLIA*) PEEL ESSENTIAL OIL FOR SHELF-LIFE EXTENSION OF CHERRY TOMATOES

Nurfatin Athirah Shahrin[1], Boon Yih Tien[1,*]

[1]Faculty of Applied Sciences, Universiti Teknologi MARA, Kuala Pilah Campus, 72000 Kuala Pilah, Negeri Sembilan, Malaysia

[*]Corresponding author: boonyihtien@uitm.edu.my

ABSTRACT

Cherry tomatoes are highly perishable due to their delicate structure and high moisture content, resulting in significant postharvest losses. Conventional preservation methods, while effective, often raise environmental and health concerns. This study introduces a sustainable and bioactive edible coating derived from chitosan and key lime (*Citrus aurantiifolia*) peel essential oil, an underutilised agricultural waste that is used to extend shelf life while maintaining fruit quality. The essential oil was extracted via Soxhlet extraction, and Response Surface Methodology (RSM) with Central Composite Design (CCD) was employed to optimise the coating formulation using essential oil, chitosan, and glycerol as variables, with antioxidant (DPPH) and antimicrobial activities (against *Escherichia coli*) as responses. Essential oil concentration emerged as the most influential factor ($p < 0.0001$), resulting in an optimised formulation with 54.05% antioxidant activity and a 14.22 mm inhibition zone, supported by strong model fits ($R^2 \approx 0.95$). Application of the optimised coating on cherry tomatoes during 18 days of ambient storage demonstrated significant improvements over uncoated samples, including reduced weight loss (19.24% vs. 24.21%), enhanced firmness retention, stabilised water activity, slower increases in total soluble solids, and delayed colour changes associated with ripening. This research highlights a dual-function, bioactive coating that not only improves food preservation but also valorises agro-waste into a high-value solution. The findings present a scalable, eco-friendly alternative to synthetic preservatives, contributing to sustainable food systems and aligning with Sustainable Development Goals (SDGs) 3 (Good Health and Well-being) and 12 (Responsible Consumption and Production). The proposed innovation demonstrates strong potential for commercialisation and contributes towards advancements in sustainable food packaging.

Keywords: edible coating, key lime peel essential oil, response surface methodology, cherry tomato shelf life

1.0 INTRODUCTION

Fresh cherry tomatoes are highly demanded for their nutritional value, but their thin skin, high moisture content, and soft texture make them highly perishable, leading to significant postharvest losses (Rohasmizah & Azizah, 2022). Conventional preservation using synthetic plastic and wax coatings can slow spoilage, but chemical migrants such as phthalates and bisphenol A raise food safety and health concerns (Adly et al., 2025; Sambu et al., 2022). At the same time, Malaysia generates substantial food and agricultural by-product waste, including key lime (*Citrus aurantiifolia*) peel discarded after juice processing, despite it containing valuable antioxidant and antimicrobial compounds (Khan et al., 2021; Nazibudin et al., 2025).

Edible coatings made from natural polymers such as chitosan provide a biodegradable barrier that limits moisture loss, gas exchange, and microbial growth on fruit surfaces (Flórez et al., 2022; Krishnan et al., 2025). Incorporating essential oils rich in bioactive terpenoids into such coatings can further enhance antioxidant and antimicrobial functionality (Yuan et al., 2016). However, essential oils are volatile and poorly water-soluble, so the coating formulation must be carefully optimised to balance functional bioactivity with film-forming stability. This study therefore developed and evaluated a chitosan-based edible coating incorporated with key lime peel essential oil for the shelf life extension of

cherry tomatoes, offering a value-added, sustainable use for an agricultural by-product that would otherwise be discarded as waste.

2.0 OBJECTIVE

The objectives of this study are:

1. To optimise a chitosan-based edible coating incorporated with key lime peel essential oil using Response Surface Methodology (RSM) based on its antioxidant and antimicrobial properties.
2. To determine the coating's effect on cherry tomatoes' postharvest quality and shelf life in terms of pH, total soluble solids (TSS), weight loss, hardness, water activity, and colour changes.

3.0 METHODOLOGY

3.1 PREPARATION OF ESSENTIAL OIL AND EDIBLE COATING SOLUTION

Fresh key lime peels were washed, dried in a cabinet dryer at 55°C, and ground into powder. The essential oil was extracted using a Soxhlet apparatus with hexane as the solvent (solvent-to-solid ratio of 1:7.5 (w/v)) at 60°C for seven hours, followed by solvent evaporation using a rotary evaporator. The chitosan-based coating solution was prepared by dissolving chitosan powder in 2% acetic acid, followed by the addition of glycerol as plasticiser, and key lime peel essential oil emulsified with Tween 80 (3% w/v) as an emulsifier, before homogenisation at 260 rpm for 10 minutes.

3.2 OPTIMISATION OF COATING FORMULATION USING RSM

A Central Composite Design (CCD) under Response Surface Methodology (Design-Expert software, version 13) was used to optimise the coating formulation. Based on Table 1, essential oil, chitosan, and glycerol were used as independent variables at three coded levels across 20 experimental runs. Antioxidant activity was evaluated using the DPPH free radical scavenging assay, while antimicrobial activity was evaluated against *Escherichia coli* using a disk diffusion assay, and these were selected as the response variables.

Table 1: Coded levels of independent variables used in the Central Composite Design

Symbol	Independent Variable	-1	0	+1
A	Essential oil (%)	0	1.5	3.0
B	Chitosan (%)	0.5	1.5	2.5
C	Glycerol (%)	10	25	40

3.3 SHELF-LIFE STUDY

The optimised edible coating was applied to fresh cherry tomatoes, which were then stored at ambient temperature (23 ± 2°C) for 18 days alongside an uncoated control. Quality parameters, namely pH, total soluble solids (TSS), weight loss, hardness, water activity, and colour (L*, a*, b*), were measured at 3-day intervals in triplicate. Data were analysed using two-way ANOVA ($p < 0.05$) in SPSS to evaluate the effects of coating treatment, storage time, and their interaction.

4.0 RESULT

4.1 OPTIMISATION OF THE EDIBLE COATING FORMULATION

Across the 20 CCD runs, antioxidant activity of the coating solutions ranged from 7.61% to 54.05%, while antimicrobial inhibition zones against *E. coli* ranged from 8.97 mm to 14.70 mm. ANOVA of the quadratic response surface models confirmed that both responses were statistically significant ($p = 0.0003$), with strong predictive reliability ($R^2 = 0.9488$ for antioxidant activity and $R^2 = 0.9494$ for antimicrobial activity), as summarised in Table 2.

Table 2: ANOVA summary for the antioxidant and antimicrobial response surface quadratic models

Response	Sum of Squares	F-value	p-value	R^2
Antioxidant (%)	3102.12	16.45	0.0003	0.9488
Antimicrobial (mm)	52.23	16.67	0.0003	0.9494

Essential oil concentration was the most influential factor for both antioxidant ($F = 93.32$, $p < 0.0001$) and antimicrobial ($F = 134.65$, $p < 0.0001$) activity, likely due to its high terpenoid and phenolic content. Chitosan showed a smaller, inverse effect on antioxidant activity, likely due to a dilution effect that limited essential oil accessibility within a denser polymer matrix, while glycerol had no significant direct effect on either response ($p > 0.05$), though it supported the coating's flexibility and structural integrity. The optimum formulation, comprising 3% essential oil, 0.5% chitosan, and 10% glycerol, produced the highest antioxidant activity (54.05%) and a strong antimicrobial inhibition zone (14.22 mm), classified as exhibiting active antimicrobial activity against *E. coli*.

4.2 EFFECT OF EDIBLE COATING ON CHERRY TOMATO SHELF-LIFE

Over the 18-day storage period, coated cherry tomatoes consistently retained better postharvest quality than the uncoated control across all measured parameters, as summarised in Table 3. The pH of uncoated tomatoes declined more rapidly, reaching 3.90 by Day 18, whereas coated samples declined more gradually to 4.27, reflecting delayed metabolic activity associated with ripening. Total soluble solids (TSS) increased more slowly in coated samples (6.12 °Brix) than in uncoated samples (6.48 °Brix) by Day 18, indicating a reduced rate of starch-to-sugar conversion. Colour analysis showed that coated tomatoes retained significantly higher lightness (L*) and lower a* and b* values than uncoated samples throughout storage, indicating delayed darkening and reddening associated with ripening, although part of the b* difference may also reflect the essential oil's own natural pigment within the coating film.

Table 3: Summary of cherry tomato postharvest quality parameters for uncoated (control) and coated samples on Day 0 and Day 18 of storage

Parameter	Day 0		Day 18	
	Uncoated	Coated	Uncoated	Coated
pH	4.55	4.55	3.90	4.27
TSS (°Brix)	4.77	4.74	6.48	6.12
Weight loss (%)	0.00	0.00	24.21	19.24
Hardness (g)	4185.20	4556.65	2999.34	3877.69
Water activity (aw)	0.9833	0.9823	0.9687	0.9661
Lightness, L*	31.64	31.16	19.10	22.19

Weight loss was significantly reduced in coated tomatoes (19.24%) compared to uncoated samples (24.21%) by Day 18 (Figure 1), consistent with the coating functioning as a semi-permeable barrier that limits transpiration and respiration. Hardness followed a similar pattern, with coated tomatoes remaining significantly firmer than uncoated samples throughout storage, and the gap between treatments widening to approximately 900 g by Day 18 (Figure 2), attributable to slower pectin degradation and turgor loss in the coated fruit. Water activity (aw) decreased progressively in both treatments over the storage period, from an initial 0.9833 (uncoated) and 0.9823 (coated) on Day 0 to 0.9687 and 0.9661, respectively, by Day 18, with the rate of decline slowing markedly in both samples after Day 12.

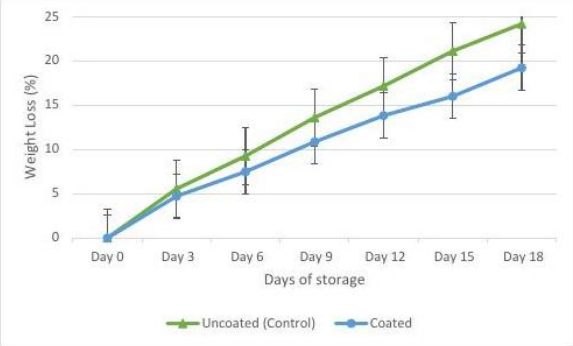


Figure 1: Weight loss of uncoated and coated cherry tomatoes during 18 days of storage

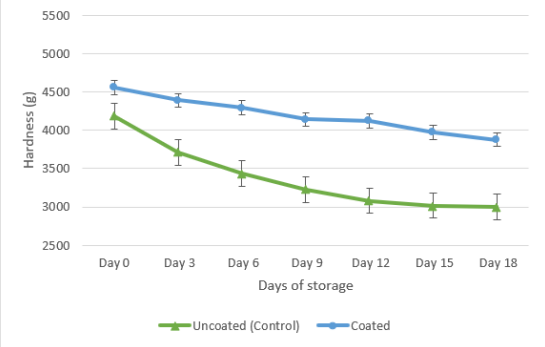


Figure 2: Hardness of uncoated and coated cherry tomatoes during 18 days of storage

5.0 CONCLUSION

This study successfully developed and evaluated a biodegradable, chitosan-based edible coating incorporated with key lime peel essential oil for the postharvest preservation of cherry tomatoes. Essential oil concentration was found to be the dominant factor affecting the coating's antioxidant and antimicrobial functionality, and the optimised formulation (3% essential oil, 0.5% chitosan, 10% glycerol) achieved strong bioactivity. When applied to cherry tomatoes, the optimised coating significantly slowed the rise in total soluble solids, reduced weight loss, improved firmness retention, and delayed colour changes relative to uncoated fruit over 18 days of ambient storage. These findings confirm that key lime peel essential oil, an underutilised agro-industrial by-product, can be valorised into a functional, sustainable edible coating that extends cherry tomato shelf life, shows potential for commercial scale-up and an eco-friendly alternative to synthetic preservatives. This contributes to Sustainable Development Goal (SDG) 3, Good Health and Well-Being, by providing a safer, chemical-free preservation method, and SDG 12, Responsible Consumption and Production, by reducing food waste and reliance on non-biodegradable packaging.

ACKNOWLEDGEMENT

The authors would like to thank the Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), Kuala Pilah Campus, for providing the laboratory facilities used in this study, and the laboratory assistants for their technical support throughout the experimental work.

REFERENCES

Adly, H. M., Saati, A. A., Obaid, M. S., & Saleh, S. A. K. (2025). Chemical migration of polycyclic aromatic hydrocarbons and other compounds from plastic food packaging: assessment of food safety risks and health impacts. Foods, 14(6), 1013. https://doi.org/10.3390/foods14061013

Barreto, T. A., Andrade, S. C. A., Maciel, J. F., Arcanjo, N. M. O., Madruga, M. S., Meireles, B., Cordeiro, Â. M. T., Souza, E. L., & Magnani, M. (2016). A chitosan coating containing essential oil from *Origanum vulgare L.* to control postharvest mold infections and keep the quality of cherry tomato fruit. Frontiers in Microbiology, 7. https://doi.org/10.3389/fmicb.2016.01724

Bremenkamp, I., & Sousa-Gallagher, M. J. (2024). Design and development of an edible coating for a ready-to-eat fish product. Polymers, 16(3), 346. https://doi.org/10.3390/polym16030346

Duguma, H. T. (2022). Potential applications and limitations of edible coatings for maintaining tomato quality and shelf life. International Journal of Food Science & Technology, 57(3), 1353–1366. https://doi.org/10.1111/ijfs.15407

Elkhawas, Y. A., El Hassab, M. A., Al kamaly, O., Negmeldin, A. T., Majrashi, T. A., Eldehna, W. M., & Mostafa, N. M. (2025). *Citrus aurantifolia* essential oil: antiaging potential through integrated in vitro and in silico studies. Frontiers in Chemistry, 13. https://doi.org/10.3389/fchem.2025.1577871

Flórez, M., Guerra-Rodríguez, E., Cazón, P., & Vázquez, M. (2022). Chitosan for food packaging: Recent advances in active and intelligent films. Food Hydrocolloids, 124. https://doi.org/10.1016/j.foodhyd.2021.107328

Jahani, R., Behnamian, M., Dezhsetan, S., Karimirad, R., & Chamani, E. (2023). Chitosan nano-biopolymer/*Citrus paradisi* peel oil delivery system enhanced shelf-life and postharvest quality of cherry tomato. International Journal of Biological Macromolecules, 225, 1212–1223. https://doi.org/10.1016/j.ijbiomac.2022.11.182

Khan, U. M., Sameen, A., Aadil, R. M., Shahid, M., Sezen, S., Zarrabi, A., Ozdemir, B., Sevindik, M., Kaplan, D. N., Selamoglu, Z., Ydyrys, A., Anitha, T., Kumar, M., Sharifi-Rad, J., & Butnariu, M. (2021). Citrus genus and its waste utilization: A review on health-promoting activities and industrial application. Evidence-Based Complementary and Alternative Medicine, 2021, 1–17. https://doi.org/10.1155/2021/2488804

Krishnan, R., Misra, M., Subramanian, J., & Mohanty, A. (2025). Emerging trends and application of edible coating as a sustainable solution for postharvest management in stone fruits: A comprehensive review. Comprehensive Reviews in Food Science and Food Safety, 24(3). https://doi.org/10.1111/1541-4337.70179

Kumar, S., Krishnan, P., Singh, P. K., Vashisth, A., & Kundu, M. (2023). Biophysical and biochemical changes in tomato (*Solanum lycopersicum*) genotypes at different fruit developmental stages under protected cultivation. The Indian Journal of Agricultural Sciences, 93(8), 875–880. https://doi.org/10.56093/ijas.v93i8.136522

Lufu, R., Ambaw, A., & Opara, U. L. (2019). The contribution of transpiration and respiration processes in the mass loss of pomegranate fruit (*cv. Wonderful*). Postharvest Biology and Technology, 157, 110982. https://doi.org/10.1016/j.postharvbio.2019.110982

Nazibudin, N. A., Sabri, S. A. M., & Manaf, L. A. (2025). Aligning with sustainable development goals (SDG) 12: A systematic review of food waste generation in Malaysia. Cleaner Waste Systems, 10, 100205. https://doi.org/10.1016/j.clwas.2025.100205

Rohasmizah, H., & Azizah, M. (2022). Pectin-based edible coatings and nanoemulsion for the preservation of fruits and vegetables: A review. Applied Food Research, 2(2). https://doi.org/10.1016/j.afres.2022.100221

Sambu, S., Hemaram, U., Murugan, R., & Alsofi, A. A. (2022). Toxicological and teratogenic effect of various food additives: An updated review. BioMed Research International, 2022(1). https://doi.org/10.1155/2022/6829409

Sree, K. P., Sree, M. S., Supriya, P., & S. (2020). Application of chitosan edible coating for preservation of tomato. International Journal of Chemical Studies, 8(4), 3281–3285. https://doi.org/10.22271/chemi.2020.v8.i4ao.10157

Yuan, G., Chen, X., & Li, D. (2016). Chitosan films and coatings containing essential oils: The antioxidant and antimicrobial activity, and application in food systems. Food Research International, 89, 117–128. https://doi.org/10.1016/j.foodres.2016.10.004

WASTE2VALUE: DIGITAL SOLUTION FOR CIRCULAR ECONOMY AND WASTE PROCESSING

Yeah Jiah Xuan[1,*], Long Yi Han[1], Lee Zan Qing[1], Shaffika Bte Mohd Suhaimi[1], Sangita A/P Jeyaram[1]

[1]Southern University College (SUC), PTD 64888, KM15, Jalan Skudai, 81300 Skudai, Johor, Malaysia

[*]Corresponding Author: B250035A@sc.edu.my

ABSTRACT

Malaysia generates 39,000 tonnes of daily waste, 44.5% of which is organic. Due to fragmented logistics, 95% of this material ends up in landfills. Aligned with Malaysia's Circular Economy Blueprint (2025–2035) and SDG 12, which refer to Responsible Consumption and Production to substantially reduce waste generation, Waste2Value is a digital marketplace designed to streamline the exchange and collection of recyclable organic waste using a three-stream waste segregation model. Commercial food-sector waste, such as peels and cooking oils, is currently mismanaged due to inefficient manual coordination. This lack of connectivity between generators and recyclers leads to excessive landfill disposal, resulting in toxic leachate and greenhouse gas emissions. These environmental impacts degrade soil and air quality, directly conflicting with Sustainable Development Goal SDG 12. The project aims to design and develop a mobile-based two-sided marketplace that facilitates real-time matching, trading, and collection of recyclable organic waste. The project follows a User-Centred Design (UCD) methodology, encompassing stakeholder interviews, requirement analysis, prototyping, and usability evaluation. Waste2Value provides tailored interfaces for waste suppliers and recyclers to schedule collections, manage transactions, and track progress. The system integrates Geographic Information System (GIS) technology for location-based matching and route optimisation, with IoT-enabled smart bins using load cell weight sensors to monitor waste levels and automatically notify collectors. The system incorporates a hybrid validation model, supporting fee-based collector sorting and quality verification. The platform enhances waste management efficiency by streamlining collection processes and reducing operational costs. Additionally, it features an ESG Reporting Dashboard, allowing businesses to monitor environmental impact through key indicators such as waste diversion rates, carbon emission reductions, and resource recovery metrics. Waste2Value offers an innovative digital marketplace that optimises the collection and recovery of organic waste. By integrating efficient logistics with ESG reporting, the platform promotes circular economy initiatives and strengthens sustainable waste management practices across Malaysia.

Keywords: circular economy, organic waste management, digital marketplace, IoT-enabled systems, ESG reporting

1.0 INTRODUCTION

Malaysia generates 39,000 tonnes of daily waste, 44.5% of which is organic (MIDA, 2025). Due to fragmented logistics, 95% of such material ends up in landfills, causing serious soil leachate pollution and greenhouse gas emissions. This situation is in direct conflict with the Malaysian Circular Economy Blueprint (2025-2035) and the United Nations Sustainable Development Goal (SDG 12), which targets responsible consumption and production to significantly reduce waste generation (United Nations, 2015). Therefore, there is an urgent need for a digital and scalable solution to achieve the transformation from linear processing to a cyclical and resource-efficient model. Currently, the organic waste management ecosystem in the commercial food sector, which includes food waste, used cooking oil, and others, suffers from inefficient coordination between producers and recyclers. This lack of connectivity has led to excessive waste accumulation and loss of economic value. To address these challenges, we developed Waste2Value, an innovative digital marketplace designed to streamline the process of exchanging and collecting recyclable organic waste. By integrating IoT-enabled smart bins with a real-time matching platform, Waste2Value effectively bridges the gap between waste generation and recycling, converting potential contaminants into quantifiable resources.

1.1 PROBLEM STATEMENT

The lack of coordination in the waste collection system leads to inefficient waste management. The current waste collection process relies heavily on manual communication between waste generators and collectors. Due to the absence of a centralised platform that enables waste generators and collectors to exchange information, waste generators often need to contact collectors individually, leading to delayed responses and an inconsistent collection schedule. Consequently, recyclable organic waste is not collected on time and is more likely to be disposed of in landfills, reducing resource recovery and increasing environmental impacts, causing toxic leachate and greenhouse gas emissions. Besides, most generators are not familiar with the categorisation process when disposing of waste. For example, in ordinary restaurants, the staff are busy with the usual operation and have limited time to classify the waste manually. The waste is disposed of in the same bin without classification of waste types. When recyclable waste is contaminated by non-recyclable materials, the quality of the recyclable resources is reduced. This increases the need for additional sorting, raises processing costs, and reduces the overall efficiency of recycling operations (Greenfield, 2025). In addition, waste generators suffer from limited visibility into the post-disposal collection process. This leads to a diminished sense of accountability and engagement in sustainability initiatives when they cannot monitor the collection progress and evaluate environmental contributions. Transitioning to a digital and circular ecosystem is essential to overcome these data silos and promote resource efficiency (Ellen MacArthur Foundation, n.d.).

2.0 OBJECTIVE

The primary objective of the project is to design and develop a mobile-based two-sided digital marketplace that connects waste generators and collectors through a centralised platform for efficient waste management. The platform aims to improve coordination among generators and collectors by providing real-time collection requests, location-based matching, and collection tracking. This can reduce the reliance on manual communication, while information can be exchanged seamlessly. The project aims to design and develop a mobile-based two-sided marketplace that facilitates real-time matching, trading, and collection of recyclable organic waste. Waste2Value seeks to increase the recovery of recyclable organic waste, promote sustainable waste management practices, and support Malaysia's transition towards a circular economy in line with the Malaysian Circular Economy Blueprint (2025–2035) and Sustainable Development Goal 12 (Responsible Consumption and Production).

3.0 METHODOLOGY

The design of this project takes a User-Centred Design (UCD) approach that includes user interviews, requirements analysis, high-fidelity prototyping, and usability testing. Waste2Value has specially designed interfaces for waste suppliers and recyclers where they can schedule their collection, manage transactions, and monitor progress. GIS Technology is used in the system for location-based matching and routing optimisation. The system incorporates IoT-enabled smart bins equipped with load cell weight sensors, which automatically notify collectors upon reaching specific waste thresholds. To ensure waste purity, the system employs a hybrid validation model that supports three-stream segregation, including food, oil and others, alongside a fee-based quality verification process performed by collectors.

3.1 RESEARCH FRAMEWORK

The design and development of the Waste2Value application adhere strictly to the User-Centred Design (UCD) process to ensure that system functionalities align seamlessly with the operational workflows of commercial food establishments and third-party waste recyclers in Malaysia. Requirement analysis was then done to convert real-life pain points into software/hardware requirements. In the prototyping phase, user interface screens were created iteratively to facilitate conversion of complex backend processes into user-friendly processes. Usability testing was done to assess the way in which real users navigate through the system.

3.2 FRONTED ARCHITECTURE AND MULTI-ROLE USER INTERFACES

The cross-platform mobile frontend for Waste2Value is configured to dynamically divide itself by user roles after login. The waste supplier version of the application emphasises maximum mobility through high mobility, showing smart bins' capacity information as well as picking up indicators. On the other hand, the collector side focuses on logistics procedures by incorporating the bidding marketplace

system along with the map of routes. High-contrast fonts and real-time notifications are applied to both sides of the app to reduce cognitive load and avoid mistakes.

3.3 SYSTEM PROCESS AND BACKEND ARCHITECTURE

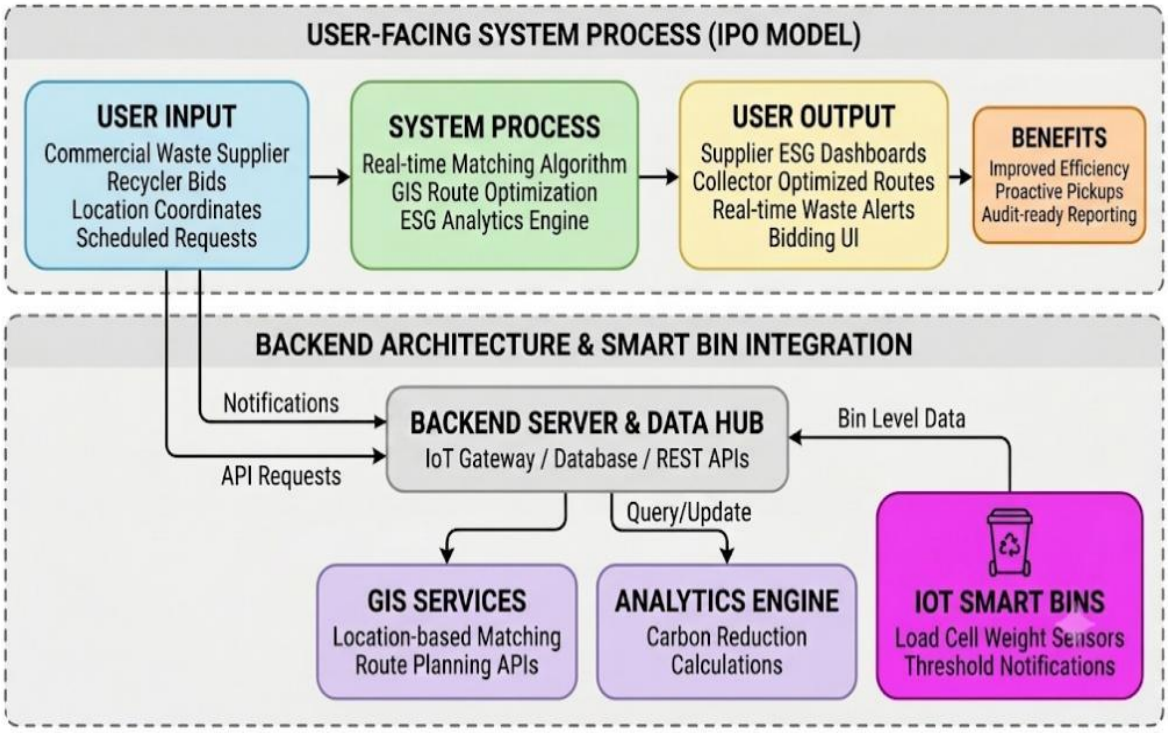


Figure 1: IPO Model and Backend Architecture

Figure 1 shows how the Waste2Value core functionalities work through an IPO (Input-Process-Output) framework to automate manual waste coordination. This system architecture responds to the large volumes of organic waste generated in the region (MIDA, 2025) by creating a highly coordinated, data-driven collection and recycling workflow. The input stage captures information on user behaviour, marketplace listings, mobile GPS telemetry, and granular, three-stream (food, oil, and other) weight measurements from load cell sensors in the IoT smart bins. In the process stage, the backend performs multi-threading activities such as real-time matchmaking, GIS route optimisation, threshold capacity triggering, and a hybrid validation-based ESG conversion engine. The output stage gives instant feedback to the user interface through navigation routes, bin prediction alerts, and ESG impact reports. This integrated design facilitates fast and secure data routing, leading to reduced transit times for collectors and verified carbon reduction logs for commercial establishments.

3.4 PROJECT INNOVATION

Figure 2 displays the system innovation, which involves automated ESG accounting as well as IoT threshold monitoring. Rather than manually logging the information, the sensors present within the bins send out live fill-level percentages of Food Waste, Oil, and Other streams. The dashboard shows the status of automated alerts that will inform the supplier whether a truck is on its way. On the other hand, the backend immediately translates the weights into compliance figures and shows the carbon emission reductions made every month (120kgCO2e) along with the total amount of waste diverted (450kg).

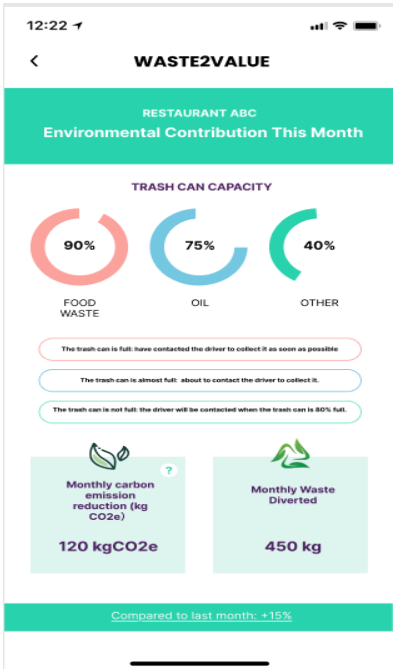


Figure 2: Automated threshold alerts and passive ESG tracking

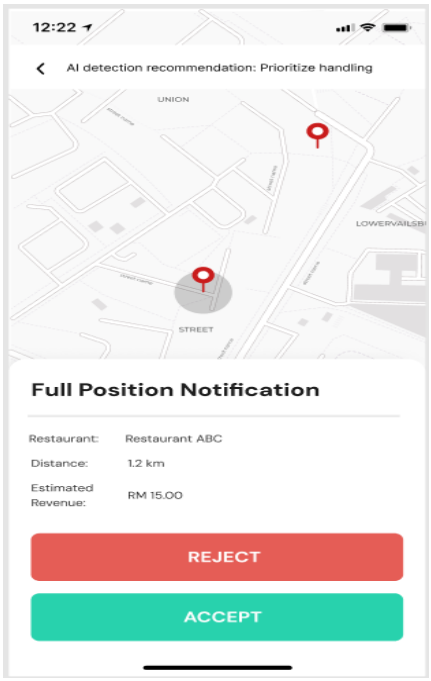


Figure 3: AI-assisted dispatch and real-time proximity matching.

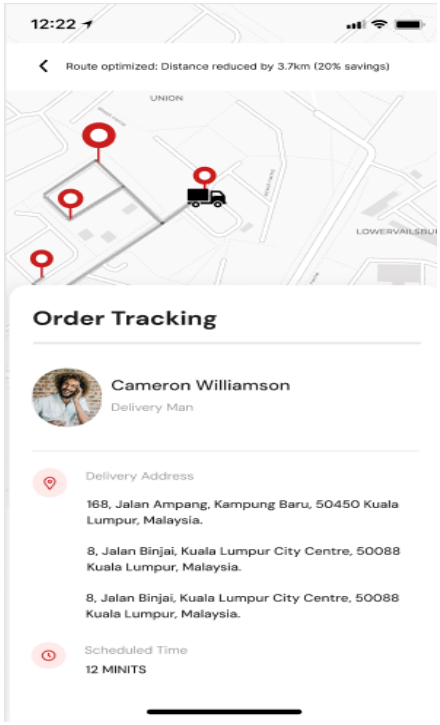


Figure 4: Intelligent multi-stop logistics.

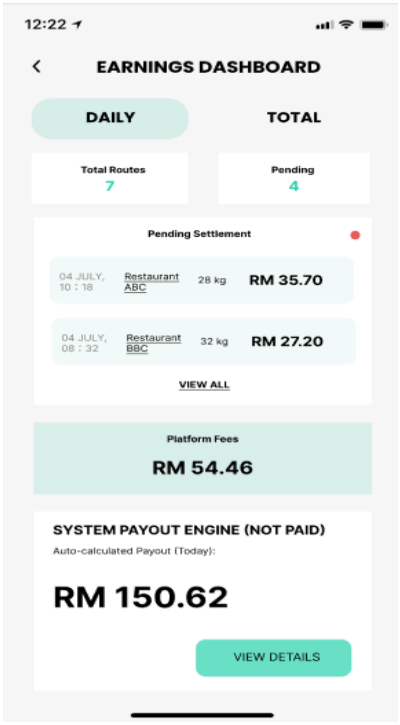


Figure 5: An automated marketplace settlement engine

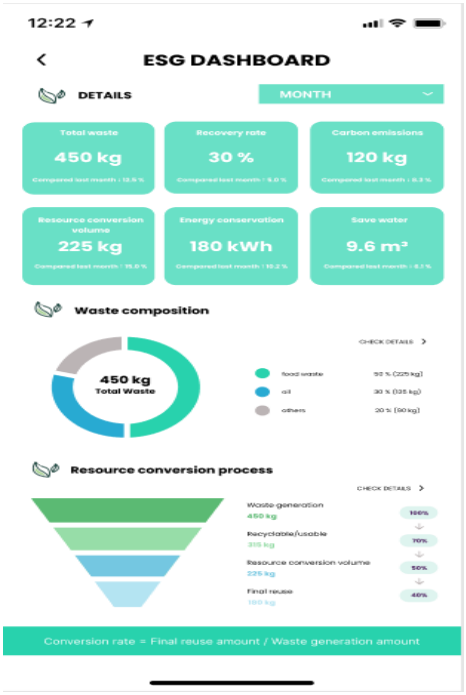


Figure 6: An automated marketplace settlement engine

Figure 3 displays where the AI-enabled proximity matching system of the platform will be demonstrated. Once the smart bin is full, the system checks its coordinates against the active operators near it. The driver gets a specific notification that comes with an AI-optimised handling recommendation banner. The map interface simplifies complicated backend location routing by providing the driver with three main information points: the name of the supplier, the distance between the two points (1.2km), and the payoff amount (RM15.00).

Figure 4 displays the intelligent multi-stop logistics system, which is aimed at reducing carbon footprints in urban areas. After the driver has accepted the dispatch, the routing algorithm then creates the collection points as an optimised and chronological multi-stop map itinerary. By calculating the shortest route, the application cuts down the distance travelled by the trucks by 3.7km, that is, a 20% reduction in fuel and emissions, while updating the arrival time to below 12 minutes.

Figure 5 displays the marketplace monetisation layer, through which real-world data about the waste gets linked directly with the economic ledger. The system itself automatically cross-checks the completed weights with financial payouts to avoid errors in manual invoicing. Through the process of listing the completed routes versus the pending ones, calculation of platform service fee, and automatic calculation of daily payout (RM150.62), a very secure and clear bookkeeping system is created.

Figure 6 displays the interface operating as an automated environmental auditing tool that translates raw collected information into a company's compliance report. The first section consists of six key sustainability goals measured in monthly trends and compared with the performance achieved before by Total Waste (450kg), Recovery Rate (30%), Carbon Emissions (120kg), Resource Conversion (225kg), Energy Saved (180kWh), and Water Saved (9.6m^3). Next, the "Waste Composition" donut shows how waste flows are divided in terms of their weight, such as Food Waste (50%), Oil (30%), and Others (20%). Finally, the "Resource Conversion Process" funnel reflects the process through which the total amount of waste is reduced from the initial amount of material to the final reused weight. The efficiency of the process is calculated using Eq. (1) and shown at the end of the interface layout to guarantee data transparency.

$$ConversionRate = \frac{Final\ Reuse\ Amount}{Waste\ Generation} \quad (1)$$

As shown in Eq. (1), the obtained result will be used as logs for auditing of corporate partners' regions.

4.0 RESULT

Waste2Value has introduced a hybrid waste management methodology that combines three-stream waste segregation, IoT-based smart bins with load cell weight sensors, and collector-assisted quality verification. This approach encourages generators to practise proper waste segregation while maintaining waste quality through a fee-based verification process by the collectors when additional sorting is required. Compared with conventional waste collection methods, the platform reduces manual coordination, improves collection efficiency through automated system notifications, and optimises logistics using GIS technology. Besides, the ESG Reporting Dashboard enables the generators to monitor the environmental impact by looking into the waste diversion, carbon emission reductions, and resource recovery performance. The platform enhances waste management efficiency by streamlining the collection process with seamless information exchange. Compared to the usual waste management method, Waste2Value can reduce the operational costs during the collection process. Besides, it encourages people to actively take part in dealing with the disposal of waste, raising their awareness of recycling. By improving recycling efficiency and reducing landfill disposal, Waste2Value supports Malaysia's circular economy initiatives and promotes long-term sustainable waste management practices.

5.0 CONCLUSION

In conclusion, the Waste2Value platform addresses the critical inefficiencies in organic waste management by bridging the gap between waste generators and collectors through a centralised, data-driven marketplace. By integrating IoT-enabled smart bins, GIS-optimised logistics, and a hybrid validation model for three-stream segregation, this project successfully transforms traditional waste disposal into a structured circular economic process. The system not only optimises operational efficiency and reduces processing costs but also provides actionable ESG insights that empower businesses to quantify sustainability contributions. By fostering active stakeholder participation and raising recycling awareness, Waste2Value transcends purely technical utility to drive positive behavioural change. Ultimately, Waste2Value serves as a scalable solution that aligns with the Malaysian Circular Economy Blueprint (2025-2035) and global SDG 12 objectives, paving the way for a more responsible, resource-efficient, and sustainable commercial food sector.

ACKNOWLEDGEMENT

The authors would like to acknowledge Southern University College for providing the funding, resources, and research facilities that enabled the successful execution of this project. Special thanks are extended to the project supervisor and domain expert for their invaluable contributions in shaping the research idea, conceptual framework, motivation, and overall direction of the study. Their continuous guidance and encouragement have been instrumental in the completion of this work.

REFERENCES

Ellen MacArthur Foundation. (n.d.). *Ellen MacArthur Foundation | Circular Economy*. Ellen MacArthur Foundation. Retrieved July 16, 2026, from https://www.ellenmacarthurfoundation.org/

Greenfield, M. (2025, April 17). *The Growing Challenges of Waste Management: Issues and Solutions*. Prime Source Expense Experts. https://primesourcex.com/the-growing-challenges-of-waste-management-issues-and-solutions/

MIDA. (2025). *Turning Waste into Wealth: Malaysia's Circular Economy in Action*. Malaysian Investment Development Authority (MIDA). https://www.mida.gov.my/turning-waste-into-wealth-malaysias-circular-economy-in-action/

United Nations. (2015). *Goal 12: Ensure sustainable consumption and production patterns - Sustainable Development Goals*. United Nations Department of Economic and Social Affairs. https://sdgs.un.org/goals/goal12

ECO-SENTINEL: PROACTIVE ENVIRONMENTAL HAZARD DETECTION AND COMMUNITY ALERT SYSTEM

Muhammad Fareez Asyraf Istas Fahrurrazi[1], Fazlinashatul Suhaidah Zahid[1,*], Nor Diyana Md.Sin[1]

[1]Faculty of Electrical Engineering, UiTM Cawangan Johor Kampus Pasir Gudang, 81750 Masai, Johor Darul Ta'zim, Malaysia

[*]Corresponding author: fazlina7803@uitm.edu.my

ABSTRACT

Malaysia often experiences natural disasters like monsoonal floods and earthquakes. These risks are made worse by the country's current monitoring system, which still depends on manual data collection. This project introduces a new disaster monitoring system built with the ESP32-WROVER-B microcontroller. It collects and shares disaster data in real time using HTTP. The system uses an ADXL345 accelerometer to detect earthquakes and an HC-SR04 ultrasonic sensor to monitor water levels. When certain thresholds are reached, the system triggers buzzers and LEDs to alert people nearby. At the same time, the TTGO T-Call V1.3 ESP32 module sends live data to a central server running on a LAMP stack (Linux, Apache, MySQL, PHP). The prototype of this Eco-Sentinel can accurately detect environmental changes, send data continuously, and display results on a website with line graphs, pie charts, and CSV downloads. This affordable and scalable early warning system connects sensor hardware with web analytics. It helps communities prepare for disasters and gives meteorologists and local authorities a proactive way to reduce risks and protect vulnerable areas.

Keywords: eco-sentinel, ESP32 microcontroller, LAMP stack, IoT, natural disaster mitigation

1.0 INTRODUCTION

Natural disasters and emergencies can cause serious damage to communities, infrastructure, and the environment. To lower these risks, it is important to detect hazards quickly, communicate clearly, and issue warnings promptly. Although disaster risk reduction has improved worldwide, many communities still lack real-time sensors, reliable connectivity, or rapid alerts. Traditional disaster monitoring systems often rely on large, centralised setups that can fail or become unreliable during major crises (Matsuoka et al., 2013; Messina et al., 2024).

Conventional disaster monitoring systems mostly depend on centralised, infrastructure-heavy solutions that can become unavailable or unreliable during severe crises. When natural disasters occur and the main communication networks are down, these systems often cannot provide the timely information needed for an effective response (Manuel et al., 2022). As a result, there is a significant gap between current disaster mitigation capabilities and the urgent needs of remote or less-developed communities.

Current systems also often lack local, edge-based processing, which can cause significant delays when monitoring urgent hazard indicators such as rapidly rising river levels or sudden heavy rain. Without flexible and reliable communication options, remote sensor networks cannot always send data when standard Wi-Fi or fixed networks are down. Setting up sensor networks in disaster situations also raises important security concerns, since maintaining data accuracy, authenticity, and protection against network issues is essential for a trustworthy monitoring system (Hercog et al., 2023).

There is a clear need for an autonomous, cost-effective disaster mitigation system. To address current infrastructure limitations, the proposed system should operate at the edge to collect environmental data, use robust alternative wireless links such as GSM/GPRS or low-power LoRa when regular networks fail, and send timely, useful alerts to vulnerable people and first responders.

In this project, we use the TTGO T-CALL V1.3 ESP32 Wireless Module as the main controller for our Eco-Sentinel model, which is a low-cost, widely available microcontroller. It has dual-core processing, Wi-Fi, Bluetooth, and support for various sensors for edge sensing and offline use. This module fits disaster mitigation systems well because it is small, energy-efficient, supports many sensors, and can connect to cellular or low-power wide-area networks when needed.

2.0 OBJECTIVE

The objectives of this project are:

1. To develop an autonomous disaster mitigation system using the TTGO T-CALL V1.3 ESP32 module that can continuously sense the environment in real time and do basic data processing directly at the edge.
2. To integrate the sensor network with centralised cloud platforms and flexible alert services to easily gather data, display hazard information to vulnerable people and first responders.

3.0 METHODOLOGY

The methodology involves a systematic integration of hardware assembly and software development to establish a continuous monitoring and alerting loop. The core processing unit is the TTGO T-Call V1.3 ESP32 Development Board, featuring built-in Wi-Fi and a SIM800L module for robust cellular communication. The sensory input relies on a dual-sensor architecture: an ADXL345 3-axis accelerometer is utilised to detect seismic ground movements and calculate real-time seismic magnitude, while an HC-SR04 ultrasonic sensor measures precise water levels to detect potential floods.

3.1 THE SYSTEM ARCHITECTURE OF ECO-SENTINEL

The block diagram illustrated in **Figure 1** shows the overall hardware and software architecture of the proposed natural disaster mitigation system. It demonstrates the seamless integration of environmental input sensors, the central edge-processing unit, and the multi-modal output mechanisms for both localised and web-based alerting.

The architecture is divided into three primary modules:

Central Processing Unit

The core of the system is the ESP32-WROVER-B microcontroller. Serving as the central computational hub, it is responsible for continuously acquiring data from the input sensors, executing lightweight decision-making algorithms at the edge, and orchestrating the appropriate physical and network-based outputs.

Input Modules

The input module on the left side of the diagram comprises the environmental sensing hardware and a manual control interface:

ADXL335/ADXL345 Accelerometer Sensor: A tri-axial sensor utilised to measure ground acceleration and vibrations for accurate real-time seismic (earthquake) detection.

HC-SR04 Water Level Sensor: An ultrasonic sensor deployed to continuously monitor the distance to water surfaces, enabling the rapid detection of rising water levels associated with flash floods.

Button: A physical manual input interface, typically used for localised user interactions such as system resets, manual overrides, or calibration.

Output and Alerting Module

The output system is a two-part alert system, which handles both immediate local warnings and remote data recording. Local Hardware Alerts: To protect the nearby area during a problem, the ESP32 activates physical hardware outputs. These include a buzzer for sound alarms and an LED for visual hazard signals. Also, an LCD provides a local interface for viewing real-time sensor data and system connection status. Cloud Integration & Data Transmission: To support remote monitoring, the microcontroller prepares the processed data and sends it via HTTP. This data goes directly to a central backend server running Apache, MySQL, and PHP (LAMP stack). This setup allows continuous remote data collection, safe database storage, and dynamic dashboard display for public and authority use.

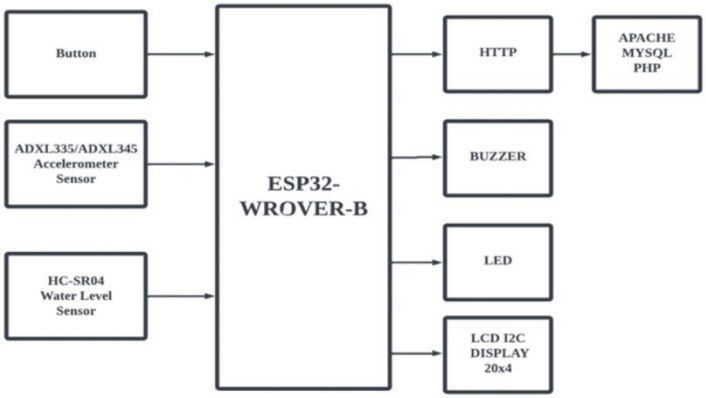


Figure 1: The Block Diagram of Eco – Sentinel

4.0 RESULT

The prototype testing demonstrated reliable and consistent performance. The ADXL345 accelerometer and HC-SR04 ultrasonic sensors provided accurate, real-time measurements of environmental conditions. The microcontroller executed decision-making algorithms locally at the edge as intended, as shown in **Figure 2**. When the seismic vibrations reached the threshold magnitude, the earthquake LED and a medium-pitched buzzer turned ON. At the same time, the device continuously and efficiently sent data to the central server via HTTP. The web dashboard showed live data with interactive X-, Y-, and Z-axis line graphs, pie charts, and real-time tables, and allowed authorised users to easily export data as CSV or Excel files for later analysis. When simulated flood levels exceeded the limit (distance less than 10 cm), the system immediately turned on the flood LED, sounded a high-pitched buzzer, and displayed a local warning on the LCD.

Local processing of the decision-making algorithms significantly reduces transmission latency. Immediate physical alerts secure the area, giving vulnerable communities critical extra seconds to evacuate without waiting for manual reports or delayed server responses.

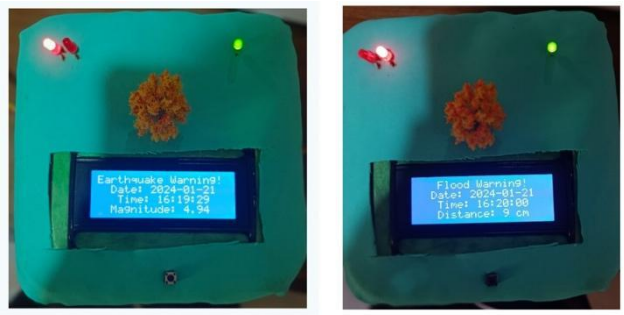


Figure 2: The Eco-Sentinel Of The Multi-Hazard Early Warning System Displaying Disaster Alerts On The LCD (a) Earthquake Warning And (b) Flood Warning Mitigation System

4.1 NOVELTY OF THE ECO-SENTINEL MITIGATION SYSTEM

1. Dual-Hazard Edge Architecture: Instead of using separate sensors for each threat, this new design combines flood and earthquake detection into a single compact IoT device.
2. Edge-Calculated Seismic Magnitude: The system uses a new method to turn raw X, Y, and Z acceleration data into a standard seismic magnitude right on the device, so it does not need to send large amounts of data to the cloud.
3. Seamless LAMP Stack Integration: The system sends real-time IoT data directly from sensors to a LAMP stack (Linux, Apache, MySQL, PHP) via HTTP. This makes web analytics easier and avoids the problems of older systems that operate in isolation and require extensive manual reporting.

4. Autonomous Hybrid Alert Mechanism: The project uses a two-part alert system. It immediately triggers local hardware alarms to protect nearby areas and updates a global web dashboard to inform authorities and the public.

5.0 CONCLUSION

The Eco-Sentinel Mitigation System provides an autonomous, real-time monitoring framework using an ESP32 microcontroller. The system offers meteorologists and researchers a continuous, exportable stream of real-time environmental data, enabling them to identify hazard patterns and develop advanced predictive algorithms. The project shows that advanced early warning systems can be affordable, with the prototype costing less than RM200. This cost-effectiveness offers a scalable model for widespread municipal deployment. By providing instant, localised warnings for floods and earthquakes, the system supports proactive emergency responses and helps reduce financial losses and property damage from natural disasters

ACKNOWLEDGEMENT

The team members would like to express their sincere gratitude to Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang**,** particularly the Faculty of Electrical Engineering, for providing the facilities, technical support, and guidance throughout the development of this project. Special appreciation is extended to all team members whose valuable contributions and continuous encouragement made this work possible. Finally, the team members are grateful to everyone who directly or indirectly supported the successful completion of this project

REFERENCES

Hercog, D., Lerher, T., Truntič, M., & Težak, O. (2023). Design and Implementation of ESP32-Based IoT Devices. *Sensors*, *23*(15), 6739. https://doi.org/10.3390/s23156739

Manuel, M. P., Faied, M., & Krishnan, M. (2022). A Novel LoRa LPWAN-Based Communication Architecture for Search & Rescue Missions. *IEEE Access*, *10*, 57596–57607. https://doi.org/10.1109/ACCESS.2022.3178437

Matsuoka, Y., Takeuchi, Y., & Shaw, R. (2013). Implementation of Hyogo Framework for Action in Makati City, Philippines. *International Journal of Disaster Resilience in the Built Environment*, *4*(1), 23–42. https://doi.org/10.1108/17595901311298982

Messina, F., Santoro, C., & Santoro, F. F. (2024). Enhancing Security and Trust in Internet of Things through Meshtastic Protocol Utilising Low-Range Technology. *Electronics*, *13*(6), 1055. https://doi.org/10.3390/electronics13061055

A LOW-COST CNN-BASED HUMAN MOTION DETECTION SYSTEM USING WI-FI CHANNEL STATE INFORMATION FOR SMART HOME APPLICATIONS

Muhammad Haritz Asrofodin[1], Noormadinah Allias[1,*]

[1]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

[*]Corresponding author: noormadinah@uitm.edu.my

ABSTRACT

Human motion detection solutions have become more common as tools to increase safety and comfort levels in homes. However, many of the existing detection systems based on cameras and specialised sensors are too expensive to implement and cause privacy concerns by constantly capturing images. In turn, there is a need for an affordable, privacy-preserving, and easily deployable solution for real-time human presence detection indoors. This project aims to develop a low-cost motion detection system that uses wireless communication signals for human motion detection without the use of cameras and wearable devices. The proposed innovation, SmartGuard-CSI uses Wireless Communication Signals (Wi-Fi Channel State Information – CSI) collected from only one ESP32 microcontroller, which simplifies hardware design and decreases the cost of the solution significantly. A traffic injection module is used to support a constant 100 Hz sampling rate of the Wi-Fi CSI using UDP packages. Amplitude data of the Wi-Fi CSI is processed with the use of CNN to distinguish between human presence and an empty room in real time. The combination of simple hardware design and artificial intelligence ensures accuracy of motion detection and preserves the privacy of users. Experimental results show that the proposed prototype works reliably for real-time human presence detection by means of low-cost and commercially available components without the use of special sensing devices. In comparison with the traditional camera-based human motion detection systems, the proposed solution provides advantages in terms of lower implementation cost, improved privacy, easy installation, and flexibility for different indoor environments. Possible applications include security systems, care for elderly people, occupancy monitoring, and intelligent building management. To conclude, SmartGuard-CSI demonstrates the possibility of providing privacy-preserving real-time human motion detection using compact and low-cost hardware. The proposed innovation is applicable in the development of next-generation smart living environments and intelligent systems.

Keywords: Wi-Fi Channel State Information (CSI), motion detection, Convolutional Neural Network (CNN), ESP32, smart home security

1.0 INTRODUCTION

Recent developments in the field of smart homes have led to the advancement of security, automation, and intelligent monitoring systems. Human motion detection has turned out to be an essential aspect in various applications such as home surveillance, elder care, and intelligent building management. The current state of the art for human motion detection is based on simple but effective technologies of Passive Infrared (PIR) sensors and surveillance cameras. However, there are several disadvantages associated with these sensing techniques, which include privacy issues, complexity of installation, cost, and line-of-sight propagation (Bhavsar et al., 2023; Gorrepati et al., 2023). PIR sensors are affected by any fluctuations in environmental conditions (such as sunlight, temperature, or airflow) and cannot recognise stationary people. At the same time, the use of cameras is accompanied by privacy issues related to the need for video analysis and the fact that these systems are not effective in occluded environments.

In order to reduce these disadvantages, one can use Wi-Fi Channel State Information (CSI) as a device-free human sensing method based on variations of the physical layer of the signal. CSI provides detailed information about fluctuations of amplitude and phase of the wireless signal caused by the influence of radio waves on humans and the environment (Hu et al., 2023; Natarajan et al., 2023). Unlike camera-based methods, CSI sensing provides user privacy by avoiding video recording and can

perform monitoring without wearables. Additionally, the accessibility of inexpensive IoT platforms (for example, ESP32 microcontrollers) has made the implementation of efficient CSI sensing systems possible.

Despite these advantages, accurately classifying human motion using Channel State Information (CSI) remains difficult. Many recent studies have employed deep learning techniques such as Convolutional Neural Network (CNN), owing to their feature extraction capabilities. However, the efficacy of deep learning models such as CNN in resource-limited IoT platforms and on customised CSI datasets needs to be analysed. Therefore, this research attempts to investigate the effectiveness of CNN-based human motion detection through a CSI dataset that is collected using an inexpensive IoT sensing platform based on ESP32. The current research aims to evaluate the practicality of privacy-centric smart home monitoring by combining low-cost IoT devices with deep learning–based CSI classification.

2.0 OBJECTIVE

1. To design and develop a Wi-Fi CSI-based motion detection system.
2. To implement machine learning algorithms that analyse CSI data for accuracy, precision, and recall for Wi-Fi CSI-based motion detection.
3. To demonstrate a real-time detection system that sends alerts or status updates to the user.

3.0 METHODOLOGY

The proposed device-free detection system works on the basis of two key phases, as displayed in Figure 1. The first phase is CNN model training, while the second phase is real-time motion detection. In general, the technique relies on changes in Channel State Information (CSI) caused by the Wi-Fi signal and uses it for the detection of human motion.

3.1 DATA GATHERING ON CSI AND CNN MODEL TRAINING

At this early stage, the problem is related to the construction of a deep learning framework for CSI pattern recognition. In the CSI measurement environment, UDP high-frequency data are emitted by a transmitter node, and a receiver node captures the measurements related to the CSI data. The collected CSI data contain subcarrier amplitude variations that depend on changes in the wireless channel environment due to the presence of humans. At the preprocessing stage, the raw signals from the CSI are transformed into signals containing meaningful subcarrier amplitude information. After that, the signals are segmented into appropriate windows and converted into two-dimensional tensors as the input data for the CNN.

Finally, the constructed dataset is used for CNN training when the network independently extracts features related to both motion and non-motion situations. At this stage, the accuracy of the model is estimated based on its validation accuracy. In case the validation accuracy does not exceed the predefined threshold (e.g., 90%), the training procedure is performed repeatedly until the required performance is achieved. When the desired level of accuracy is reached, the final model can be evaluated based on performance measures such as a confusion matrix.

3.2 REAL-TIME CSI-BASED MOTION DETECTION AND ALERTS SYSTEM

The second step involves applying the trained convolutional neural network (CNN) model to real-time sensing applications. Once the system starts, the trained model will be loaded into the sensor device. The receiver keeps collecting live CSI from the Wi-Fi channel, which is then followed by the process of pre-processing to convert the collected CSI into input data.

The pre-processed CSI data will be provided to the CNN inference unit, where the trained model will carry out real-time classification. Whether there is motion activity or not, it is determined using the collected CSI patterns. If no motion is detected, then the sensing process continues in a loop. In case of detecting motion activity, the system creates a notification alert that is sent via Telegram Bot API so users can get real-time notifications remotely. Once the notification has been sent, the system resumes the process of monitoring CSI.

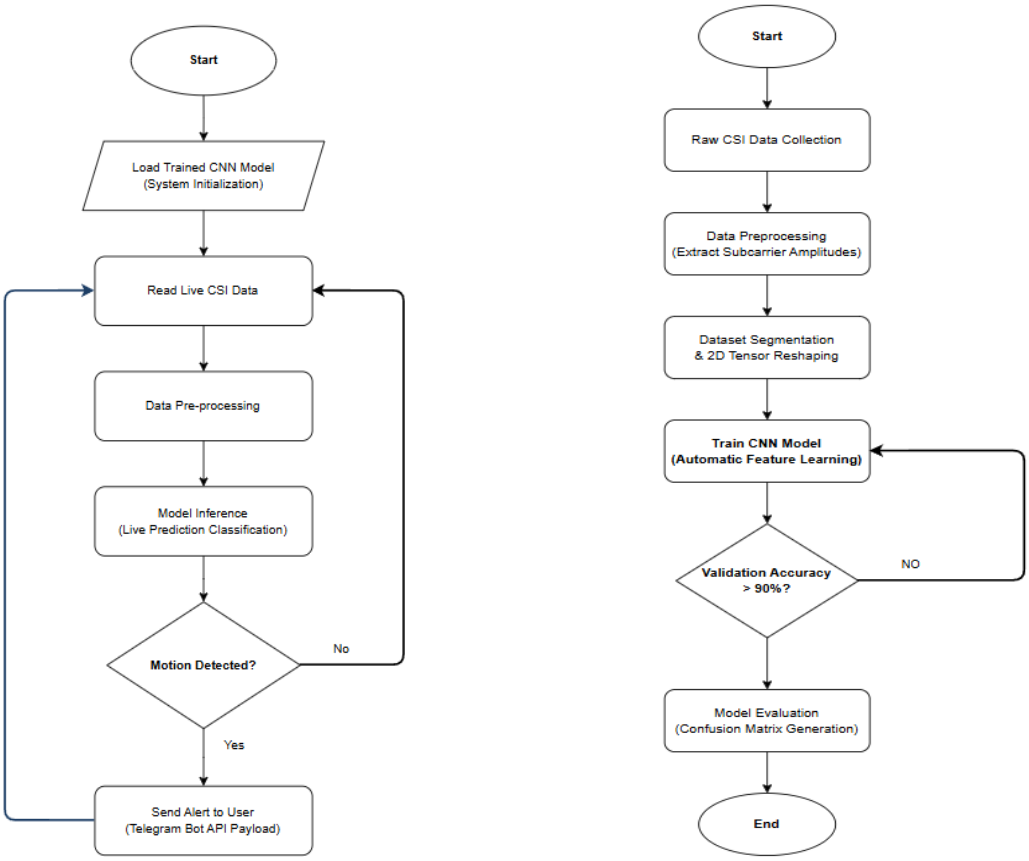


Figure 1: System block diagrams describing the CNN model training process (left) and the live real-time motion detection deployment pipeline (right).

4.0 RESULT

From the experimental assessments, it is evident that the proposed architecture is robust in the tested environments. Through the transformation of the variations in the amplitude for the 52 active subcarriers into the 2D form, the CNN is able to automatically recognise the discriminatory spatial-temporal patterns contained within the CSI. This approach reduces the dependence on manual design of the features and enables the identification of complex reflection patterns created by the activities of people.

Table 1: Classification model performance metrics comparison based on historical literature logs.

Classification Model	A	C	D
Proposed CNN Engine	In-House Physical Setup	100.00%	Optimal convergence reached by Epoch 3 with zero over-fitting.
Support Vector Machine (SVM)	Simulation Environment	97.66%	Outperformed deep variants on sparse datasets.
BLSTM-TCN Framework	Public UT-HAR Logs	98.80%	TCN layer was crucial to grasp temporal features

The proposed system achieved perfect classification performance on the test samples and was able to distinguish the motions caused by walking from those caused by static and respiratory micro-movements. The CNN architecture was able to identify frequency changes in the signal caused by Doppler effects during active movement, along with identifying amplitude changes due to static and breathing motions. Thus, the approach eliminates false alarms that occur in traditional IR sensing technologies.

5.0 CONCLUSION

From the experimental outcomes, the developed CNN classification framework successfully performs the task of discriminating the two conditions under investigation by means of detecting the discriminative patterns in changes in CSI amplitudes. Moreover, due to the ability of the model to automatically learn characteristics of signals, there is no need for feature extraction. This makes the system more adaptable to various indoor settings. Compared to traditional camera-based surveillance systems, SmartGuard-CSI provides significant benefits in terms of cost savings, privacy protection, easy installation, and flexibility of deployment.

In conclusion, the results obtained demonstrate the potential of Wi-Fi CSI sensing in combination with deep learning approaches as one of the promising alternatives for use in future smart living systems. The developed system represents a great step towards the creation of intelligent, non-intrusive, and inexpensive monitoring systems.

ACKNOWLEDGEMENT

Alhamdulillah, all praises to Allah S.W.T., the Most Gracious and Merciful, for granting me the strength to complete this research. I express my special gratitude to my supervisor, Dr. Noormadinah Binti Allias, for her guidance, constructive criticisms, and excellent suggestions throughout this project. Thank you also to my family and friends for their support along my journey.

REFERENCES

Bhavsar, M., K. Roy, J. Kelly & O. Olusola, 2023. Anomaly-based intrusion detection system for IoT application. Discover Internet of Things, 3 (1): 45-52. DOI: 10.1007/s43926-023-00034-5

Gorrepati, G., A.K. Sahoo & S.K. Udgata, 2023. WiFi Sensing Model for Intrusion Detection in Smart Home Environment. Proceedings of IEEE Region 10 Humanitarian Technology Conference, R10-HTC, IEEE Xplore Press, USA, pp: 329–334. DOI: 10.1109/R10-HTC57504.2023.10461789

Hu, P., W. Liu, C. Yang, Y. Sun & J. Li, 2023. WiFi CSI Based Passive Human Activity Recognition Method Using BLSTM-CNN. Proceedings of the International Conference on Communication Technology, ICCT, IEEE Xplore Press, USA, pp: 210–215. DOI: 10.1109/ICCT59356.2023.10419414

Natarajan, A., V. Krishnasamy & M. Singh, 2023. A Machine Learning Approach to Passive Human Motion Detection Using WiFi Measurements From Commodity IoT Devices. IEEE Transactions on Instrumentation and Measurement, 72: 1-11. DOI: 10.1109/TIM.2023.3272374

SLECARE: EXPLAINABLE AI DECISION SUPPORT FOR LUPUS NEPHRITIS RISK PREDICTION

Muhammad Izzul Islam Bin Faisal[1,*], Muhammad Ezairiel Azieq Bin Shahromnizal[1], Shahnorbanun Binti Sahran[1], Syahrul Sazliyana Shaharir[2]

[1]Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
[2]Faculty of Medicine, Universiti Kebangsaan Malaysia / Hospital Canselor Tuanku Muhriz, 56000 Cheras, Kuala Lumpur, Malaysia

[*]Corresponding author: A200263@siswa.ukm.edu.my

ABSTRACT

Lupus nephritis is a severe renal manifestation of systemic lupus erythematosus that can lead to chronic kidney disease, kidney failure, delayed remission, and irreversible organ damage. Early patient-level risk review remains difficult because relevant signals are fragmented across laboratory results, biopsy findings, treatment timing, demographic characteristics, and kidney-function trends. SLECare addresses this gap through a Malaysian lupus nephritis-specific explainable artificial intelligence decision-support system that integrates dual-outcome risk prediction, patient-level explanation, prioritisation, and longitudinal review within one clinician-facing workflow. SLECare was developed from 212 biopsy-confirmed proliferative lupus nephritis episodes involving 145 patients treated at Hospital Canselor Tuanku Muhriz between 2000 and 2020. Conventional machine learning and ensemble models were benchmarked across baseline, six-month, and twelve-month scenarios to predict kidney damage, represented by chronic kidney disease, and delayed remission. SHapley Additive exPlanations identified cohort-level and patient-specific risk drivers, while dependence plots revealed clinically interpretable model transition points. The strongest kidney-damage configuration, a six-month stacked ensemble, achieved precision 0.77, recall 0.83, and F1-score 0.80; the strongest delayed-remission configuration, a twelve-month CatBoost model, achieved precision 0.81, recall 0.74, and F1-score 0.77. Baseline creatinine shifted from a negative to a positive CKD-risk contribution at approximately 80 µmol/L and became strongly positive above 100 µmol/L. Treatment intervals of 0–2 months supported remission, whereas intervals exceeding three months shifted the model toward positive delayed remission risk. The functional dashboard supports cohort overview, individual risk assessment, high-risk prioritisation, patient timelines, global risk-driver review, and research export. Its clinical relevance, explainable findings, and specialist workflow were validated by the project's rheumatology stakeholder at HCTM. Using routinely collected hospital data and software rather than new diagnostic hardware, SLECare provides a scalable pathway from controlled hospital pilot evaluation to institutional licensing through the applicable regulatory process.

Keywords: lupus nephritis, explainable artificial intelligence, clinical decision support, machine learning, risk prediction

1.0 INTRODUCTION

Lupus nephritis is one of the most serious manifestations of systemic lupus erythematosus and may progress to chronic kidney disease, kidney failure, delayed remission, and irreversible organ damage. Approximately 40–60% of patients with systemic lupus erythematosus may develop renal involvement, making earlier recognition of higher-risk disease important for closer monitoring and specialist review (KDIGO Lupus Nephritis Work Group, 2024; Mohd et al., 2026). Risk assessment remains difficult because disease progression varies between patients and clinically relevant signals are distributed across laboratory results, biopsy findings, treatment history, asnd multiple follow-up time points (KDIGO Lupus Nephritis Work Group, 2024). Clinicians must manually synthesise these fragmented data, making review time-consuming, experience-dependent, and difficult to standardise. Existing analyses are rarely translated into one integrated workflow that predicts two major outcomes, explains individual risk, and prioritises patients for review. SLECare addresses this gap as a locally grounded explainable-AI decision-support prototype for rheumatology and nephrology workflows. It combines kidney-damage

and delayed-remission prediction with patient-specific explanations, high-risk prioritisation, longitudinal review, cohort-level risk-driver visualisation, and research export. The innovation is therefore positioned as a usable clinical workflow rather than a standalone algorithm.

2.0 OBJECTIVE

1. To develop and evaluate dual-outcome models for kidney-damage and delayed-remission risk among Malaysian lupus nephritis patients.
2. To evaluate the models across baseline, six-month, and twelve-month scenarios and generate global, patient-specific, and SHAP dependence-plot analyses.
3. To translate the validated modelling and explainability workflow into a functional clinician-facing prototype for risk assessment, prioritisation, longitudinal monitoring, and research reporting.

3.0 METHODOLOGY

3.1 PRODUCT DEVELOPMENT WORKFLOW

The source cohort comprised 212 biopsy-confirmed proliferative lupus nephritis episodes among 145 patients treated at Hospital Canselor Tuanku Muhriz (HCTM) between 2000 and 2020 (Mohd et al., 2026). Approximately 74 demographic, clinical, laboratory, biopsy, treatment, and outcome variables were available before outcome-specific preprocessing. Identifiers, constant variables, and post-outcome fields that could encode future information were removed. After stratified train-test splitting, numerical missing values were imputed with training-set medians, while selected categorical missing values were encoded using clinically guided categories. Feature engineering and recursive feature elimination were then applied. The baseline scenario used pre-treatment variables only; the six-month scenario added early follow-up variables; and the twelve-month scenario used baseline, three-month, and six-month variables. Held-out performance was evaluated using precision, recall, and F1-score. Figure 1 summarises the complete data-to-dashboard workflow.

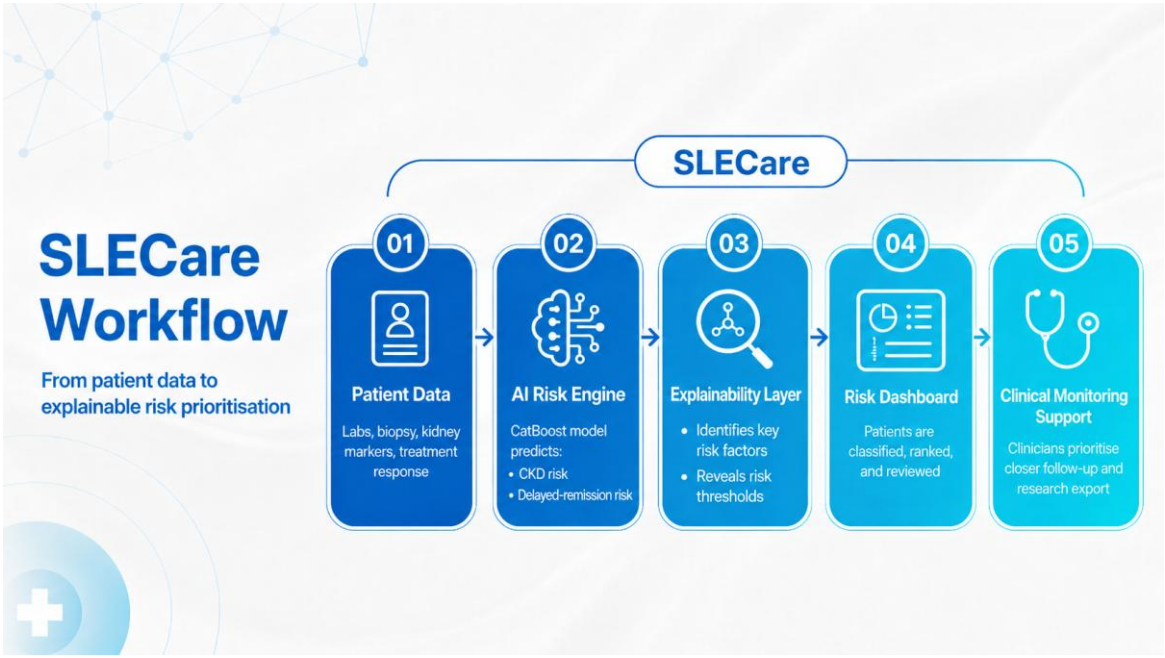


Figure 1: SLECare workflow from patient data to explainable risk prioritisation.

3.2 EXPLAINABLE AI RISK PREDICTION

The risk engine predicts kidney damage, represented by chronic kidney disease (CKD), and delayed remission. SHAP outputs were translated into clinically meaningful statements showing whether each factor increased CKD risk, supported remission, or shifted the prediction toward delayed remission. CatBoost was selected as the primary clinical-facing model because it combined strong performance with explanations linked directly to original clinical variables (Prokhorenkova et al., 2018); conventional machine learning and ensemble approaches were retained as benchmarks. SHAP was applied at three levels: global analysis ranked influential cohort-level variables, local analysis explained individual predictions, and dependence analysis examined how feature contributions changed across observed values to identify model-derived transition points (Lundberg & Lee, 2017). These transition points and their clinical interpretation were reviewed and validated by the project's rheumatology stakeholder, Prof. Syahrul Sazliyana Shaharir of HCTM. SLECare therefore presents each risk estimate with its principal contributing factors and relevant value ranges, while preserving clinician judgement.

3.3 DASHBOARD FUNCTIONALITY AND PRACTICAL USE

Prediction and explanation outputs were implemented in a functional clinician-researcher dashboard developed with clinical expert guidance. Its six core components are Cohort Overview, Patient Risk Assessment, High-Risk Patient Prioritisation, Patient Timeline, Global Risk Drivers, and Research Export. Together, they support population review, individual dual-outcome assessment, patient-specific explanation, prioritised follow-up review, longitudinal monitoring, and structured research reporting. SLECare is a clinician-controlled decision-support system, not an autonomous diagnostic or treatment-recommendation system, and is positioned for controlled hospital pilot evaluation.

4.0 RESULTS

4.1 PREDICTIVE PERFORMANCE AND EXPLAINABLE FINDINGS

In terms of machine learning model performance, the strongest configured CKD and delayed-remission models achieved F1-scores of 0.80 and 0.77, respectively. Figure 2 shows how CatBoost translates key clinical variables into interpretable risk contributions.

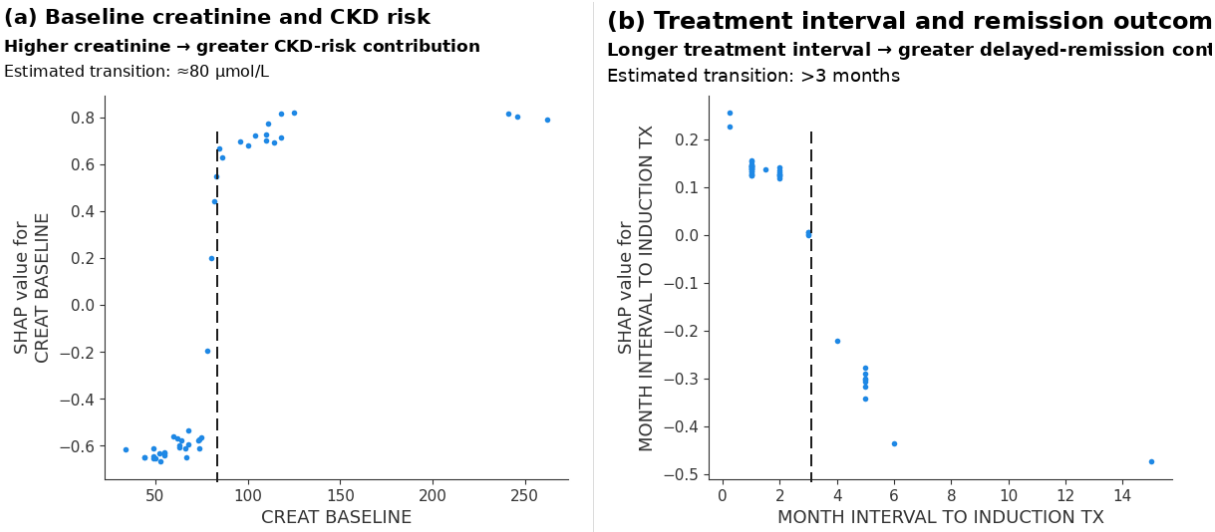


Figure 2: SHAP dependence plots showing how baseline creatinine contributes to CKD-risk prediction and how treatment timing contributes to remission outcome.

CatBoost was selected for the clinical-facing system because it combines strong performance with direct patient-specific SHAP explanations. Baseline creatinine shifted the model toward CKD risk at approximately 80 µmol/L and contributed strongly above 100 µmol/L. Longer treatment intervals increased delayed-remission contribution, with the transition occurring beyond three months. These findings were clinically validated by Prof. Syahrul Sazliyana Shaharir of HCTM. Other prominent signals included Malay ethnicity and positive lupus anticoagulant for CKD, and existing CKD and greater global sclerosis for delayed remission.

4.2 FUNCTIONAL PROTOTYPE AND CLINICAL ADVANTAGE

Compared with fragmented manual review, SLECare unifies cohort review, dual-outcome risk assessment, patient-specific explanations, high-risk prioritisation, longitudinal monitoring, and global risk-driver analysis within a single clinician-facing workflow. This enables clinicians to identify which patients may require closer attention, understand the factors driving each risk estimate, and review disease progression without moving between disconnected analytical steps. The functional prototype was designed around a clinician-researcher workflow, with traceable model outputs and explicit decision-support safeguards that preserve clinical judgement. Figure 3 presents the integrated SLECare prototype.

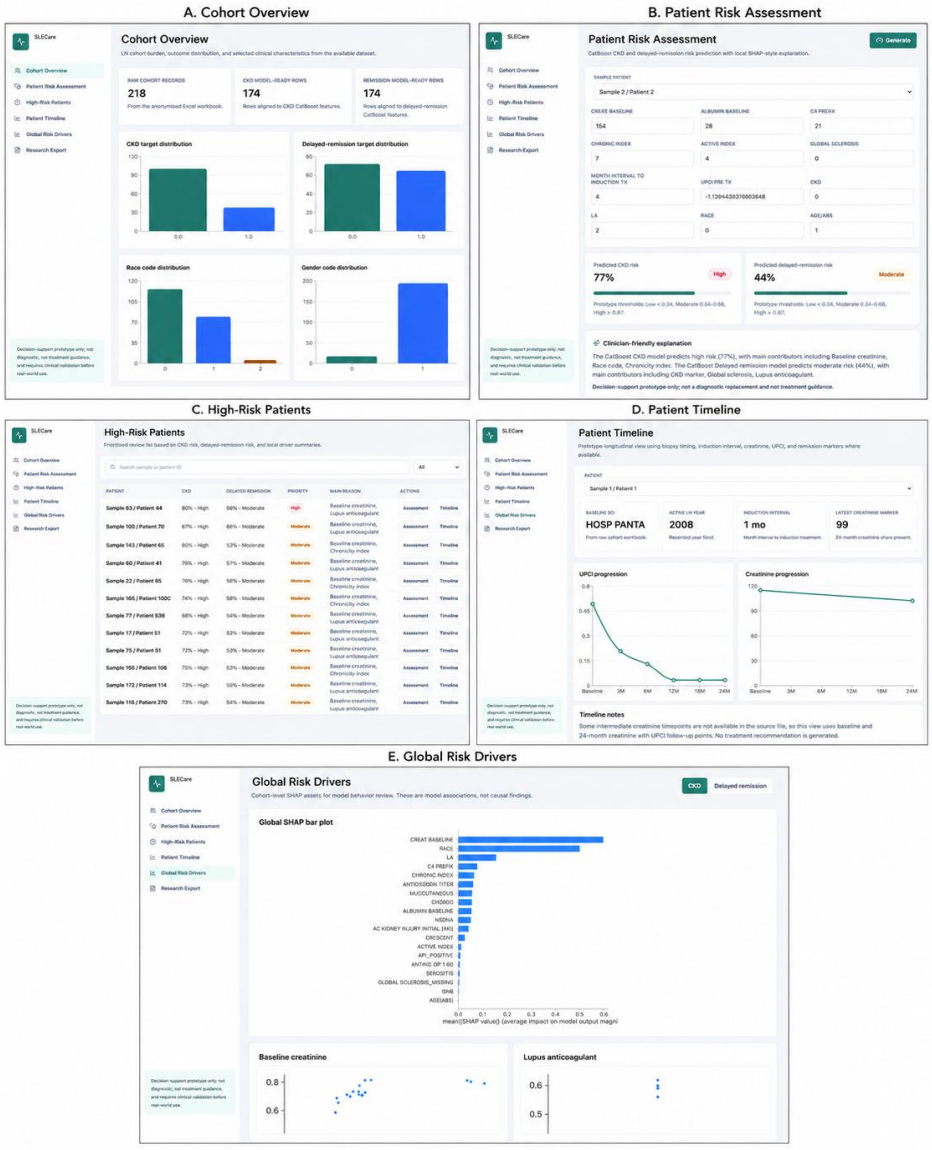


Figure 3: SLECare's integrated clinician-facing workflow comprising cohort overview, individual risk assessment, high-risk patient prioritisation, patient timeline, and global risk-driver analysis.

4.3 NOVELTY, SUSTAINABILITY, READINESS, AND COMMERCIAL POTENTIAL

SLECare's novelty is the integration of Malaysian lupus nephritis data, dual-outcome prediction, longitudinal scenarios, global and local SHAP explanations, clinically validated transition points, and a functional specialist workflow. Sustainability and health-system resilience are supported through routine hospital data and software rather than new diagnostic hardware, enabling limited specialist capacity to be directed toward higher-risk patients. The intended users are rheumatology and nephrology clinical teams; institutional buyers are tertiary hospitals and academic medical centres. SLECare is a stakeholder-validated functional prototype positioned for a secure hospital pilot and is progressing through the applicable Medical Device Authority pathway (Medical Device Authority, 2026). Its commercial route is pilot evaluation followed by institutional licensing after prospective performance assessment, calibration, fairness, governance, and regulatory review. External credibility of SLECare is demonstrated by winning the Grand Winner, Gold Award, and Best Research Presentation awards at the International Innovation and Research Competition (INNOVERSE) 2026, an INOVASI RICH Gold Medal, and the Best Clinical Project Award at the 17th Medical Undergraduates' Annual Scientific Research Meeting (MUASRM). The research underpinning SLECare was also accepted for presentation and publication at the 28th Asia Pacific League of Associations for Rheumatology Congress (APLAR) 2026.

5.0 CONCLUSION

SLECare transforms routine Malaysian lupus nephritis data into explainable patient-level decision support for kidney damage and delayed remission. The strongest configurations achieved F1-scores of 0.80 and 0.77, while CatBoost offered the best clinical-facing balance of performance and direct SHAP interpretability. Its key contribution is the integration of dual-outcome modelling, clinically validated transition points, patient-specific explanation, risk prioritisation, and longitudinal monitoring within one functional dashboard. The stakeholder-validated prototype uses routine data and software rather than new diagnostic hardware, providing a scalable foundation for controlled hospital pilot evaluation and progression toward institutional licensing through the applicable governance and regulatory pathway.

ACKNOWLEDGEMENT

The authors thank Universiti Kebangsaan Malaysia, HCTM, the Faculty of Information Science and Technology, and the Faculty of Medicine for supporting the research and prototype development, facilitating access to de-identified clinical data, and providing academic and clinical expert guidance.

REFERENCES

Kidney Disease: Improving Global Outcomes (KDIGO) Lupus Nephritis Work Group. (2024). KDIGO 2024 Clinical Practice Guideline for the management of lupus nephritis. *Kidney International, 105*(1S), S1–S69. https://doi.org/10.1016/j.kint.2023.09.002

Lundberg, S. M., & Lee, S.-I. (2017). A unified approach to interpreting model predictions. *Advances in Neural Information Processing Systems, 30*, 4765–4774. https://papers.neurips.cc/paper_files/paper/2017/hash/8a20a8621978632d76c43dfd28b67767-Abstract.html

Medical Device Authority. (2026). *Guidance documents under the Medical Device Act 2012 (Act 737)*. Ministry of Health Malaysia. https://www.mda.gov.my/index.php/doc-list/guidance-document

Mohd, R., Abdul Rahaman, N. S. I., Kamaruzaman, L., Wan Daud, W. R., Abu Shamsi, M. Y., Lim, K. Y., Mustafar, R., Abdul Gafor, A. H., & Shaharir, S. S. (2026). Clinical and biochemical factors associated with delayed renal response in proliferative lupus nephritis: A 20-year single-center multiethnic cohort study. *Biomedicines, 14*(3), 512. https://doi.org/10.3390/biomedicines14030512

Prokhorenkova, L., Gusev, G., Vorobev, A., Dorogush, A. V., & Gulin, A. (2018). CatBoost: Unbiased boosting with categorical features. *Advances in Neural Information Processing Systems, 31*, 6638–6648.

THE INNOVATIVE AUTO-CATALYTIC PERACID EPOXIDATION OF NEEM OIL

Anas Shah Malik Bin Zainal, Wan Muhammad Basysyar*, Mohd Jumain Jalil, Intan Suhada Azmi, Norfazillah Abdullah

Faculty of Chemical Engineering, Universiti Teknologi MARA Cawangan Johor, Kampus Pasir Gudang, Masai, Johor

* Corresponding author: mjumain0686@uitm.edu.my

ABSTRACT

This study investigated the auto-catalytic in situ performic acid epoxidation of crude neem oil *(Azadirachta Indica)* using formic acid and hydrogen peroxide without mineral acid catalysts. The raw neem oil contained a high proportion of unsaturated fatty acids, mainly oleic and linoleic acids providing abundant double bonds for oxirane ring formation. Reaction kinetics were monitored using hydrobromic acid titration to measure oxirane content over time. The reaction achieved its peak oxirane conversion within the first ten minutes due to rapid initial epoxidation. however, extended exposure to high heat and the acidic environment triggered severe oxirane ring opening through acid-catalyzed hydrolysis, causing a continuous drop in epoxy yield over the remaining reaction time. These result show that a short reaction duration is crucial to maximise epoxy yield before thermal and acidic degradation dominates.

Keywords: neem oil, epoxidation, oxirane ring

1.0 INTRODUCTION

The declining availability of petrochemical reserves, coupled with environmental concerns surrounding synthetic polymer toxicity and non-biodegradability, has driven substantial research toward sustainable, bio-based alternatives derived from renewable agricultural resources. Plant-derived precursors in the synthesis of bioplastics, bio-lubricants, polyols, and resin plasticizers. Among non-edible plant oils, crude neem oil *(Azadirachta Indica)* is particularly attractive because its utilization does not compete directly with human food supplies or agricultural land allocation for edible oil crops.

The chemical utility of neem oil is governed by the presence of unsaturated ethylenic carbon-carbon double bonds *(c=c)* along its fatty acid hydrocarbon chains. Through electrophilic addition, these double bonds can be functionalised addition, these double bonds can be functionalised into reactive three-membered oxirane rings via peracid epoxidation. Epoxidized vegetable oils serve as critical platform chemical intermediates; their high oxirane reactivity enables further functionalisation into polyols, glycol esters, and thermoset networks. Industrially, the epoxidation of vegetable oils is most carried out via the Prilezhaev reaction mechanism. In this approach, organic peracids such as performic or peracetic acid are generated *in situ* within an aqueous organic biphasic system by reacting short chain carboxylic acids with hydrogen peroxide (Santacesaria et al., 2020).

While mineral acid catalysts such as sulfuric acid are traditionally introduced to accelerate peracid formation, they frequently induce localised over-acidification, accelerating undesirable oxirane ring opening side reactions that destroy epoxy yield. Auto-catalytic epoxidation, which relies exclusively on the intrinsic acidity of formic acid, eliminates the need for strong mineral acids while offering a safer and cleaner reaction system. However, the kinetics of auto-catalytic systems remain sensitive to operational parameters such as temperature, mixing speed, reactant dosing, and residence time. High temperatures and prolonged reaction times can shift the reaction pathway from primary oxirane synthesis to secondary ring opening, producing dihydroxystearic acid ($DHSA$) and oligomeric byproducts (Rasib et al., 2025).

This study evaluates the kinetic evolution of oxirane formation and degradation during the auto-catalytic *in situ* performic acid epoxidation of crude neem oil. Operating at 75 °C and 700 RPM with a 1:1 molar ratio of formic acid to hydrogen peroxide, this work quantifies the experimental oxirane oxygen content (OOC_{exp}) and relative conversion to oxirane (RCO) at regular intervals over a 60-minute reaction period to identify the critical residence time threshold for maximising epoxy yield.

2.0 OBJECTIVE

1. Investigate the kinetics of oxirane ring formation and secondary ring-opening degradation during the auto-catalytic *in situ* performic acid epoxidation of crude neem oil without using mineral acid catalyst.
2. Measure the experimental oxirane oxygen content and relative conversion to oxirane (RCO) at regular intervals over a 60-minute reaction period at 75°C and 700 RPM.
3. Identify the critical reaction duration needed to maximize epoxy yield before thermal energy and acid-catalyzed hydrolysis cause severe epoxy degradation.

3.0 METHODOLOGY

The auto-catalytic epoxidation of crude neem oil was performed using standard laboratory glassware placed in a regulated heating bath. Crude neem oil served as the main starting material, supplying the necessary carbon-carbon double bonds from its unsaturated fatty acids. Formic acid was used as the organic oxygen carrier and intrinsic catalyst, combined with 50 wt% hydrogen peroxide as the oxygen donor at a 1.0:1.0 molar ratio. The mixture was heated to a constant temperature of 75°C and stirred continuously at 700 RPM using a magnetic stirrer to ensure proper mixing. Hydrogen peroxide was added gradually in small increments to control the reaction heat and prevent rapid temperature spikes. The reaction was run for a total time of 60 minutes.

To monitor the oxirane content over time, samples were collected at regular intervals and analyzed following AOS Official Method Cd 9-57 via hydrobromic acid titration. For each measurement, 3 g of the reaction sample was mixed with 10 mL of glacial acetic acid. The mixture was titrated with hydrobromic acid (HBr) using crystal violet indicator until a greenish-yellow endpoint appeared. The experimental oxirane oxygen content was then calculated to determine the relative conversion to oxirane percentage throughout the 60-minute process.

3.1 CHEMICALS AND MATERIALS

Neem oil was the primary material in the epoxidation reaction, serving as the base material or substrate. Hydrogen peroxide (1:1 mol, 50%) was the oxidising agent in the reaction, and formic acid (1:1) acted as the oxygen carrier for the in-situ generation of performic acid. Hydrogen bromide was the catalyst used in this process, accelerating the epoxidation reaction rate. Crystal violet was used as the oxirane oxygen indicator, and methanol (1:1) was the solvent in the analysis and titration processes, as shown in Table 1.

Table 1 List of chemicals

Name of Chemicals	Chemical formula	Molecular weight (g/mol)
Hydrogen Peroxide (50%)	H_2O_2	34.01
Formic Acid	CH_2O_2	46.025
Hydrogen Bromide (48-50%)	HBr	80.91
Crystal Violet	$C_{25}N_3H_{30}Cl$	407.98

3.2 IN SITU AUTO CATALYTIC PERFORMIC ACID EPOXIDATION EXPERIMENTAL SETUP

The liquid-phase epoxidation reaction was conducted in a biphasic reactor system operating under auto-catalytic peracid conditions without the addition of inorganic mineral acid catalysts such as sulfuric acid. Formic acid was employed as the organic oxygen carrier at a concentration of 2.6393 wt% relative to the oil phase, while 50 wt% hydrogen peroxide served as the primary oxygen donor. The stoichiometric reactants were proportioned to maintain a hydrogen peroxide molar ratio of 1.0 and a formic acid oxygen carrier molar ratio of 1.0. Reaction conditions were fixed at a stirring speed of 700 RPM to eliminate liquid-liquid interphase mass transfer limitations and a constant reaction temperature of 75 °C maintained via a regulated heating bath. To prevent rapid exothermic thermal runaways and

control peracid decomposition, hydrogen peroxide was introduced into the mixture gradually in small increments ("small amount of HP"). The total duration of the epoxidation process was maintained for 60 minutes.

3.3 RELATIVE CONVERSION OXIRANE (RCO)

The oxirane oxygen content (OOC) was determined by titrating epoxy groups with HBr in glacial acetic acid according to the AOCS Official Method Cd 9-57. This test examined the effects of processing variables on the reaction rate and yield of epoxidized neem oil. OOC was determined by adding a sample containing 3 g of the sample in combination with 10 mL of acetic acid to an Erlenmeyer flask. Titration with HBr was continued until a greenish-yellow colour appeared. The relative conversion of oxirane (RCO) was determined using the theoretical and experimental OOC values.

In this equation, X_o is the initial value of iodine, A_o is the molar mass of oxygen, N is the normality of HBr, and V is the volume of HBr used for blank analysis in millilitres (mL), and W is the weight for the sample. Equations 1, 2, and 3 are the equations for RCO, OOC theoretical, and OOC experimental, respectively.

$$RCO = \frac{RCO_{experimental}}{OOC_{theoretical}} X\ 100 \quad (1)$$

$$OOC_{theoretical} = \left\{ \frac{\frac{X_O}{A_i}}{\left[100 + \left(\frac{X_O}{2A_i}\right)(A_O)\right]} \right\} X\ A_O\ X\ 100 \quad (2)$$

$$OOC_{experimental} = 1.6\ X\ N\ X\ \frac{(V-B)}{W} \quad (3)$$

4.0 RESULT

Increasing the reaction temperature significantly accelerates the forward rate constant *(k)* for uncatalyzed formation of oxirane rings, thereby yielding peak oxirane oxygen content (~18.7% RCO); nevertheless, due to the thermodynamic instability of the strained three-membered epoxy ring, sustained high heat subsequently favours ring cleavage and degradation mechanism, resulting in a pronounced decline in RCO percentage beyond the optimal reaction period.

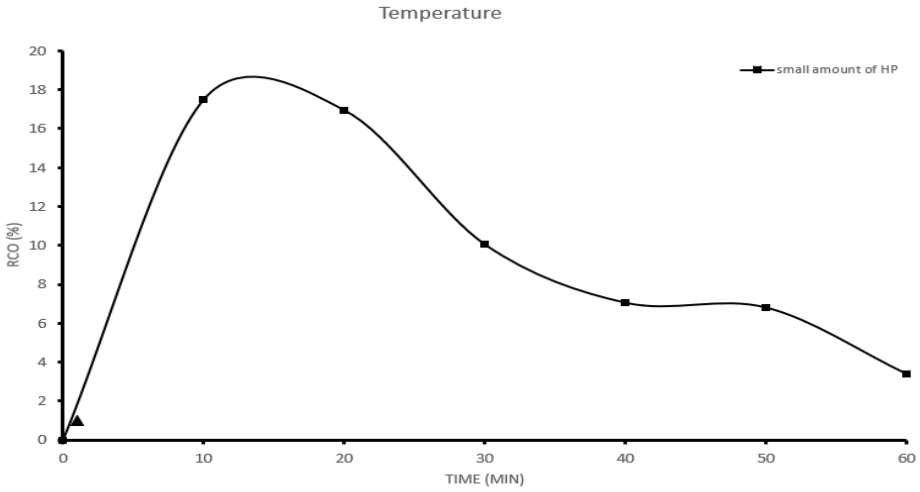


Figure 1: illustrates the time-dependent oxirane conversion profile of uncatalyzed neem oil epoxidation at operating temperatures (75 °C).

In the absence of an added heterogeneous or mineral acid catalyst, the system undergoes an autocatalytic epoxidation process where formic acid ($HCOOH$) acts as both the oxygen carrier and an acid catalyst. Formic acid reacts in situ with hydrogen peroxide (H_2O_2) to generate performic acid ($HCOOOH$), which subsequently transfers active oxygen to the double bonds ($C = C$) of neem oil to form oxirane rings. Because excess formic acid remains unconsumed throughout the cyclic reaction, its intrinsic acidity continuously catalyses both the in situ peracid generation and the kinetic rate of epoxidation without requiring an external catalyst (Ahamad & Abdulrahim, 2025).

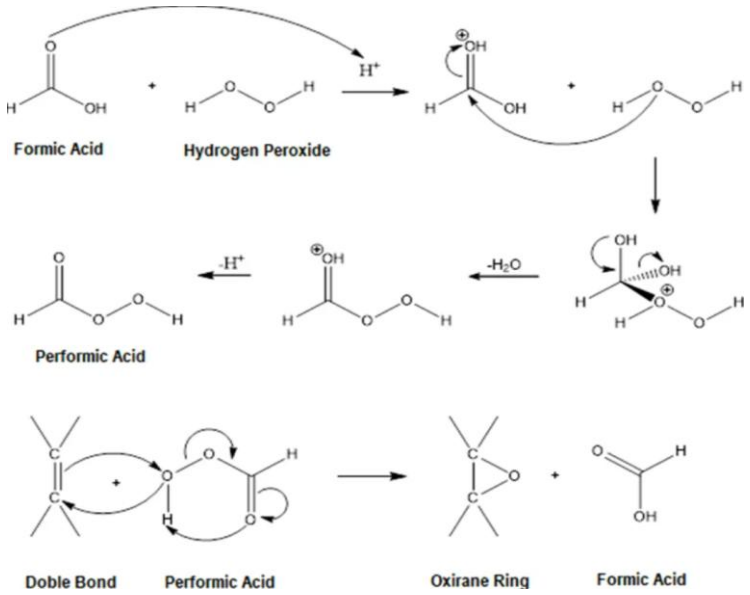


Figure 2: proposes a reaction mechanism for the uncatalytic, in situ peracid epoxidation of neem oil via the Prilezhaev (butterfly) route (Gunawan et al., 2023)

5.0 CONCLUSION

This study investigated the kinetics of auto-catalytic *in situ* performic acid epoxidation of crude neem oil (*Azadirachta indica*) under un-catalyzed acidic conditions at 75 °C and 700 RPM. The findings confirm that while auto-catalytic performic acid generation efficiently initiates primary epoxidation across unsaturated fatty acid double bonds, high thermal energy accelerates secondary oxirane ring opening reactions. A peak relative oxirane conversion (RCO) of 17.51% ($OOC_{exp} = 0.9338\ wt\%$) was achieved at a critical reaction residence time of 10 minutes. Extended reaction times beyond 10 minutes resulted in severe epoxy degradation due to acid-catalyzed ring hydrolysis, lowering the final RCO to 3.38% ($OOC_{exp} = 0.1803\ wt\%$) after 60 minutes. These insights demonstrate that maximising oxirane yield requires precise control over residence time and lower operating temperatures (45–50 °C). Alternatively, conducting the reaction at 75 °C for 60 minutes offers an effective single-pot strategy for producing hydroxylated biopolyol precursors and dihydroxystearic acid ($DHSA$).

ACKNOWLEDGEMENT

Special thanks to the Faculty of Chemical Engineering, Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang for providing the necessary laboratory facilities and resources.

REFERENCES

Ahamad, M. K. F., & Abdulrahim, K. bin. (2025). OPTIMIZATION OF TILT ANGLE FOR FIXED TILT SOLAR PV SYSTEM: CASE STUDY FOR USIM, NILAI, NEGERI SEMBILAN. *Journal of Engineering and Technology (JET)*, *16*(1), 1–14. https://doi.org/10.54554/jet.2025.16.1.001

Gunawan, E. R., Suhendra, D., Arimanda, P., Asnawati, D., & Murniati. (2023). Epoxidation of Terminalia catappa L. Seed oil: Optimization reaction. *South African Journal of Chemical Engineering*, *43*, 128–134. https://doi.org/10.1016/j.sajce.2022.10.011

Rasib, I. M., Jalil, M. J., Mubarak, N. M., & Azmi, I. S. (2025). Hybrid in-situ and ex-situ hydrolysis of catalytic epoxidation neem oil via a peracid mechanism. *Scientific Reports*, *15*(1). https://doi.org/10.1038/s41598-024-84541-7

Santacesaria, E., Turco, R., Russo, V., Tesser, R., & Di, M. (2020). Soybean oil epoxidation: Kinetics of the epoxide ring opening reactions. *Processes*, *8*(9). https://doi.org/10.3390/PR8091134

SMART GESTURE-CONTROLLED HOME SYSTEM

Lim Jie Lyn[1,*], Leong Kai Yong[1], Kok Yi Hen[1], Shaffika Bte Mohd Suhaimi[1], Renuka Nalinggam[1]

[1]Southern University College (SUC), PTD 64888, KM15, Jalan Skudai, 81300 Skudai, Johor, Malaysia

[*]Corresponding author: b250053a@sc.edu.my

ABSTRACT

Malaysia's population aged 65 years and above increased to 8.0% in 2025, highlighting the growing need for accessible and user-friendly smart home technologies that support independent living among older adults. Conventional home control methods rely on wall switches, multiple remote controls, voice commands, or text-based mobile interfaces, which may be inconvenient for elderly users with limited mobility, reduced physical strength, hand tremors, visual impairments, or difficulty understanding complex interfaces. Therefore, a more intuitive, touchless, and elderly-friendly home control solution is required. The Smart Gesture-Controlled Home System is proposed as a mobile application-based home automation prototype that enables users to operate virtual home appliances through predefined hand gestures captured using a camera-based gesture recognition interface. The objective of this project is to improve convenience and accessibility by allowing users to control appliances such as lights, fans, and televisions without physical contact. The proposed system provides an icon-based appliance selection interface followed by gesture execution through the smartphone camera, where captured gestures are processed through image acquisition, hand detection, feature extraction, and gesture recognition before being translated into corresponding appliance commands. To further enhance accessibility, the system can also be deployed on a large Smart Display (Smart Home Hub) as an alternative interaction device, providing a larger user interface, fixed camera positioning for improved gesture detection, hands-free operation, and continuous monitoring for bedridden elderly users, wheelchair users, and elderly care environments. By centralising multiple appliance controls into a single application, the proposed innovation reduces dependence on physical switches, multiple remote controls, and voice commands while promoting a more natural human-computer interaction experience. In conclusion, this project offers a practical and accessible smart home solution that improves the quality of life for elderly users and provides a foundation for future integration with real Internet of Things (IoT) home automation systems.

Keywords: gesture recognition, smart home, mobile application, elderly users, touchless interaction

1.0 INTRODUCTION

The Smart Gesture-Controlled Home System is designed to provide an intuitive human-computer interaction method for controlling home appliances. Existing smart home solutions commonly depend on physical switches, multiple remote controls, voice assistants, or mobile applications, which may not always be suitable for elderly users, individuals with disabilities, or environments where voice interaction is impractical. The proposed solution addresses these limitations by introducing AI-based gesture recognition that allows users to interact naturally without physical contact. The system also supports a manual touch interface as an alternative interaction method, improving reliability, accessibility, and overall usability.

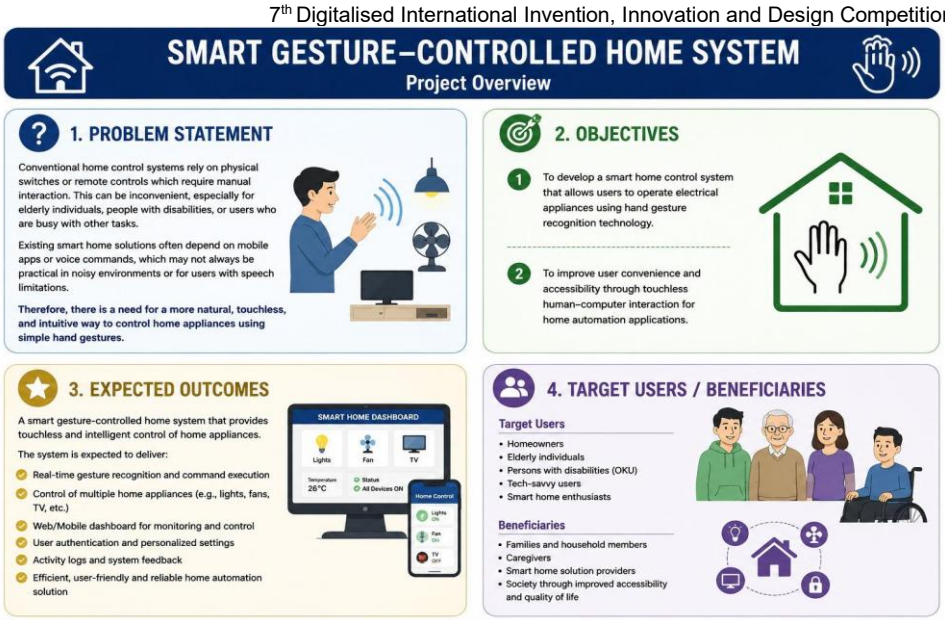


Figure 1: Project overview of the Smart Gesture-Controlled Home System

2.0 OBJECTIVE

The objectives of this project are:

1. To develop a smart home control system that allows users to operate electrical appliances using AI-based hand gesture recognition.
2. To improve user convenience, accessibility, and human-computer interaction through touchless control while providing an optional manual interface for greater usability.
3. To establish a scalable software architecture that supports cloud storage, monitoring, analytics, and future IoT integration.

3.0 METHODOLOGY

This section describes the methodology and system design approach of the proposed Smart Gesture-Controlled Home System. The project adopts a user-centred and accessibility-focused approach by integrating computer vision, gesture recognition, and smart home interaction techniques to provide a touchless appliance control experience for elderly users. The proposed system consists of several stages, including user profile selection, onboarding tutorial, appliance selection, camera-based gesture input, gesture processing, command mapping, and appliance status feedback. Users can select a virtual appliance such as a light, fan, or television through an icon-based interface before performing predefined hand gestures captured through a camera. The captured gesture data is processed through image acquisition, hand detection, feature extraction, and gesture recognition techniques before being converted into corresponding appliance control commands. In addition, accessibility features such as adjustable text sizes, high-contrast display modes, multilingual support, and manual control alternatives are incorporated to improve usability for elderly users and individuals with disabilities. Besides the mobile application, the system also proposes deployment on a large Smart Display (Smart Home Hub) as an alternative interaction device, providing a larger interface, fixed camera positioning, hands-free operation, and improved accessibility for users with limited mobility, wheelchair users, bedridden elderly users, and elderly care environments.

3.1 SYSTEM CONCEPT AND USER FLOW

The proposed system follows a mobile-first approach. The user opens the application, selects a virtual appliance such as a light, fan, or television, and performs a fixed hand gesture in front of the phone camera. The system captures the gesture input, recognises the gesture pattern, and maps the recognised gesture to a specific appliance command. If the gesture is valid, the virtual appliance changes its status; if the gesture is incorrect, the system can display an error or feedback message.

3.2 GESTURE COMMAND MAPPING

Fixed gestures are used instead of customised gestures to keep development manageable and make the system easier for elderly users to learn. The initial command mapping is shown in Table 1.

Table 1: Proposed fixed gesture command mapping for the prototype

Gesture	Appliance	Mapped Action
Hand Gesture Number 1	Light	Light selected to be controlled
Hand Gesture Number 2	Fan	Fan selected to be controlled
Hand Gesture Number 3	TV	TV selected to be controlled
Swipe Right	All Appliances	Turn ON selected appliances
Swipe Left	All Appliances	Turn OFF selected appliances
Swipe Up	Light	Increase the light brightness
Swipe Down	Light	Decrease the light brightness
Swipe Up	Fan	Increase fan speed
Swipe Down	Fan	Decrease fan speed
Swipe Up	TV	Increase volume
Swipe Down	TV	Decrease volume
Right Arc Swipe	TV	Change to the next channel
Left Arc Swipe	TV	Change to the previous channel

3.3 SOFTWARE ARCHITECTURE

The system architecture is designed as a software-based pipeline. First, the phone camera captures the hand gesture. Then, input processing is performed through image acquisition, pre-processing, hand detection, and feature extraction. The intelligent processing stage classifies the gesture and checks the confidence scoring before the action interpreter maps it to the intended appliance command. The command execution stage controls the virtual appliance, while the user interface displays the control panel, status monitoring, gesture feedback, and system logs.

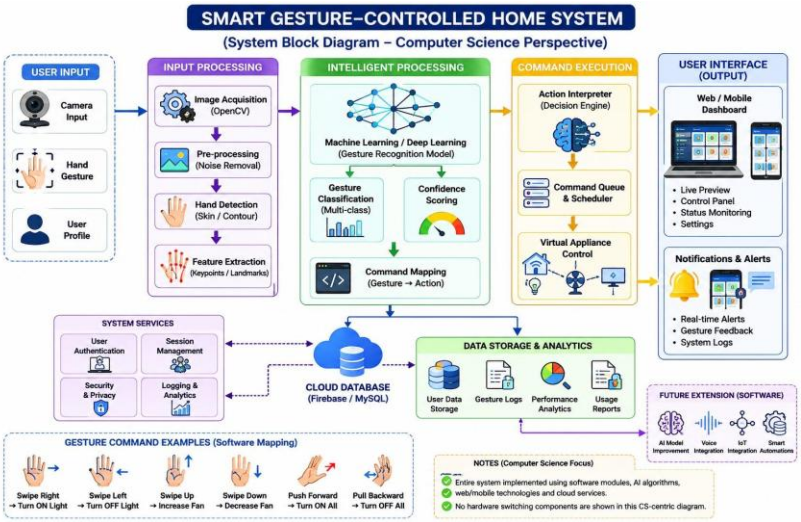


Figure 2: System block diagram from the computer science perspective

3.4 PROTOTYPE DEVELOPMENT AND TESTING

The prototype will be developed as a software demonstration using virtual appliances rather than real electrical switching hardware. The application interface may be designed using a prototyping tool and implemented using suitable mobile development technologies. For gesture recognition, computer vision libraries such as OpenCV can support image acquisition and processing, while hand landmark or gesture recognition tools such as MediaPipe can support hand detection and gesture classification.

The prototype will be tested by performing both correct and incorrect gestures. A correct gesture should trigger the expected virtual appliance response, while an incorrect gesture should produce an error or no action. Testing will also consider user distance from the camera, especially around 0.5 to

1.0 metre, and different user positions such as sitting, standing, or lying down because the stakeholder highlighted that elderly users may not always be able to stand.

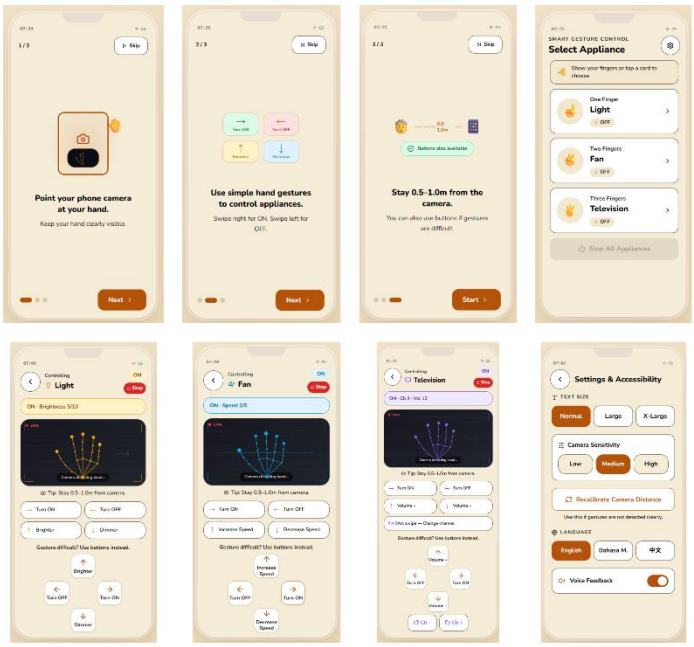


Figure 3: Mobile Application Prototype of the Smart Gesture-Controlled Home System

As shown in Figure 3, the Mobile Interface is designed as the primary interaction platform for the Smart Gesture-Controlled Home System. It guides users through an onboarding tutorial, appliance selection, and camera-based hand gesture recognition to control home appliances such as lights, fans, and televisions. The interface incorporates elderly-friendly Human–Computer Interaction (HCI) principles, including large buttons, adjustable text sizes, high-contrast colours, simple navigation, and manual control buttons as a fallback when gesture recognition is unsuccessful. Accessibility features such as camera sensitivity adjustment, multilingual support, and voice feedback further enhance usability for elderly users and individuals with limited mobility.

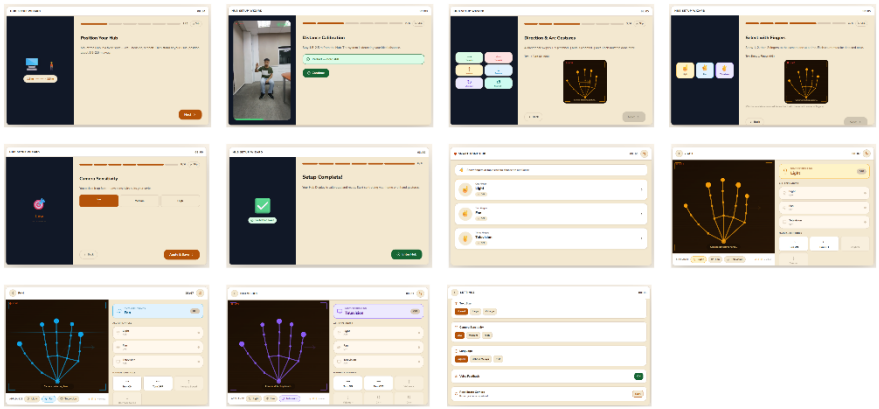


Figure 4: Smart Home Hub Interface Prototype of the Smart Gesture-Controlled Home System

As shown in Figure 4, the Hub Interface is designed as an alternative interaction platform for users who require a larger display and a fixed camera setup. Running on a Large Smart Display (Smart Home Hub), it provides guided setup and calibration, real-time gesture recognition, appliance management, and accessibility settings through a spacious, easy-to-read interface. The fixed camera position improves gesture detection accuracy while enabling hands-free operation, making it particularly suitable for wheelchair users, bedridden elderly users, caregivers, and elderly care centres. The Hub Interface complements the mobile application by offering greater visibility, improved comfort, and continuous monitoring in home or care environments.

4.0 RESULT

The expected result of this project is a functional smart home control prototype that demonstrates real-time hand gesture recognition and command execution for virtual home appliances, including lights, fans, and televisions. The system is primarily implemented as a mobile application, allowing users to control appliances through predefined hand gestures captured by the smartphone camera. As an alternative deployment platform, the system can also be implemented on a Large Smart Display (Smart Home Hub), providing a larger interface, a fixed camera position, and continuous hands-free operation for elderly users, wheelchair users, bedridden patients, and elderly care centres.

The novelty of this project lies in integrating AI-based gesture recognition, computer vision, cloud-supported software architecture, and user-friendly appliance management into a single smart home control platform. Unlike conventional home control systems that rely mainly on physical switches, remote controls, or voice commands, the proposed system offers a natural touchless interaction while maintaining an optional manual touch interface as a fallback method to improve accessibility, reliability, and usability.

The proposed Smart Gesture-Controlled Home System centralises multiple appliance controls into a single application, reducing dependence on physical switches, remote controls, and voice commands while providing a more natural and touchless interaction through AI-based hand gesture recognition. The system improves accessibility for elderly users and individuals with limited mobility by supporting both gesture-based control and an optional manual touch interface for greater reliability. Furthermore, the system can be deployed on both mobile devices and a Large Smart Display (Smart Home Hub), offering flexibility for different user needs and environments. Its simple icon-based interface reduces the learning curve for elderly users, while user information, gesture logs, and system activity records support monitoring and future performance analysis. In addition, the scalable software architecture provides a strong foundation for future integration with real Internet of Things (IoT) smart home devices and advanced home automation systems.

The proposed system is expected to achieve a gesture recognition accuracy of at least 90% under controlled testing conditions, with an average response time of 1–2 seconds for command execution. The prototype is also expected to successfully control multiple virtual home appliances while demonstrating reliable system performance, high usability, and improved accessibility for everyday smart home applications.

5.0 CONCLUSION

The Smart Gesture-Controlled Home System presents a practical, user-friendly, and accessible solution for modern home automation by combining AI-based hand gesture recognition with an intuitive mobile application. The proposed system enables users to control virtual home appliances through natural, touchless interaction while reducing dependence on physical switches, multiple remote controls, and voice commands. To improve usability and reliability, the system also provides an optional manual touch interface as a fallback control method, ensuring continuous operation under different usage conditions.

In addition to the mobile application, the proposed solution can be deployed on a Large Smart Display (Smart Home Hub), offering a larger interface, a fixed camera position, and continuous hands-free operation for elderly users, wheelchair users, bedridden patients, and elderly care facilities. This flexible deployment enhances accessibility and broadens the potential applications of the system.

Overall, the proposed prototype demonstrates the feasibility of integrating computer vision, gesture recognition, and cloud-supported software technologies into a single smart home platform. Future work will focus on integrating real Internet of Things (IoT) devices, enhancing gesture recognition accuracy using advanced AI models, and expanding smart automation features to provide a more intelligent, reliable, and inclusive home automation solution.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to Southern University College for providing the funding, resources, and research facilities that enabled the successful completion of this project. The support and conducive learning environment provided by the university played a vital role in allowing the team to explore, design, and develop the proposed system to its fullest potential.

The authors would also like to extend their appreciation to the faculty members and mentors who provided valuable guidance, constructive feedback, and continuous encouragement throughout the

course of this project. Their insights greatly contributed to shaping the research direction, refining the system design, and improving the overall quality of this work.

Finally, the authors would like to thank all group members, Lim Jie Lyn, Leong Kai Yong, and Kok Yi Hen, for their dedication, teamwork, and cooperation throughout the development process. Their combined effort, mutual support, and shared commitment to problem-solving were instrumental in overcoming challenges and achieving the successful completion of this project.

REFERENCES

Current Population Estimates. (31 July, 2025). Retrieved from https://www.dosm.gov.my/portal-main/release-content/current-population-estimates-2025

Gesture Recognition Task Guide. (2026). Retrieved from https://developers.google.com/edge/mediapipe/solutions/vision/gesture_recognizer

Hand Landmarks Detection Guide. (2026). Retrieved from https://developers.google.com/edge/mediapipe/solutions/vision/hand_landmarker

MediaPipe Hands: On-Device Real-Time Hand Tracking. (2020). Retrieved from https://arxiv.org/abs/2006.10214

OpenCV: Open Source Computer Vision Library. (n.d.). Retrieved from https://opencv.org/about

CATEGORY B2

TERTIARY LEVEL

SOCIAL SCIENCE

SUSTAINSMART: TOE-INTEGRATED SAAS DASHBOARD FOR SUSTAINABILITY TRANSFORMATION

Nur Rahmas Mohd Saman[1, *], Ahmad Suhaimi Alias[2], Mohd Hafedz Bohari[3], Nurazree Mahmud[4], Mohd Ariff Kamaludin[5]

[1]Faculty of Business & Management, Universiti Teknologi MARA, UiTM Shah Alam, 40450 Shah Alam, Selangor, Malaysia
[2]Faculty of Business, Unitar University College Kuala Lumpur (UUCKL), Jalan Perak, 50450 Kuala Lumpur, Malaysia
[3]Sekolah Pengurusan dan Sains Sosial (SPSS), Kolej Universiti Yayasan Pelajaran Johor.
[4]Faculty of Business & Management, Universiti Teknologi MARA, UiTM Melaka, 75350 Melaka, Malaysia
[5]Faculty of Business & Management, Universiti Teknologi MARA, UiTM Dungun, 23000 Kuala Dungun, Dungun, Malaysia

[*]Corresponding author: nurrahmas@yahoo.com

ABSTRACT

Sustainability has become a strategic priority across organisations seeking to align their operations with environmental and social responsibilities. However, many small and medium enterprises (SMEs) still face challenges in effectively assessing and improving their sustainability performance due to limited data integration and practical digital tools. Current approaches are often fragmented, theoretical, and lack a comprehensive framework that connects technology adoption, organisational readiness, and environmental context. The objective of this innovation is to develop SustainSmart Advisor, a digital sustainability dashboard that enables organisations to monitor, evaluate, and enhance sustainability performance using intuitive visualisation and integrated analytics. The invention uses the Technology–Organization–Environment (TOE) framework to apply green innovation and sustainability performance metrics, making complex data easier to understand and use. Through interactive charts, radar graphs, and real-time performance summaries, the platform allows users to track initiatives, audits, and compliance while strengthening strategic decision-making. It unifies scattered sustainability records into one dynamic dashboard, providing a holistic view spanning economic, social, and environmental dimensions. Findings from design evaluation reveal that SustainSmart Advisor improves data transparency, accelerates reporting, and supports measurable progress toward sustainable targets. Its TOE-based integration offers a unique advantage over conventional reporting systems by combining operational tracking with decision support and digital innovation. As a scalable software-as-a-service (SaaS) solution, it supports customisation, analytics, and branding for diverse organisational contexts. In conclusion, SustainSmart Advisor represents a practical and research-informed innovation that bridges the gap between sustainability theory and implementation. It empowers organisations, particularly SMEs, to embrace data-driven sustainability management, advancing global ESG practices and the Sustainable Development Goals (SDGs).

Keywords: sustainability tool, green innovation, TOE dashboard, digital TOE

1.0 INTRODUCTION

SustainSmart Advisor is a new digital tool that helps organisations keep track of and improve their sustainability efforts using easy-to-understand visuals like interactive charts and real-time summaries based on the Technology–Organization–Environment (TOE) framework. Despite the growing need for sustainability, SMEs still struggle with disorganised manual records, theoretical tools, and separated data that make it difficult to track their green efforts, meet regulations, and make progress in economic, social, and environmental areas. This innovation was developed to bridge that gap, transforming complex sustainability data into actionable insights via a scalable SaaS platform that supports rapid decision-making, ESG alignment, and greener operations for practical SME adoption.

2.0 OBJECTIVE

The objectives to develop SustainSmart Advisor, a TOE-integrated digital sustainability dashboard, focus on addressing SME challenges through practical innovation.

1. Objective 1: To create a user-friendly SaaS platform that consolidates fragmented sustainability data into interactive visualisations, enabling real-time monitoring of green initiatives, audits, and TOE factors.
2. Objective 2: To integrate green innovation metrics with triple-bottom-line performance indicators, facilitating rapid identification of improvement areas and strategic decision-making for SMEs.
3. Objective 3: To develop a flexible tool that improves ESG compliance, helps align with SDGs, and creates business opportunities in various industries.

3.0 METHODOLOGY

SustainSmart Advisor employs a design-driven methodology to create a practical, TOE-integrated SaaS dashboard for SME sustainability management. The development process uses user-focused design, adapts the TOE framework, and follows best practices for visualisation to make sure the features meet real-world needs, such as combining data and providing useful insights.

3.1 PRODUCT DESCRIPTION

SustainSmart Advisor is a digital sustainability management tool that consolidates sustainability-related information into one visual dashboard. The platform displays metrics such as green initiatives, TOE compliances, sustainability audits, and performance indicators across economic, social, and environmental dimensions. Its interface uses colour-coded charts and simple visual summaries to help users quickly interpret progress and identify areas that need improvement.

Organisations that desire a user-friendly system to monitor sustainability activities without relying on fragmented manual records can use the product. Business owners, sustainability officers, researchers, and management teams can use it to support reporting, internal review, and strategic planning. The design emphasises clarity, accessibility, and ease of understanding, making it suitable for digital competition presentation and real-world adoption.

3.1 FEATURES

The platform includes interactive elements such as radar graphs for TOE-green innovation balance, colour-coded charts for triple-bottom-line metrics (economic, social, and environmental), and real-time performance summaries. Additional features encompass customisable dashboards, compliance trackers, audit logs, and exportable reports for ESG/SDG alignment.

3.2 FUNCTIONALITY

Users upload sustainability data (e.g., initiatives, audits), which the system processes into dynamic visuals: line trends for progress tracking, stacked bars for pillar comparisons, and summary indicators for quick scans. TOE integration connects how well technology is used, how ready the organisation is, and the environmental situation to the results of green innovation, creating automatic suggestions.

3.3 USEFULNESS AND PRACTICALITY

This new system brings together separate records into one user-friendly interface, making it faster to understand the information than looking at manual reports and allowing non-experts (like SME owners) to make decisions. Its SaaS model provides flexibility, easy access, and personalisation for Malaysian SMEs, helping them follow rules and sell their products, which is essential for these businesses to adjust to market changes and comply with local laws.

3.4 RELATED VISUALS



Figure 1: Prototype SustainSmart Dashboard.

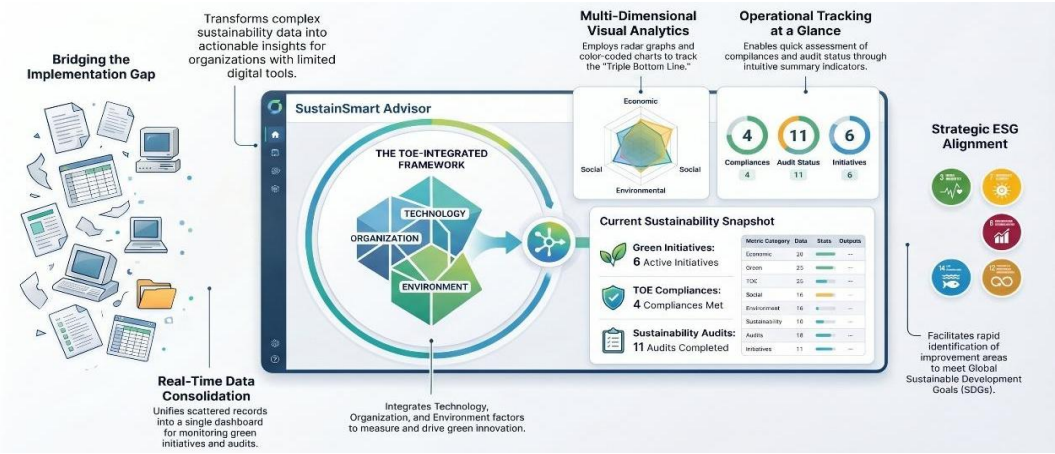


Figure 2: Visualisation path to sustainability.



Figure 3: Strategic Enhancement for Impactful Sustainability

4.0 RESULT

This section explains the originality of SustainSmart, its benefits to users and society, and its potential for commercialisation as an innovative sustainability solution.

4.1 NOVELTY AND UNIQUENESS

The novelty of SustainSmart Advisor lies in its integrated approach to sustainability monitoring. Unlike ordinary reporting tools that only present isolated indicators, this dashboard combines TOE-based organisational factors, green innovation elements, and sustainability performance measures in a single visual platform. This makes the product distinctive because it links sustainability capability with operational tracking and strategic decision support.

Its uniqueness also comes from the way information is displayed. The dashboard turns sustainability data into a neat, visually appealing display using different types of charts, like summary indicators, radar analysis, line trends, and stacked performance bars. This combination improves interpretation speed and makes the system more engaging, practical, and presentation-ready than conventional static sustainability reports.

Recent research indicates that the extension of Technology-Organization-Environment (TOE) beyond mere technological adoption into green innovation and sustainable performance for small and medium-sized enterprises (SMEs) is still in its nascent stages and predominantly model-driven rather than tool-driven. This underscores the uniqueness of an applied TOE dashboard. Aligarh et al. explicitly use TOE to explain how technological, organisational, and environmental factors drive green innovation and, in turn, sustainable performance in MSMEs and emphasise the necessity of practical tools for SMEs to implement eco-friendly initiatives (Aligarh et al., 2025). Costa Melo et al. (2023) show that most digital-transformation performance tools for SMEs still ignore environmental and social pillars, calling for integrated sustainability performance tools. Bennett & Loose (2024) develop what they position as the first online dashboard for SME economic sustainability, noting a gap in more holistic, multi-pillar dashboards.

4.2 BENEFIT TO MANKIND

SustainSmart Advisor benefits users by making sustainability management easier, clearer, and more actionable. It helps organisations track environmental, social, and economic performance in a way that supports responsible business practices, better compliance, and continuous improvement. This can encourage more firms to adopt greener operations and make sustainability part of everyday decision-making. For society, the product contributes to better resource use, stronger organisational accountability, and more informed sustainability practices. In the long term, such a tool can support more resilient institutions, improved environmental stewardship, and wider adoption of sustainable innovation across industries. This aligns well with the competition's focus on smart innovations for a sustainable and resilient future.

Evidence links green innovation (often TOE-driven) with economic, social, and environmental SME performance, including resilience in crisis (Aligarh et al., 2025; Alraja et al., 2022; Aslam et al., 2025; Wasiq et al., 2023). Wasiq et al. (2023) find that green innovation adoption improves the economic, social, and environmental performance of SMEs. A 2025 review shows that green innovation consistently enhances SME sustainability and competitiveness when supported by leadership, strategy, and digital tools (Mohd Saman et al., 2025). Systematic reviews on SME digital transformation and sustainability emphasise that better measurement tools and dashboards are essential to advance SDGs and reduce poverty and inequality through SME performance (Bálint et al., 2025; Costa Melo et al., 2023).

4.3 COMMERCIALIZATION POTENTIAL

SustainSmart Advisor has strong commercialisation potential because it addresses a real and growing market need for sustainability tracking tools. It can be developed as a subscription-based web application or licensed to SMEs, universities, consulting firms, and corporate sustainability departments. The product is scalable because it can be adapted for different sectors, reporting requirements, and levels of organisational maturity, making it suitable for a wide range of users, including small and medium enterprises (SMEs), educational institutions, and corporate sustainability departments.

The potential for customisation, branding, and intellectual property protection strengthens its commercial value. Possible revenue models include software licensing, premium analytics features, dashboard customisation, training services, and institutional packages. Because sustainability reporting and ESG-related practices are expanding, this product has excellent potential for market acceptance and long-term business growth.

Reviews and empirical studies stress strong demand for visual reporting, analytics, and sustainability dashboards to support SME decision-making and ESG alignment (Bálint et al., 2025; Eyeregba et al., 2024; Okfalisa et al., 2022). Eyeregba et al. (2024) argue that integrated visual dashboards and ESG

metrics offer SMEs cost reduction, productivity gains, and competitive advantage while noting barriers that scalable tools can address, such as high implementation costs and lack of technical expertise among staff. Evaluation of digital-readiness dashboards for SMEs shows that dashboards can be embedded as decision-support systems, using weighted indices and visual performance mapping, reinforcing the viability of subscription-based, analytics-rich platforms (Chaichana et al., 2024). The TOES framework explicitly calls for technology-adoption models that integrate sustainability as a core analytical dimension, supporting IP-able designs that embed sustainability into digital tools (Satyro et al., 2024).

5.0 CONCLUSION

Recent research confirms the central role of TOE-driven green innovation in improving SME sustainability, while also highlighting a clear gap in practical, triple-bottom-line dashboards. Evidence on SME DSS and sustainability dashboards supports the value and commercial viability of a SaaS tool like SustainSmart Advisor, especially when it integrates TOE factors, green innovation metrics, and ESG-aligned performance indicators into intuitive visualisations.

REFERENCES

Aligarh, F., Probohudono, A., Sudaryono, E., Widarjo, W., Arifin, M., Raharja, B., & Purwantini, A. H. (2025). Green innovation for sustainable performance: insights from the TOE framework. *BIS Economics and Business*. https://doi.org/10.31603/biseb.226

Alraja, M. N., Imran, R., Khashab, B. M., & Shah, M. (2022). Technological Innovation, Sustainable Green Practices and SMEs Sustainable Performance in Times of Crisis (COVID-19 pandemic). *Information Systems Frontiers*, *24*(4), 1081–1105. https://doi.org/10.1007/s10796-022-10250-z

Aslam, M., Ahmad, B., & Rasheed, T. (2025). Navigating the Impact of Green Innovation, Technological Linkages, and Knowledge Management on Sustainable Performance of SMEs. *Journal of International Entrepreneurship*. https://doi.org/10.1007/s10843-024-00371-8

Bálint, L., Várallyai, L., & Botos, S. (2025). Evaluation of Data-Driven Sustainability Potential at SMEs Using an Altered Ecocanvas Model. *Economies*. https://doi.org/10.3390/economies13020049

Bennett, A., & Loose, S. M. (2024). User-Centered Development of an Online Dashboard Tool for Economic Sustainability for Small and Medium Enterprises. *Sustainability*. https://doi.org/10.3390/su16020557

Chaichana, T., Reeve, G., Jaisan, C., & Chakrabandhu, Y. (2024). Modelling and assessing new SME digital business status for visualising virtual economics and sustainability economic indicators: Empirical evidence from poultry business. *Heliyon*, *10*. https://doi.org/10.1016/j.heliyon.2024.e30624

Costa Melo, D. I., Queiroz, G. A., Alves Junior, P. N., Sousa, T. B. de, Yushimito, W. F., & Pereira, J. (2023). Sustainable digital transformation in small and medium enterprises (SMEs): A review on performance. *Heliyon*, *9*(3), e13908. https://doi.org/10.1016/j.heliyon.2023.e13908

Eyeregba, M. E., Mokogwu, C., Ewim, S., & Olorunyomi, T. D. (2024). Integrating visual reporting, analytics, and sustainable dashboards to support decision-making and growth in small and medium enterprises (SMEs). *International Journal of Frontiers in Science and Technology Research*. https://doi.org/10.53294/ijfstr.2024.7.2.0059

Mohd Saman, N. R., Mahmud, N., Mat Nor, N., & Kamaludin, M. A. (2025). *Green Innovation and SMEs ' Sustainability Performance: A Comprehensive Review*. *41*, 28–38.

Okfalisa, Mahyarni, Anggraini, W., Saktioto, & Pranggono, B. (2022). Assessing Digital Readiness of Small Medium Enterprises: Intelligent Dashboard Decision Support System. *International Journal of Advanced Computer Science and Applications*. https://doi.org/10.14569/ijacsa.2022.0130412

Satyro, W. C., Contador, J., Gomes, J. A., Monken, S., Barbosa, A. P., Bizarrias, F., Contador, J., Silva, L. S., & Prado, R. G. (2024). Technology-Organization-External-Sustainability (TOES) Framework for Technology Adoption: Critical Analysis of Models for Industry 4.0 Implementation Projects. *Sustainability*. https://doi.org/10.3390/su162411064

Wasiq, M., Kamal, M., & Ali, N. (2023). Factors Influencing Green Innovation Adoption and Its Impact on the Sustainability Performance of Small- and Medium-Sized Enterprises in Saudi Arabia. *Sustainability*. https://doi.org/10.3390/su15032447

TALENT+: AN INTELLIGENT SKILL LEVEL CLASSIFICATION PLATFORM FOR MALAYSIA'S LABOUR MARKET

Rabi'atul'adawiah Shabli[1,2], Ahmad Zia Ul-Saufie[1,*], Nurain Ibrahim[1], Azlina Mahmud[2], Siti Sarah Che Dan[2], Wan Siti Zaleha Wan Zakaria[2]

[1]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[2]Department of Statistics Malaysia, Ministry of Economy, Federal Government Administrative Centre, 62514 Putrajaya, Wilayah Persekutuan Putrajaya, Malaysia

[*]Corresponding author: ahmadzia101@uitm.edu.my

ABSTRACT

Talent+ is an intelligent web-based platform that classifies Malaysian workers into skilled, semi-skilled and low-skilled categories without depending on occupational information. The platform addresses a persistent gap in Malaysia's labour market dataset, where more than seven million formal sector workers are recorded without occupation or skill-level data, limiting the extension of workforce skill-level profiling beyond periodic surveys. Talent+ converts demographic, educational and labour market inputs into a skill level prediction, complete with a confidence score and class probability distribution, powered by a Random Forest multiclass classification model built from the Salaries and Wages Survey (SWS) dataset. The platform integrates workforce analytics, model transparency and real-time individual worker classification within a single interface, giving policymakers, researchers, and human resource practitioners a fast, accessible and interpretable tool for workforce intelligence. By removing the dependency on occupational grouping, Talent+ opens a pathway to extend skill level profiling across Malaysia's broader labour market records, supporting more responsive human capital planning and evidence-based policymaking.

Keywords: labour market, machine learning, multiclass classification, Random Forest, skill level

1.0 INTRODUCTION

Malaysia requires accurate and detailed information on the skill-level composition of its workforce to support labour market monitoring, workforce planning, and targeted human capital policies (Ministry of Economy, 2025). Skill level is categorised into skilled, semi-skilled, and low-skilled (Ministry of Human Resources, 2020), but existing classifications rely heavily on occupational information that is not consistently recorded in the administrative datasets. This leaves detailed skill-level analysis dependent on periodic surveys and rule-based descriptive analytics, rather than predictive analytics that could extend skill-level information across the wider administrative dataset.

Most skills intelligence platforms address a related problem, but at the level of a single company rather than a national workforce. They use labour market information to help organisations match employees to suitable skills and plan workforce changes. Standard skills assessment tools and skills data providers work in a similar way, in which they compare an employee's competencies against what the organisation needs, typically relying on self-reported skills, job-posting data, or skills information already recorded in a company's human resource system. These platforms are useful for big companies that already have their own digital human resource systems in place, but they are built around occupation and taxonomy-based skill matching, priced for company-wide adoption, and not designed to work with the demographic and labour market features found in statistical administrative records.

Talent+ is positioned differently. It is a localised, single-purpose platform built specifically for Malaysia's labour market data environment, where occupation is often the one feature that is missing. Rather than requiring an existing skills taxonomy or human resource integration, Talent+ predicts skill level directly from demographic, educational, and labour market features already present in labour market datasets. This makes it a practical, low-barrier alternative for government agencies, researchers, and human resource practitioners who need workforce skill-level intelligence without the cost and complexity of company-focused platforms.

2.0 OBJECTIVE

Talent+ was developed with the following objectives:

1. To develop an intelligent digital platform that integrates workforce analytics and machine learning for skill level classification in Malaysia's labour market.
2. To classify Malaysian workers into skilled, semi-skilled, and low-skilled using demographic, educational, and labour market features without relying on occupation information.
3. To provide an interactive web-based tool that enables users to explore workforce distributions, review model insights, and generate real-time skill level predictions for individual worker profiles.

3.0 METHODOLOGY

Talent+ was developed following the Cross-Industry Standard Process for Data Mining (CRISP-DM) framework, guiding the project from problem definition through to a deployed, functional platform.

3.1 MODEL DEVELOPMENT

The project began by identifying skill level classification as a structural data gap, with existing classification relying on a rule-based descriptive approach according to MASCO 2020, which depends on occupational information that is not consistently recorded in administrative datasets (Department of Statistics Malaysia, 2026). The business goal was set accordingly: to shift skill level classification from this rule-based descriptive approach to a predictive analytics approach, building a model and platform that estimate skill level without occupation. (Department of Statistics Malaysia, 2026)

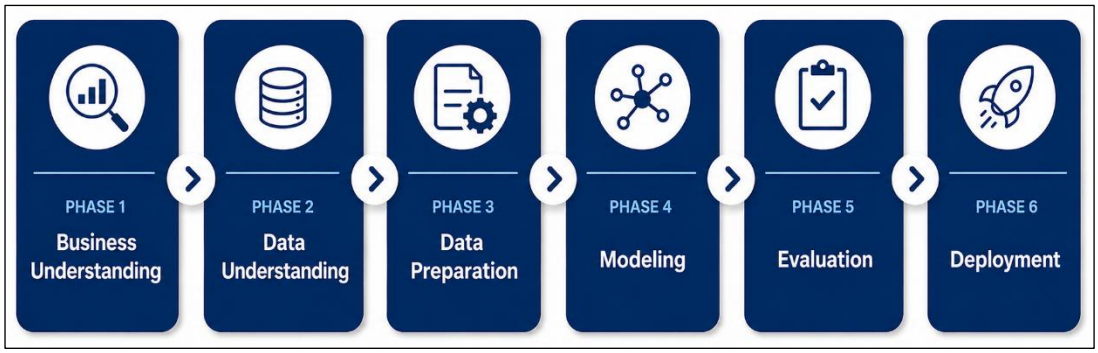


Figure 1: Graphical Workflow for Prediction of Labour Skill Classification

The SWS 2023 dataset was obtained from the Department of Statistics Malaysia (DOSM), comprising 12,051 cases, 19 input features and one target feature, skill level, which is categorised into skilled, semi-skilled, and low-skilled. Initial exploration confirmed class imbalance across the three skill level categories. The input features were segmented into three themes, namely, demographic, educational, and labour market, for modelling purposes. Categorical features were encoded for model training (Roshinta & Gábor, 2024). The dataset was divided into training and validation subsets using a stratified 80:20 split (Mansor & Othman, 2024), while class imbalance was addressed using a balanced class-weight setting (Visibelli et al., 2025).

The predictive model was developed using Random Forest, a tree-based ensemble algorithm selected for its ability to handle mixed data types and produce feature importance scores that support model interpretation (Breiman, 2001). The model was trained on all 19 input features, with embedded feature importance used to identify and rank the worker characteristics contributing most strongly to skill-level classification. Model performance was evaluated using accuracy, sensitivity, specificity, F1-score and AUC-ROC (Manafi Varkiani et al., 2025).

3.2 PRODUCT DEVELOPMENT: TALENT+ PLATFORM ARCHITECTURE

The Random Forest classification model was deployed into Talent+, an interactive web-based application. The platform presents its functions through a single-page interface with four modules, as stated in Table 1. It is designed to move users from workforce-level analysis to model interpretation and individual worker classification within the same product.

Table 1. Core Modules of the Talent+ Platform

Module	Functionality	User Value
Workforce at a Glance	Presents interactive visualisations of skill level, gender, age group, education level, economic activity, and monthly salaries and wages.	Provides an immediate overview of workforce patterns based on the SWS 2023 dataset.
Prediction Model Insights	Displays the trained model, input features, target feature, model performance and ranked feature importance.	Promotes transparency by showing how the model performs and which features contribute most strongly to the predictions.
Try It: Classify a Worker	Allows users to enter demographic, educational and labour market inputs.	Produces an immediate predicted skill level, confidence score and class probabilities according to skill level categories.
About Project	Summarises the purpose, scope and application of Talent+.	Provides new users with a clear explanation of the platform and its relevance to labour market analysis.

4.0 RESULT

4.1 FUNCTIONAL DIGITAL APPLICATION AND REAL-TIME CLASSIFICATION DEMONSTRATION

Talent+ has been developed as a functional web-based application that integrates workforce visualisations, model-performance indicators, ranked feature importance, and an interactive prediction panel within a single interface. Users enter demographic, educational, and labour market characteristics. Once the user selects Predict Skill Level, the platform immediately generates a predicted skill-level category, confidence score, and class-probability distribution.

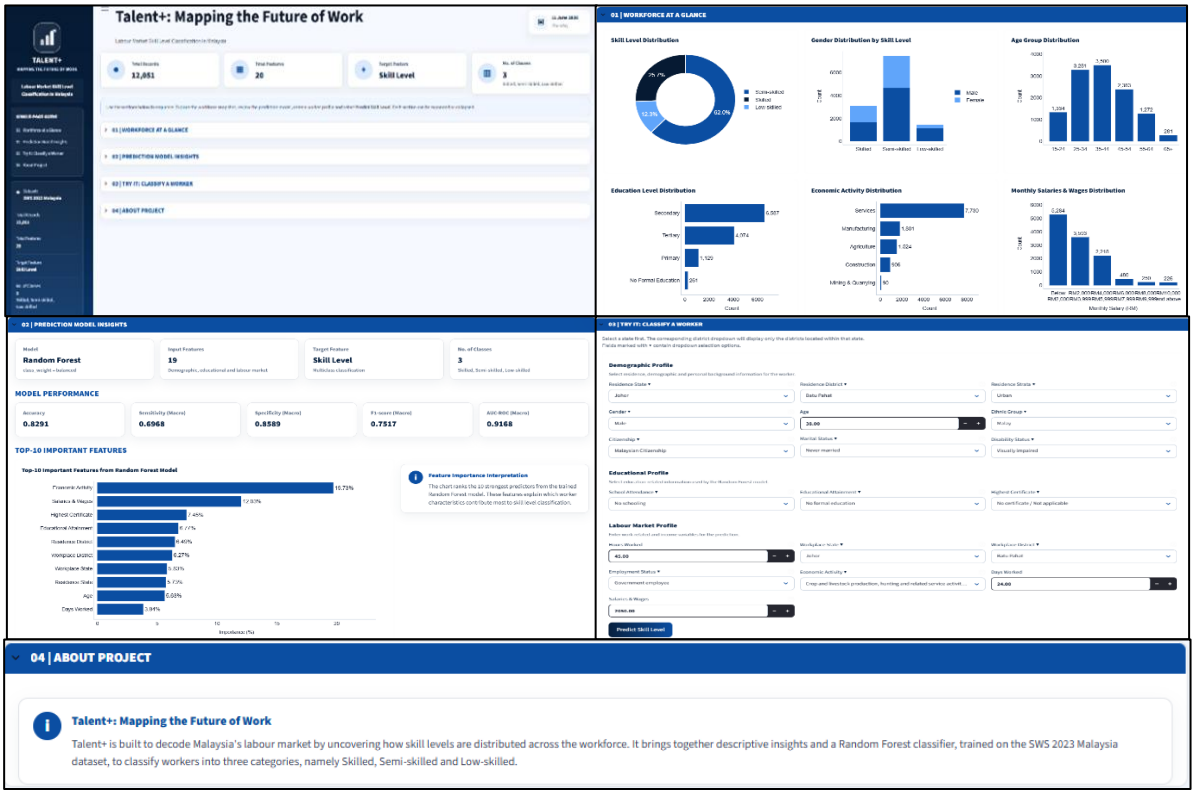


Figure 2. Talent+ Web-based Dashboard

4.2 MODEL PERFORMANCE

The Random Forest classification model achieved an accuracy of 0.8291, a sensitivity of 0.6968, a specificity of 0.8589, an F1-score of 0.7517 and an AUC-ROC of 0.9168 (Table 2). These findings indicate strong classification performance and high discriminative ability across the three skill-level categories, reflecting the model's ability to distinguish cases correctly (Manafi Varkiani et al., 2025).

Table 2: Random Forest Model Performance

Metric	Accuracy	Sensitivity	Specificity	F1-score	AUC-ROC
Random Forest	0.8291	0.6968	0.8589	0.7517	0.9168

4.3 KEY PREDICTORS OF SKILL LEVEL

Feature importance analysis identified economic activity as the strongest predictor, contributing 19.73% to the Random Forest classification model (Table 3). Salaries and wages ranked second at 12.03%, followed by the highest certificate at 7.45% and educational attainment at 6.77%. Collectively, the top 10 predictors account for 79.77% of the model's total feature importance, indicating that skill level in Malaysia's labour market is concentrated in a relatively compact set of economic, educational and geographic features (Afsharinia & Gurtoo, 2024; Charkasova & Al-Asfour, 2024; Josten et al., 2024).

Table 3: Top-10 Predictors of Skill Level

Rank	Feature	Importance (%)	Rank	Feature	Importance (%)
1	Economic Activity	19.73%	6	Workplace District	6.27%
2	Salaries & Wages	12.03%	7	Workplace State	5.83%
3	Highest Certificate	7.45%	8	Residence State	5.73%
4	Educational Attainment	6.77%	9	Age	5.63%
5	Residence District	6.49%	10	Days Worked	3.84%

4.4 INNOVATION AND NOVELTY

The novelty of Talent+ lies in its integration of machine learning, labour market analytics and an interactive classification tool within a localised digital platform (Table 4). First, Talent+ addresses the absence of skill-level information in many administrative datasets by estimating a worker's skill level without relying on occupational information by using 19 features. Second, the platform's model is built on Random Forest with embedded feature importance, allowing the classification process to remain both accurate and transparent so users can see which worker characteristics drive each prediction rather than treating the model as a black box. Third, Talent+ transforms this trained classification model into a functional web application that integrates three levels of labour market intelligence within a single interface, namely, workforce patterns, model interpretation, and individual profile classification. Fourth, the system provides interpretable outputs, giving users a predicted skill level, confidence score, and class probability distribution.

Table 4: Innovation Value of Talent+

Dimension	Talent+ Contribution
Problem Addressed	Skill-level information is absent from many large-scale administrative datasets.
Core Innovation	Predicts skill level without occupation information, using a Random Forest model with embedded feature importance for interpretable classification.
Digital Product	Integrates descriptive analytics, model insights and real-time worker classification within a single web application.
Technology Used	Random Forest classification model deployed via a web-based application.
Practical Value	Supports faster, clearer and more accessible labour market analysis.
Future Scaling Potential	A framework for enriching administrative datasets with estimated skill level profiles.
Target Users	Policymakers, government agencies, researchers, labour market analysts and human resource practitioners.

4.5 IMPACT AND FUTURE APPLICATION

Talent+ offers practical value for labour market monitoring and human capital planning, supporting exploratory workforce analysis alongside immediate individual skill-level predictions. Subject to further validation using administrative data structures, the platform provides a foundation for skill level profiling, with potential relevance to national development priorities such as the Thirteenth Malaysia Plan 2026-2030 and the New Industrial Master Plan 2030. Future enhancements include downloadable analytical reports and state-level dashboards.

5.0 CONCLUSION

Talent+ presents an accessible and interpretable alternative for classifying workforce skill level in Malaysia's labour market. By integrating workforce analytics, a benchmarked machine-learning model, and real-time worker classification into a single web-based platform, Talent+ strengthens the availability of skill-level intelligence beyond traditional survey sources. The current stage reflects a fully functional web application, moving beyond model development towards a deployed and user-ready digital product. Future development should focus on validating the model against administrative labour market datasets, expanding coverage across states and strengthening integration with government and industry data systems. Overall, Talent+ has the potential to improve workforce visibility, support evidence-based human capital planning, and advance labour market digitalisation in Malaysia.

ACKNOWLEDGEMENT

Sincere gratitude is extended to the Department of Statistics Malaysia for providing the annual labour market dataset that forms the empirical foundation of this project. Appreciation is also extended to Universiti Teknologi MARA (UiTM) for providing the supervision and academic environment that made this work possible.

REFERENCES/RUJUKAN

Afsharinia, B., & Gurtoo, A. (2024). COVID-19 impact on food consumption of low-skilled employees in India. *Global Food Security*, *42*, 100791. https://doi.org/10.1016/j.gfs.2024.100791

Breiman, L. (2001). Random Forests. *Machine Learning*, *Volume 45*, pages 5-32. https://doi.org/https://doi.org/10.1023/A:1010933404324

Charkasova, A., & Al-Asfour, A. (2024). *Am I underpaid because I am an immigrant? Exploring the lived experiences of the skilled temporary worker visa holders in STEM occupations in the American workplace*.

Department of Statistics Malaysia. (2026). *Employee Wages Statistics (Formal Sector) Report* [Statistical report]. Department of Statistics Malaysia. https://www.dosm.gov.my/portal-main/release-content/employee-wages-statistics-formal-sector-q42025

Josten, C., Krause, H., Lordan, G., & Yeung, B. (2024). What skills pay more? The changing demand and return to skills for professional workers. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4706059

Manafi Varkiani, S., Pattarin, F., Fabbri, T., & Fantoni, G. (2025). Predicting employee attrition and explaining its determinants. *Expert Systems with Applications*, *272*, 126575. https://doi.org/10.1016/j.eswa.2025.126575

Mansor, A., & Othman, Z. (2024). Malaysian community college graduates employability prediction model using machine learning approach. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, *16*(3), 1–7. https://doi.org/10.54554/jtec.2024.16.03.001

Ministry of Economy. (2025). *Thirteenth Malaysia Plan 2026-2030*. https://rmk13.ekonomi.gov.my/wp-content/uploads/2025/09/120925-Main-Document-e-Book.pdf

Ministry of Human Resources. (2020). *Malaysia Standard Classification of Occupations 2020* [Occupational classification manual]. https://emasco.mohr.gov.my/system-api/storage/uploads/masco_2020_en.pdf

Roshinta, T. A., & Gábor, S. (2024). *A comparative study of LIME and SHAP for enhancing trustworthiness and efficiency in explainable AI systems*. 2024 IEEE International Conference on Computing (ICOCO). https://doi.org/10.1109/ICOCO62848.2024.10928183

Visibelli, A., Finetti, R., Roncaglia, B., Poli, P., Spiga, O., & Santucci, A. (2025). Predicting therapy dropout in chronic pain management: A machine learning approach to cannabis treatment. *Frontiers in Artificial Intelligence*, *8*, 1557894. https://doi.org/10.3389/frai.2025.1557894

TRAVELSAVER: AN ALL-IN-ONE SMART TRAVEL PLANNING APPLICATION

Nur Alya Jasmira Mohd Fakarruddin[1] and Nor Azahana Abdul Rahim[1,*]

[1]Kolej Poly-Tech MARA Batu Pahat

[*]Corresponding author: azahana_rahim@kptm.edu.my

ABSTRACT

TravelSaver is an integrated mobile application developed to address the financial and logistical challenges faced by modern travellers, particularly the issue of budget shock and unorganised planning. While existing tools often focus on basic expense logging, TravelSaver introduces a proactive approach through its core feature, the Autobudget engine. This feature provides instant estimations for transportation costs and travel durations, allowing users to plan more accurately. Developed on the Android platform and powered by Firebase, the application ensures seamless real-time cloud synchronisation across its various modules, including a Profile Manager, an interactive Packing List, and an automated Bill Splitter for group trips. By utilising Agile methodology, the project focuses on delivering a user-centric experience that simplifies complex travel data into actionable financial insights. The result is a comprehensive digital assistant that acts as a financial conscience, helping users stay within their limits while reducing the stress of manual calculations. TravelSaver effectively bridges the gap between logistical preparation and financial management, ensuring a more organised and enjoyable travel experience.

1.0 INTRODUCTION

TravelSaver is a comprehensive travel budget management application built on Android and Firebase, designed to streamline both the financial and logistical complexities of modern wandering. By integrating a dynamic Budget Planner with an automated Autobudget engine, the app eliminates uncertainty about travel costs by providing instant price estimations and travel durations for different transport modes. Beyond mere expense tracking, TravelSaver serves as an all-in-one digital assistant featuring an interactive Packing List to prevent logistical oversights and an automated Bill Splitter to resolve group financial friction seamlessly. Powered by real-time cloud synchronisation, the app acts as a proactive financial conscience, empowering travellers to manage their resources efficiently and enjoy their journeys without the stress of overspending or unorganised planning.

2.0 OBJECTIVE

1. To provide a Travel Cost Reality Check that shows the real estimated travel cost, including hidden fees, so users can avoid overspending.
2. To include a Budget Breakdown Auto-Fix that suggests cheaper alternatives automatically when the planned expenses exceed the user's budget.
3. To create a Time vs Money Optimiser that helps users compare travel options and choose based on whether they want to save time, money or both.
4. To generate a Personality-Based Travel Plan that produces itineraries tailored to the user's preferences and travel style.
5. To offer a Smart Packing List Generator that recommends items based on destination, weather, duration, and planned activities.
6. To provide a Split Bill Travel Calculator that helps individuals or groups calculate and divide shared expenses fairly

3.0 METHODOLOGY

The development of TravelSaver is governed by the Agile Development Methodology, specifically utilising the Scrum framework to ensure flexibility and high-quality output throughout the project lifecycle. This methodology was selected because it allows the development process to be divided into small, manageable cycles known as Sprints. Each sprint focuses on delivering specific functional modules, such as the Firebase Authentication system, the Autobudget algorithm and the Google Maps integration.

By adopting an iterative approach, any technical challenges, particularly those involving real-time data synchronisation or API response latency, can be identified and addressed immediately during regular testing intervals.

This ensures the application remains stable and that new features, such as the Budget Warning System, are seamlessly integrated without disrupting existing functionalities like the Packing List or Bill Splitter.

3.1 REQUIREMENT ANALYSIS

This phase outlines the functional and non-functional requirements of TravelSaver, derived from a comprehensive review of travel literature, budgeting behaviours, and feedback gathered from active travellers and students. The analysis highlighted critical pain points, such as disjointed itinerary planning, unmonitored travel expenses, social awkwardness during group bill-splitting, and unorganised packing routines. To address these gaps, TravelSaver centralises essential travel tools by combining an automatic budget engine, an interactive trip planner, a customised packing list generator and a collaborative cost-splitter into a single, seamless mobile application.

3.2 SYSTEM DESIGN

The TravelSaver application is designed using a robust, object-oriented software architecture to deliver a highly scalable, secure, and responsive travel management platform. Developed primarily as an Android mobile application in Kotlin, the system establishes secure communication with Firebase cloud services to handle real-time data synchronisation, user authentication, and media storage.

The core system architecture integrates the following main components:

- Kotlin-Based Android Application: The front-end client that hosts the interactive trip planner, automatic budget warning and user dashboard with an intuitive Material Design interface.
- Firebase Authentication: Handles secure user registration, credential validation, and session management.
- Firebase Realtime Database: Stores and synchronises trip itineraries, dynamic packing lists, and group bill-splitting records instantly across multiple devices.
- Firebase Cloud Storage: Provides secure storage for user profile images and travel-related media assets.

By integrating these cloud-based services, TravelSaver ensures seamless data persistence, immediate updates on shared group expenses, and secure access to offline-ready travel logistics.

3.3 PROTOTYPE DEVELOPMENT

The TravelSaver prototype was developed in Android Studio, leveraging Kotlin as the primary programming language for constructing a native, responsive frontend. The development process adopted the Agile Software Development Methodology, where the system was implemented through iterative sprints. Each sprint focused on the rapid design, coding, testing and optimisation of individual features based on the functional requirements defined during the analysis phase. This iterative cycle facilitated continuous refinement, enabling incremental stability while ensuring the application remained closely aligned with the user's travel needs.

The completed prototype consists of several integrated modules designed to streamline travel planning and financial management:

- User Authentication Module (Handles secure signup and login)
- Main Dashboard & Explore Malaysia Module (Displays trip summaries, history, and state attractions)
- Trip Planner Module (Enables creating, editing, and deleting daily itineraries)

- Budget Planner & Warning Module (Tracks travel expenses and triggers automatic alerts when budget limits are breached)
- Auto Budget & Transportation Engine (Estimates fares and durations based on transport mode and routes)
- Smart Packing Checklist Module (Generates categorised checklists based on destination, weather, and style)
- Bill Splitter Module (Splits group expenses dynamically and equally among travel members)
- Profile & Setting Management Module (Manages profile updates, dark/light theme switching, and AI Chatbot access)

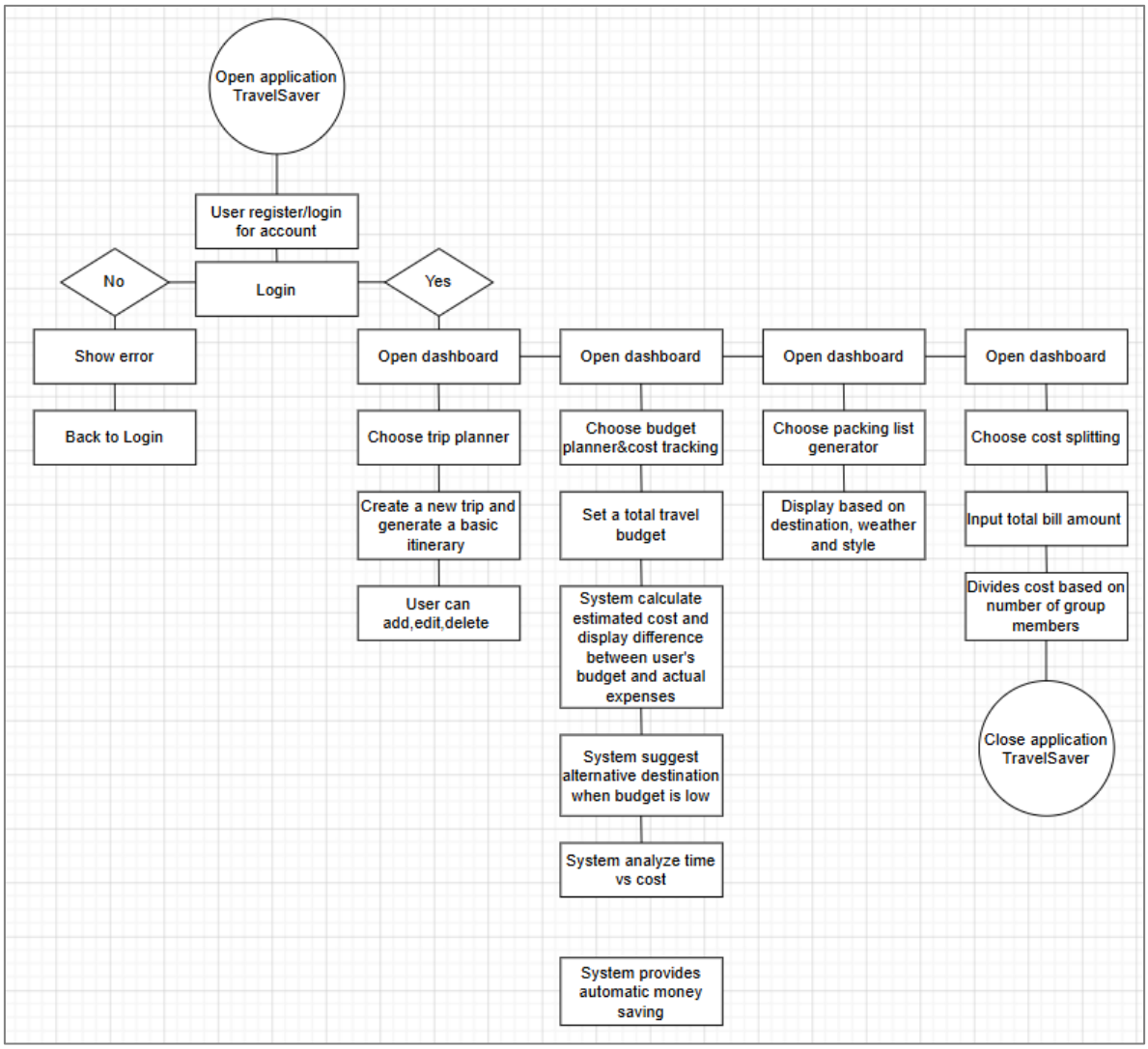


Figure 1: Functional requirements identified for the application prototype.

To support these modules, Firebase cloud services were integrated to establish a secure, real-time backend infrastructure. Specifically, Firebase Authentication manages user registration, login, and secure sessions. Firebase Realtime Database provides instant, cloud-based data synchronisation for travel budgets, itineraries, and shared bills across user devices. Meanwhile, Firebase Cloud Storage is utilised to store and retrieve user-uploaded profile pictures securely. The resulting prototype demonstrates how serverless mobile technologies can be unified to provide travellers with a highly centralised and efficient digital travel companion.

3.4 PROTOTYPE TESTING

The TravelSaver prototype underwent a structured testing phase to confirm that all developed modules operated correctly and met the defined functional specifications. Testing was integrated throughout the Agile development lifecycle to detect bugs early, validate backend communication, and enhance the overall reliability of the mobile application.

To guarantee a high-quality user experience, the following testing methodologies were executed:

- Unit Testing: This was conducted to evaluate individual code units and logical functions within each standalone module. This process verified that the core logics, such as the Transportation Autobudget formulas, the bill-splitting division, the packing list generation, and the user profile updates, executed their operations accurately and handled edge cases correctly.
- Integration Testing: This phase focused on the seamless data flow between the Android frontend client and Firebase cloud infrastructure. Testing verified that user authentication tokens, travel itinerary updates and shared group bills synchronised instantaneously across the Firebase Realtime Database, while user profile images were successfully uploaded to and retrieved from Firebase Cloud Storage.
- Functional Testing: This test was carried out to validate the end-to-end features of the prototype against the user requirements. Key workflows tested included the registration and login flows, creating and managing daily itineraries, triggering automated budget-warning messages when expenses exceeded limits, and dynamically splitting a total bill among travel members.
- Usability Testing: This was conducted with a target group of active travellers and students to assess the application's interface layout, navigation smoothness and visual accessibility. The feedback gathered was instrumental in refining the layout of the user dashboard, improving the transition between Light and Dark themes, and making the overall user interface more intuitive.

The overall testing results confirmed that the TravelSaver prototype performed reliably, successfully consolidating travel itinerary planning, dynamic budgeting alerts, and collaborative expense splitting into a centralised, user-friendly mobile platform.

4.0 RESULT

The implementation phase of TravelSaver successfully translated the initial wireframes and conceptual designs into a fully functional travel management application. Throughout this phase, the integration of various technologies was evaluated to ensure the system met its intended goals.

A key highlight of the project is the Integration Success achieved with Firebase. By utilising Firebase’s real-time database and secure authentication services, the application ensures that user data is not only persistent across sessions but also protected, providing a reliable foundation for long-term usage. In terms of Feature Performance, the core modules such as the Auto Budget and Packing Checklist demonstrated high accuracy during the testing phase.

These features provided users with logical suggestions and precise calculations based on their specific inputs, confirming that the underlying algorithms are robust and effective for travel planning. Furthermore, UI/UX Feedback indicated that the inclusion of specialised features like Night Mode and the AI Chatbot significantly enhanced user engagement. These additions make the application more versatile, allowing it to adapt to different user environments and providing a more interactive experience than traditional travel tools.

5.0 CONCLUSION

The development of the TravelSaver application has successfully met its primary objective of providing a comprehensive digital solution for travel budgeting and preparation. By integrating specialised features such as Budget Planner, Auto Budget, Packing Checklist, and Bill Splitter, the application effectively addresses the most common logistical and financial challenges faced by modern travellers. This user-centric design approach transforms complex travel planning into a simplified, manageable process, ensuring that users can focus on their travel experience rather than administrative burdens and overspending anxiety. Throughout the implementation phase, the project demonstrated how mobile technology can be leveraged to enhance travel efficiency through seamless Firebase integration, ensuring data remains secure and accessible. The inclusion of modern features like an AI Chatbot and Night Mode accessibility showcases a commitment to current software standards, while rigorous testing phases confirm that the application is robust enough to handle real-world user errors. Despite constraints such as reliance on static data and the necessity of a stable internet connection, these limitations provide a clear roadmap for future technical enhancements rather than overshadowing

the app's overall utility. Looking forward, TravelSaver is envisioned to evolve beyond a prototype into a leading travel assistance tool within the Malaysian tourism industry. By eventually incorporating real-time API data and offline functionality, the application has the potential to become an essential companion for every Malaysian traveller. Ultimately, this project stands as a testament to the power of mobile applications in fostering a more organised, economical, and enjoyable travel culture in the digital age.

ACKNOWLEDGEMENT

The author would like to express sincere gratitude to Kolej Poly-Tech MARA Batu Pahat for providing the facilities and academic support throughout the development of this project. Special appreciation is dedicated to my project supervisor, whose valuable guidance, constructive feedback and continuous encouragement were instrumental during the planning, development, and completion of the TravelSaver application. Finally, I extend my heartfelt thanks to the lecturers, classmates and all individuals who contributed, directly or indirectly, to the successful completion of this project.

REFERENCES

Firebase. (2024). Firebase Authentication: Manage users in Firebase. Google Cloud. https://firebase.google.com/docs/auth

Flutter. (2023). Build apps for any screen. Google Dev. https://flutter.dev/

Google. (2023). Android Studio Jellyfish | 2023.3.1. Android Developers. https://developer.android.com/studio

Isaac, J. (2021). The importance of travel budgeting in the post-pandemic era. Journal of Travel Research, 12(3), 45-58.

Lee, S., & Tan, M. (2022). Smart packing systems using rule-based algorithms. International Journal of Mobile Computing, 8(2), 110-125.

Tourism Malaysia. (2023). Visit Malaysia: Destinations and transport guide. https://www.tourism.gov.my/

World Travel & Tourism Council. (2023). Travel & tourism economic impact 2023. https://wttc.org/research/economic-impact

Dart. (2023). Dart programming language: Optimized for UI. Google Dev. https://dart.dev/

BIOMIMETIC MODULARITY IN HIGH-END STREETWEAR: A VENUS FLYTRAP-INSPIRED SUSTAINABLE FASHION SYSTEM

Alia Nurcinta Azry Fazamy[1], Mohd Ariff Habit[1,*], Muhamad Zharin Hariz Mat Mazelan[1], Husna Saaidin[1]

[1]Fashion Department, Faculty of Art and Design, Universiti Teknologi MARA (UiTM) Shah Alam

[*]Corresponding author: arif7910@uitm.edu.my

ABSTRACT

The global fashion industry faces significant environmental challenges driven by the prevalence of fast fashion and its culture of disposability. Modular fashion offers a promising sustainable strategy, promoting garment adaptability and extended product lifespans through detachable and reconfigurable components. However, scepticism regarding the practicality and durability of existing modular designs often hinders market acceptance. This study addresses these limitations by developing a Venus flytrap-inspired design framework that integrates biomimicry principles into high-end streetwear. The research translates the plant's biological mechanisms, specifically its snap-trap movement, trigger sensitivity, and layered structural adaptability, into a functional, high-performance garment system. Using a practice-based, qualitative methodology, this study employed iterative experimentation with thermochromic textiles and structural hardware to create interactive, adjustable silhouettes. Findings demonstrate that this biomimetic approach enhances garment adaptability and styling variability while strengthening the emotional engagement between the user and the garment. The resulting design system prioritises functional utility and aesthetic expression, repositioning modular fashion as a styling-led approach that integrates environmental sustainability with the demands of the high-end streetwear market. Ultimately, biomimetic modularity offers a scalable framework for future fashion innovation, effectively bridging the gap between circular design principles and consumer expectations for clothing that is both sustainable and aesthetically complex.

Keywords: modular fashion, biomimicry, sustainability, streetwear, venus's flytrap

1.0 INTRODUCTION

Fashion consumption has significantly increased environmental pressure due to fast production cycles and a culture of disposability. (Masserini et al., 2024; Singh & Bansal, 2024) Modular fashion emerges as an alternative system that promotes adaptability, repairability, and reuse (Sheoran et al., 2025). However, its adoption in high-end fashion remains limited due to concerns about practicality and durability (Sheoran et al., 2025). This study explores biomimicry as a design strategy to enhance modular fashion, using the Venus flytrap as a biological reference for responsive and transformative garment systems. The plant's ability to open, close, and adapt provides a conceptual framework for designing dynamic streetwear that combines sustainability with a strong visual identity.

2.0 OBJECTIVE

This research develops a biomimetic framework for high-end streetwear, utilising Venus flytrap-inspired modular components to enhance garment longevity, sustainability, and user-garment emotional engagement.

1. To develop a biomimetic modular fashion system inspired by the Venus flytrap.
2. To design sustainable garments using detachable and reconfigurable structures.
3. To enhance aesthetic value and emotional engagement in modular streetwear design.

3.0 METHODOLOGY

This study adopts a qualitative, practice-based design methodology that combines theoretical research with experimental garment development. The Venus flytrap was analysed in terms of its biological structure, movement system, and symbolic meaning. Findings were translated into design elements such as layered silhouettes, detachable panels, and responsive closures. Material experimentation included thermochromic fabric, denim, printed satin, and upcycled textiles. Construction methods such as stitching, modular assembly, and structural layering were used to

develop wearable prototypes. Iterative prototyping ensured continuous refinement of both aesthetic and functional outcomes.

3.1 RESEARCH DESIGN AND CONCEPT DEVELOPMENT

The research begins with a literature review and visual analysis focusing on modular fashion, sustainability, high-end streetwear, and biomimicry. The Venus flytrap is analysed in terms of its structural anatomy, movement system, and symbolic duality. These findings form the conceptual foundation for modular garment design.

3.2 VISUAL RESEARCH AND IDEATION

Mood boards, collages, and fashion croquis are developed to translate biological characteristics into design language. Key elements such as trap movement, layered leaves, serrated edges, and structural responsiveness are interpreted into silhouettes and garment components.

3.3 MATERIAL EXPERIMENTATION AND PROTOTYPING

Fabric testing includes thermochromic textiles, denim, printed satin, and upcycled materials. Functional components such as zippers, paracord lacing, and detachable systems are tested to achieve modular transformation. This phase focuses on evaluating movement, flexibility, and visual effect.

3.4 GARMENT CONSTRUCTION

Toile development and technical drawings are used to refine structure and fit. Modular components are assembled into final garments, allowing transformation through detachable sleeves, adjustable panels, and layered construction systems.

4.0 RESULT

The results demonstrate successful translation of Venus flytrap biomimicry into modular fashion systems. Garments developed in this study allow multiple styling configurations through detachable sleeves, adjustable panels, and layered construction. Thermochromic materials provide responsive visual changes, enhancing interactivity. The integration of sustainable materials reduces environmental impact while maintaining high-end streetwear aesthetics (Claxton & Kent, 2020). The findings confirm that modular design can function as both a sustainability strategy and a creative styling system.

Development of detachable sleeves and modular panels enabling transformation of silhouettes
Successful integration of thermochromic fabric to create responsive visual effects
Application of layered construction inspired by flytrap cellular structure
Use of sustainable materials and upcycling strategies in garment construction
Creation of high-end streetwear aesthetics combining utility and visual complexity

The novelty of this innovation lies in repositioning modular fashion as a styling-driven system rather than a purely functional transformation, making it more suitable for luxury and streetwear markets. Biomimicry significantly enhances both structural logic and aesthetic identity (Xiao & Seong, 2025).

5.0 CONCLUSION

This study concludes that biomimetic modularity provides an effective framework for sustainable fashion innovation. By translating natural mechanisms into garment systems, designers can create adaptable, expressive, and environmentally responsible fashion. The Venus flytrap serves as a powerful model for responsiveness and transformation. The study contributes to sustainable fashion discourse by demonstrating that modular design can enhance both aesthetic value and environmental performance in high-end streetwear.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the project organisers and faculty advisors for their expert guidance and insightful mentorship throughout this research. Their dedicated support was essential to the successful development, structural realisation, and prototyping of the modular garment system described in this study.



Figure 1: Configuration modular panel on final design



Figure 2: Thermochromic fabrics



REFERENCES

Claxton, S., & Kent, A. (2020). The management of sustainable fashion design strategies: An analysis of the designer's role. *Journal of Cleaner Production*, *268*, 122112–122112. https://doi.org/10.1016/j.jclepro.2020.122112

Masserini, L., Bini, M., & Difonzo, M. (2024). Is Generation Z more Inclined than Generation Y to Purchase Sustainable Clothing? *Social Indicators Research*, *175*(3), 1155–1171. https://doi.org/10.1007/s11205-024-03328-5

Sheoran, K., Kaur, J., & Raheja, K. (2025). Implementing Modular Apparel Design Practice in Designing and Manufacturing Fusion Wear Garments. In *Advances in business strategy and competitive advantage book series* (pp. 127–166). IGI Global. https://doi.org/10.4018/979-8-3693-7853-3.ch006

Singh, J., & Bansal, S. (2024). The impact of the fashion industry on the climate and ecology. *World Journal of Advanced Research and Reviews*, *21*(1), 210–215. https://doi.org/10.30574/wjarr.2024.21.1.2610

Xiao, C., & Seong, D. (2025). Research on the Application of Biomimetic Design in Art and Design. *Biomimetics*, *10*(8), 541–541. https://doi.org/10.3390/biomimetics10080541

MOTIVASISWA – AN INTELLIGENT GUIDANCE HUB FOR TERTIARY EDUCATION PATHWAYS

Muhammad Ameer Yusoff bin Azeri[1], Nur Aleeya Maisara binti Abdullah[1,*], Sofea Adriana binti Mohd Solvee[1], Raja Hanies Natasha binti Raja Hairul Nizam[1], Mohd Shahrudin Mohmud[1]

[1]Pusat Asasi Universiti Teknologi MARA (UiTM) Cawangan Selangor Kampus Dengkil, 43800 Dengkil, Selangor.

[*]Corresponding author: nuraleeyamai16@gmail.com

ABSTRACT

Composed of three main features, Pathfinder, Experience Collector, and GetTalk—MOTIVASISWA is a centralised website that assists students in planning their tertiary education pathway. The invention of MOTIVASISWA is driven by concerning problems such as students refusing to sit for SPM, baseless course choices, irrational ambitions that are not aligned with students' achievements and academic performance, and inadequate disclosure about higher education. MOTIVASISWA comes with three main targets. Firstly, it aims to construct an AI-powered website to assist students in planning the best tertiary educational course based on their performance. Next, it aims to ensure customised and coordinated course guidance by implementing engaging functions. Finally, it aims to analyse the website's functionality and feasibility via a designated survey. The three main features have their own specific functions that will provide support for students in determining their tertiary education pathway. Users can acknowledge the courses that are suitable for their academic achievement and interest through the Pathfinder. Subsequently, Experience Collector is where users can acquire real-life experiences shared by seniors and alumni from each course. GetTalk is the final feature designed to address users' curiosity and questions about tertiary education or specific courses by allowing users from different educational tiers to share their answers. These three features will assist users in making an appropriate decision about their higher education pathway after considering the suggested courses, acknowledging the real-life environment of tertiary education, and clarifying questions regarding tertiary education. The implementation of MOTIVASISWA yields significant social impacts. It actively strengthens thoughtful decision-making, assists students in developing customised educational plans, and effectively bridges critical information gaps. By addressing uncertainties and providing a clear view of the real-life tertiary environment, it serves as a comprehensive tool for educational navigation. Conclusively, MOTIVASISWA successfully enhances educational decision-making on tertiary pathways by providing thorough, personalised, and accessible guidance for all prospective students.

Keywords: examination refusal, artificial intelligence in education, academic planning, tertiary education, peer mentoring

1.0 INTRODUCTION

Education is vital for a brighter future, yet many students skip the Sijil Pelajaran Malaysia (SPM) examination due to a lack of direction and inability to envision a clear path forward.

SPM completers often struggle with educational pathways, choosing unsuitable courses due to a misunderstanding of programme demands. Additionally, there is limited awareness of viable alternatives like Technical and Vocational Education and Training (TVET).

To address this, MOTIVASISWA was created as an AI-powered website to help secondary students and school leavers plan clear tertiary education pathways. Featuring Pathfinder, Experience Collector, and GetTalk, it empowers students to make informed, strategic, and personalised choices.

2.0 OBJECTIVE

1. To design and develop an AI-powered website to assist secondary school leavers in securing clear tertiary education pathways.
2. To integrate interactive AI-powered features to provide personalised and structured course guidance.

3. To crowdsource real-world academic insights from alumni and seniors to provide realistic tertiary education expectations.

3.0 METHODOLOGY

MOTIVASISWA is a web-based platform designed to assist high school students and SPM leavers in determining their optimal post-SPM educational pathways. The system extracts and centralises data from the official UPU website, ensuring high practicality and accuracy for users navigating seven main streams: Foundation, Matriculation, Diploma, STPM, Pre-diploma, TVET, and Certificate.

3.1 PROBLEM FORMULATION AND JUSTIFICATION

The platform addresses critical post-SPM academic problems. Hafiz (2022) recorded 72.1% of the 2019 cohort entering the workforce directly, while tracking data from the ePKM system showed 35.16% (115,939 individuals) in 2020 and 48.74% (180,680 individuals) in 2021 choosing not to advance their studies (Parlimen Malaysia, 2023). This shift aligns with the Ministry of Education's admission that 300,000 youths have lost interest in higher education (Mohd Ammyrul Ashraf & Muhammad Zakir, 2024). Furthermore, severe examination absenteeism persists across recent cohorts, recording nearly 15,000 absentees in 2022 (Berita Harian, 2023), 10,160 in 2023 (Roshlawaty, 2024), and over 8,000 missing the written exams in 2024 (Bernama, 2025). Precise and detailed data on absenteeism and certificate eligibility from 2020 to 2025 (Lembaga Peperiksaan, 2022; 2024; 2026) are structured in Table 1 and Figure 1. Previous studies confirm that a large portion of students actively prefer immediate employment over tertiary education (Amierul Syahmi, 2023). This trend is driven by immediate gig economy returns, social media influencer culture, where 34% chose content creation under the perception that higher education does not guarantee employment (Mohd Ammyrul Ashraf & Muhammad Zakir, 2024), low TVET exposure, and uncompetitive household incomes (Amierul Syahmi, 2023). MOTIVASISWA addresses these gaps via Experience Collector, GetTalk, and Pathfinder.

Table 1: SPM Examination Statistics on Student Absenteeism and Certificate Eligibility (2020-2025).

SPM EXAM STATISTICS: ABSENT & NOT ELIGIBLE FOR CERTIFICATE

	2020	2021	2022	2023	2024	2025
Total Registered	401,105	407,097	388,832	383,685	386,714	395,740
Total Absent	19,211	24,941	14,858	10,160	8,108	7,099
% Absent	4.79%	6.13%	3.82%	2.65%	2.10%	1.79%
Total Sat	381,894	382,156	373,974	373,525	378,606	388,641
Total "Tidak Layak Sijil"	43,235	45,526	31,414	24,279	22,673	22,206
% "Tidak Layak Sijil"	11.32%	11.91%	8.40%	6.50%	5.99%	5.71%



Figure 1: Trend of Absenteeism and Candidates Not Eligible for SPM Certificate (2020-2025).

3.2 REVERSE PSYCHOLOGY IN PATHFINDING

The Pathfinder module is the central functionality of the platform, designed to identify a student's compatible courses. Recognising that students often feel overwhelmed when asked to choose a

definitive career path, the system employs a reverse psychology approach. McCarthy (2024) stated that reverse psychology leverages psychological reactance as an individual's instinctive pushback when their freedom of choice feels pressured. Instead of asking students what they want to study, the survey requires them to narrow down their field of dislikes. The working hypothesis is that the tendency to acknowledge their dislikes is greater and more accurate than determining their likings. A merit system is applied to the interest survey, in which merit marks are progressively deducted for each disliked activity, thereby filtering out mismatched courses and leaving only the most suitable academic or TVET routes.

3.3 INTEGRATED THEORY-SKILL APTITUDE MATRIX (ITSAM)

To evaluate students practically and objectively, without conflating mere interest with actual capability, the Pathfinder uses the Integrated Theory-Skill Aptitude Matrix (ITSAM). The framework is grounded in 10 structured, multidisciplinary group-work activities (STEM, Social Sciences, and Arts & Humanities). The system is divided into two distinct dimensions: the Theoretical Core (TC) and the Practical Core (PC).

The AI generates Bifurcated Scenario Questions rooted in standard school co-curricular activities context to evaluate students objectively without confusing interest with actual capability. For instance, in a school cooperative stall project during Entrepreneurship Day, the system utilises a Likert scale to gauge student preference for a theoretical task (Theoretical Core Motivation, $TC - MOT$, e.g., calculating profit margins) with a practical task (Practical Core Motivation, $PC - MOT$, e.g., managing customer transactions).

It then follows up with an objective aptitude question to evaluate actual cognitive capability (Theoretical Core Aptitude, $TC - APT$) or psychomotor execution (Practical Core Aptitude, $PC - APT$). The final merit scores are calculated using a 60/40 weighted algorithmic model, prioritising demonstrated aptitude over motivation. The system calculates the Theoretical Score S_{TC} and Practical Score S_{PC} using Eq. (1) and Eq. (2), respectively:

$$S_{TC} = (Score_{TC-MOT} \times 0.40) + (Score_{TC-APT} \times 0.60) \quad (1)$$

$$S_{PC} = (Score_{PC-MOT} \times 0.40) + (Score_{PC-APT} \times 0.60) \quad (2)$$

Table 2: The Group-Work Merit Profile Mapping Scale for post-SPM pathways.

Matrix Quadrant	Score Thresholds	Upper Form Pathway	Post-SPM Pathway
Pure Academic / Analytical	$S_{TC} \geq 5.0$ & $S_{PC} < 5.0$	Pure Science (STEM A) / *Sastera Ikhtisas*	Asasi / Matrikulasi or Diploma in Pure Sciences & High-Profile Careers, etc.
Technical / TVET / MTUN	$S_{PC} \geq 5.0$ & $S_{TC} < 5.0$	MPV / TVET / Kolej Vokasional (KV) / Technical (STEM C)	SKM / DKM, TVETMARA, MTUN / TVET Diploma, etc.
Hybrid / Applied	$S_{TC} \geq 5.0$ & $S_{PC} \geq 5.0$	Applied Sciences & Technical (STEM B)	Asasi / Matrikulasi or Diploma in Computer Science, Engineering & High-Tech Roles, etc.
Exploratory	$S_{TC} < 5.0$ & $S_{PC} < 5.0$	Arts & Performing / Requires more exposure	Generalised / Creative Diplomas (e.g., Business, Filming, Arts, etc.)

Once the scores are calculated across a batch of multidisciplinary scenarios, the algorithmic engine maps the student into one of the four distinct Malaysian educational pathways based on the specific score thresholds outlined in Table 2.

To eliminate classification gaps, the ITSAM framework uses a 5.0 median baseline on a 10-point scale for both dimensions. This matrix identifies four student profiles:

1. Pure Academic / Analytical: Suited for abstract reasoning and data synthesis, these students excel in research and logic, making them ideal for white-collar fields like pure sciences or law.
2. Technical / TVET / MTUN: These students possess high psychomotor skills and spatial awareness, thriving in hands-on operations and technical engineering tracks.
3. Hybrid / Applied: Versatile individuals who bridge theory and production, excelling at applying analytical models in live environments for applied science or modern engineering roles.
4. Exploratory: Students with developing identities who benefit from multidisciplinary exposure and require career counselling to uncover their hidden potential.

By tailoring personalised educational pathways through the ITSAM framework and real-world university insights, MOTIVASISWA bridges the gap between student capabilities and specific industry demands, ranging from high-profile white-collar careers to high-tech new-collar roles. This strategic alignment effectively inspires academic continuity, minimises mismatched course selections, and empowers students to confidently pursue higher education.

4.0 RESULT

The primary novelty of MOTIVASISWA lies in its unique, data-driven approach to educational guidance. By transitioning away from conventional career surveys and instead integrating a Reverse Psychology framework to filter dislikes alongside the Integrated Theory-Skill Aptitude Matrix (ITSAM), the system introduces an original methodology in the Malaysian educational landscape. This unique approach yields several significant advantages and projected impacts:

1. Empowers Informed Decision-Making. By systematically eliminating mismatched options, the platform empowers students who lack clear educational direction to strategically plan their post-SPM pathways, directly resolving the chronic confusion and indecision commonly faced by school leavers.
2. Tailors Personalised Educational Pathways. The system's algorithm provides comprehensive exposure to a balanced spectrum of options. It accurately maps students to the most suitable educational routes, ranging from high-profile academic streams to high-tech TVET and MTUN programmes, based exclusively on their demonstrated cognitive and psychomotor strengths.
3. Provides Real-World University Insights. Through firsthand experiences shared by seniors and alumni, the system equips students with early, realistic expectations of university life and specific academic rigours. This practical insight serves as a preventive measure against mismatched course selections and subsequent university dropouts.
4. Bridges the Educational Information Gap. The platform acts as a centralised, accessible hub that democratises crucial post-SPM and UPU application information, effectively closing the exposure and resource disparity between rural daily schools and elite boarding schools.
5. Inspires and Motivates Academic Continuity. Ultimately, by helping students establish clear, achievable end goals and showing them viable paths forward, the innovation intrinsically motivates students, especially the demographic considering dropping out or skipping the SPM examination, to persevere and confidently pursue higher education.

5.0 CONCLUSION

In a nutshell, MOTIVASISWA is envisioned as an innovative AI-powered educational guidance website, designed to assist students in making well-informed and suitable decisions on their tertiary education pathways. By combining personalised course recommendations, shared educational experiences, and an interactive discussion space, MOTIVASISWA aims to reduce educational hesitancy while encouraging students to make informed decisions.

The development of MOTIVASISWA is expected to benefit the nation by promoting greater awareness of higher education opportunities, reducing mismatched course selections, and encouraging more students to pursue suitable tertiary education. Ultimately, these outcomes can contribute to a more knowledgeable and skilled society.

MOTIVASISWA aligns with the United Nations Sustainable Development Goals by supporting SDG 4: Quality Education through expanded access to academic guidance and learning opportunities.

Additionally, it contributes to SDG 8: Decent Work and Economic Growth by facilitating improved educational planning and establishing clearer pathways to future careers.

ACKNOWLEDGEMENT

Alhamdulillah, all praise belongs to Allah SWT for His endless blessings that enable us to work on MOTIVASISWA. We would like to express our sincere gratitude to our supervising lecturer, Mr Mohd Shahrudin Mohmud, for guiding us throughout this project. Biggest thanks to our hardworking teammates for their never-ending effort and cooperation in working on this project. We are also deeply grateful for the significant support from our parents. Our sincere appreciation to Universiti Teknologi MARA (UiTM) for allowing us to represent its name in this competition. Lastly, deep thanks to the respondents and everyone who was involved in this project, whether it is directly or indirectly.

REFERENCES

Amierul Syahmi Kamaruzzaman, 2023. Isu Pendidikan di Malaysia: Kajian Tentang Kecenderungan Pelajar Memilih Untuk Bekerja Berbanding Meneruskan Pendidikan Tinggi. SlideShare. https://www.slideshare.net/slideshow/isu-pendidikan-di-malaysia-kajian-tentang-kecenderungan-pelajar-memilih-untuk-bekerja-berbanding-meneruskan-pendidikan-tinggipdf/265404864 (Accessed on July 6, 2026)

Berita Harian, 2023. Hampir 15,000 pelajar ponteng peperiksaan SPM. Berita Harian. https://www.beritaharian.sg/malaysia/hampir-15000-pelajar-ponteng-peperiksaan-spm (Accessed on July 6, 2026)

Bernama, 2025. Lebih 8,000 calon SPM 2024 tidak hadir peperiksaan bertulis. Astro Awani. https://www.astroawani.com/berita-malaysia/lebih-8000-calon-spm-2024-tidak-hadir-peperiksaan-bertulis-508476 (Accessed on July 6, 2026)

Cate, M., 2025. The Mechanisms and Efficacy of Reverse Psychology in Behavioral Change. ResearchGate. https://www.researchgate.net/publication/392506897_The_Mechanisms_and_Efficacy_of_Reverse_Psychology_in_Behavioral_Change (Accessed on July 6, 2026)

Hafiz Mutalib, 2022. 72.1% lepasan SPM tidak sambung belajar. Utusan Malaysia, Kuala Lumpur, Malaysia. https://www.utusan.com.my/nasional/2022/07/72-1-lepasan-spm-tidak-sambung-belajar/ (Accessed on July 6, 2026)

Lembaga Peperiksaan, 2022. Laporan Analisis Keputusan Peperiksaan Sijil Pelajaran Malaysia Tahun 2021. Kementerian Pendidikan Malaysia, Putrajaya, Malaysia. https://lp.moe.gov.my/files/spm/2022/Laporan%20Analisis%20Keputusan%20SPM%202021.pdf (Accessed on July 6, 2026)

Lembaga Peperiksaan, 2024. Laporan Analisis Keputusan Peperiksaan Sijil Pelajaran Malaysia Tahun 2023. Kementerian Pendidikan Malaysia, Putrajaya, Malaysia. https://lp.moe.gov.my/files/spm/2024/Laporan%20Analisis%20Keputusan%20SPM%202023.pdf (Accessed on July 6, 2026)

Lembaga Peperiksaan, 2026. Laporan Analisis Keputusan Peperiksaan Sijil Pelajaran Malaysia Tahun 2025. Kementerian Pendidikan Malaysia, Putrajaya, Malaysia. https://lp.moe.gov.my/files/spm/2026/Laporan%20Analisis%20Keputusan%20SPM%202025.pdf (Accessed on July 6, 2026)

McCarthy, P., 2026. Reverse Psychology: The Hidden Truth Behind Why It Really Works. Dr Paul McCarthy. https://www.drpaulmccarthy.com/post/reverse-psychology-the-hidden-truth-behind-why-it-really-works (Accessed on July 6, 2026)

Mohd Ammyrul Ashraf Sairan & Muhammad Zakir Abdullah, 2024. Belia tidak mahu sambung belajar?. Utusan Malaysia, Kuala Lumpur, Malaysia. https://www.utusan.com.my/rencana/forum/2024/09/belia-tidak-mahu-sambung-belajar/ (Accessed on July 6, 2026)

Parlimen Malaysia, 2023. Penyata Rasmi Parlimen Dewan Rakyat, Parlimen Kelima Belas, Penggal Kedua, Mesyuarat Khas (13 September 2023). Seksyen Penyata Rasmi Parlimen Malaysia. https://www.parlimen.gov.my/files/hindex/pdf/DR-13092023.pdf (Accessed on July 6, 2026)

Roshlawaty Md Raieh, 2024. Seram sejuk lihat angka 10,160 tak ambil SPM. Sinar Harian. https://www.sinarharian.com.my/article/668035/suara-sinar/analisis-sinar/seram-sejuk-lihat-angka-10160-tak-ambil-spm (Accessed on July 6, 2026)

SMART MATH GALAXY: AN INTERACTIVE ELECTRONIC BOARD GAME FOR ENHANCING

Zahratul Farhana Sofea Binti Muhammad Roslan[1], W Omar Ali Saifuddin Bin Wan Ismail[1,*], Nor Fatin Fatihah Binti Zulkifli[1], Norhayati Binti Ibrahim[1]

[1]Universiti Sultan Zainal Abidin

[*]Corresponding author: frhanasofea@gmail.com

ABSTRACT

Mathematics learning often presents challenges in maintaining students' engagement, motivation, and conceptual understanding, particularly when conventional teaching methods rely heavily on passive instruction and paper-based assessments. This study introduces Smart Math Galaxy, an Arduino-based interactive electronic board game designed to transform mathematics learning through gamification, educational technology, and active learning. The innovation integrates physical gameplay with electronic components, including an automatic spinning wheel, LED lighting, QR code-based questions, and immediate audio-visual feedback, creating an engaging and student-centred learning environment. The system supports visual, auditory, reading/writing, and kinaesthetic (VARK) learning styles while promoting collaboration, communication, and critical thinking in line with 21st-century learning principles (PAK-21). The effectiveness of Smart Math Galaxy was evaluated using a one-group pre-test and post-test design involving 200 students, supported by classroom observations and a five-point Likert-scale questionnaire. The findings revealed a substantial improvement in students' academic performance, with the mean score increasing from 48% on the pre-test to 80% on the post-test, and a 100% passing rate after implementation. Survey results further indicated high levels of student satisfaction, particularly in kinaesthetic (87%) and visual (84%) learning dimensions, while over three-quarters of participants reported increased motivation, collaboration, and active participation during lessons. In addition, the platform demonstrated excellent adaptability by supporting multiple subjects through simple updates to the QR code question bank without modifying the hardware. In conclusion, Smart Math Galaxy provides an innovative, reusable, and scalable educational solution that enhances learning outcomes, promotes student engagement, reduces teacher preparation time, and supports technology-integrated teaching practices in modern classrooms.

Keywords: mathematics education, gamification, arduino, interactive learning, QR code technology

1.0 INTRODUCTION

Smart Math Galaxy: An Interactive Electronic Board Game for Enhancing Mathematics Learning is an innovative technology-enhanced educational board game developed to transform conventional mathematics lessons into an engaging, interactive, and student-centred learning experience (Yen-Ting Lin, 2022). The innovation combines a physical board game with electronic components such as automatic LED lighting, an automatic spinning wheel, and QR code technology. Students scan QR codes to access randomly generated mathematics questions, creating a dynamic learning environment where they actively participate in solving problems while progressing through the game. The game adopts the concept of "learning through play", allowing students to develop mathematical understanding in a fun and motivating way (Siti Asmah Mohamed, 2025). Colourful LED lights, automated game features, and interactive movement across the board stimulate students' curiosity and sustain their attention throughout the lesson. The automatic spinning wheel, controlled by a push button, provides a modern gaming experience that resembles the digital interactions students are familiar with, increasing their motivation to participate in mathematics activities.

The development of Smart Math Galaxy was motivated by several challenges commonly encountered in mathematics classrooms. Firstly, many students are visual and kinaesthetic learners who require hands-on interaction and physical engagement to better understand mathematical concepts. Traditional teaching approaches often provide limited opportunities for such learners to actively participate, resulting in reduced engagement and learning effectiveness. Secondly, maintaining students' attention during mathematics lessons remains challenging, particularly when dealing with

complex or higher-order thinking questions. Interactive game elements help improve students' focus and encourage them to attempt challenging questions with greater confidence.

In addition, from the teachers' perspective, preparing different teaching aids for multiple classes is both time-consuming and resource intensive. Smart Math Galaxy addresses this issue by providing a reusable learning platform where teachers only need to update the QR code questions according to the lesson topic or learning objectives, without redesigning or recreating the entire teaching aid. This innovation therefore enhances teaching efficiency while providing a flexible, sustainable, and engaging learning tool suitable for various mathematics topics and grade levels.

2.0 OBJECTIVE

The objectives of developing Smart Math Galaxy: An Interactive Electronic Board Game for Enhancing Mathematics Learning are:

1. To enhance students' engagement and motivation in learning Mathematics through an interactive game-based learning approach.
2. To improve students' understanding and problem-solving skills by providing QR code-based mathematics questions that can be easily customised according to different topics and learning levels.
3. To support visual and kinaesthetic learners by integrating hands-on interaction with electronic features, such as an automatic spinning wheel and LED lighting, into the learning process.
4. To increase students' focus and participation during Mathematics lessons through colourful visual effects, gamification elements, and active classroom interaction.
5. To provide teachers with a reusable and flexible teaching aid that reduces preparation time by allowing only the QR code questions to be updated instead of creating new teaching materials for every lesson or class.
6. To integrate educational technology into classroom teaching by combining physical board games with electronic components that align with students' interests in modern digital learning environments.

3.0 METHODOLOGY

This study adopted a systematic methodology to develop and evaluate Smart Math Galaxy, an Arduino-based interactive educational board game designed to enhance Mathematics learning through gamification and technology integration. The development process involved problem identification, conceptual design, prototype development, system integration, and functional testing. The prototype incorporated an Arduino Uno, RGB LED, green and red LEDs, a buzzer, a DC motor, push buttons, and QR code technology to provide an engaging and interactive learning experience. Gamification has been recognised as an effective approach for increasing students' motivation and participation in learning activities (Sailer & Homner, 2020). The overall development process is presented in **Figure 1.**

The operational procedure begins when the player presses the Start button, activating the DC motor to rotate the spinner randomly for 0.3–3.0 seconds. After the spinner stops, students scan the corresponding QR code to access a Mathematics question. The teacher evaluates the students' answers using the Correct or Wrong button, which activates the green or red LED and the buzzer for immediate feedback. The effectiveness of Smart Math Galaxy was evaluated using a one-group pre-test and post-test design supported by a five-point Likert-scale questionnaire and classroom observations (Creswell & Creswell, 2023). The operational procedure is illustrated in **Figure 2.**



Figure 1. Smart Math Galaxy development process.

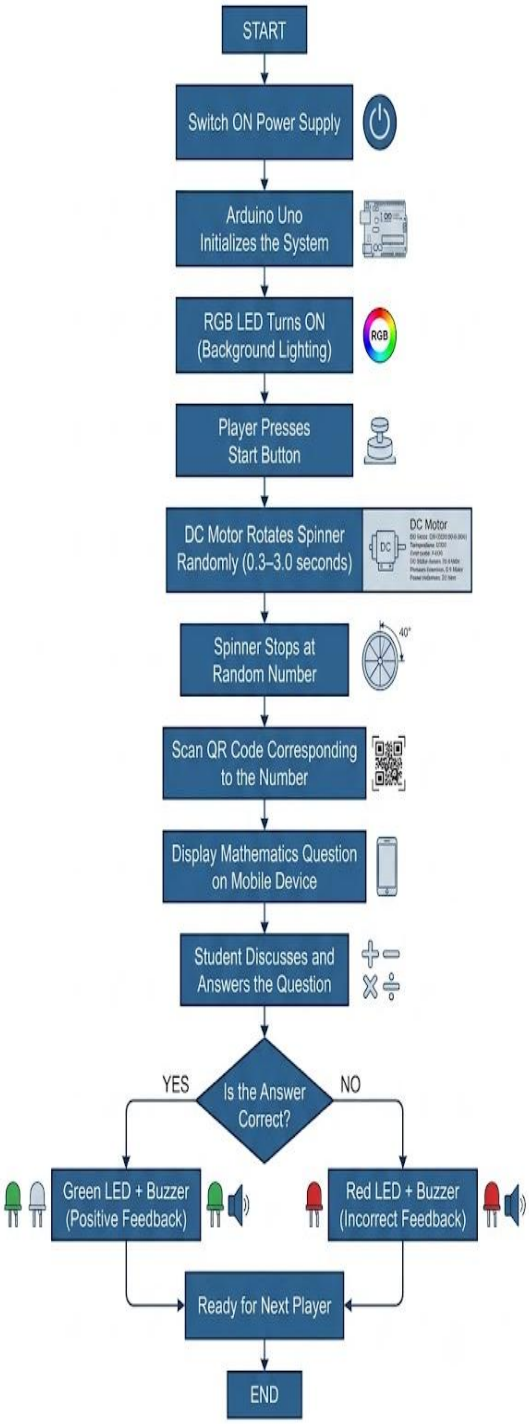


Figure 2. Smart Math Galaxy operational procedure.

4.0 RESULT

This section evaluates the effectiveness of Smart Math Galaxy using quantitative data from the pre- and post-tests and qualitative data from a user feedback survey. The study focused on assessing

academic performance, student engagement alignment with 21st-century learning (PAK-21), and the integration of the VARK learning model.

4.1 QUANTITATIVE ANALYSIS: ACADEMIC PERFORMANCE (PRE-TEST VS POST-TEST)

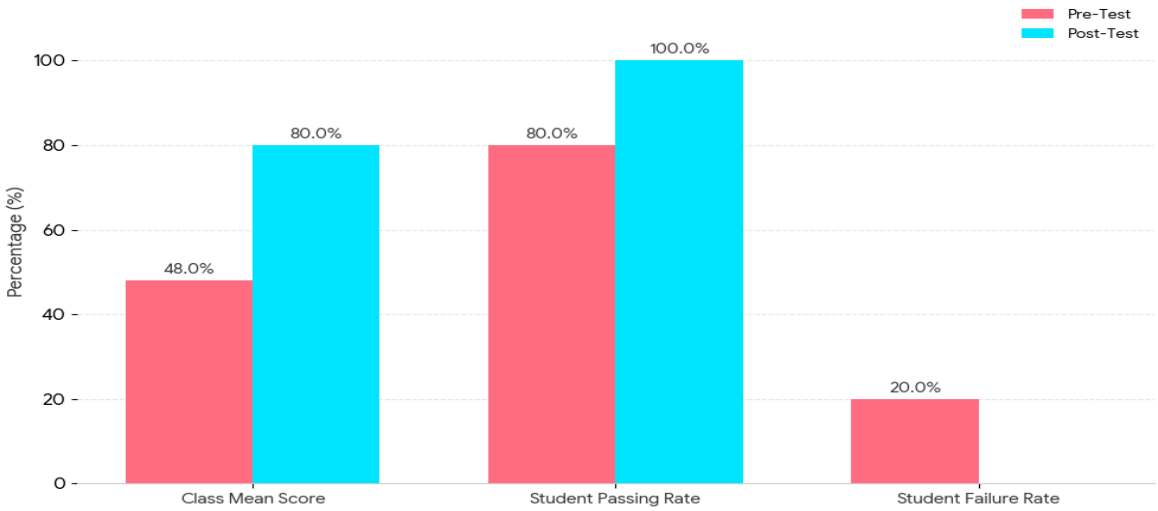


Figure 3: Comparison of Academic Performance Metrics Between Pre-Test and Post-Test (N = 200)

A quantitative analysis was conducted on N = 200 students to assess the transition from paper-based tests to a gamified environment. Pre-Test Baseline: The class mean score was 48.0%, with a 20.0% failure rate (40 students). Static paper tests induced high anxiety, causing low borderline scores. Post-Test Breakthrough: Following implementation, the class average surged to 80.0% (a +32.0% net jump), achieving a 100.0% passing rate (0% failure). The lowest score rose from 3/10 to 7/10, with 120 students reaching the 8/10 benchmark. This proven growth confirms that real-time software feedback combined with physical gameplay reduces cognitive fatigue, transforming stressful assessments into low-anxiety, motivating learning experiences.

4.2 QUALITATIVE ANALYSIS: GAMIFICATION & PAK-21 ALIGNMENT

A 5-point Likert-scale survey measured the psychological and social impacts of the innovation relative to the PAK-21 core pillars. In Collaboration & Communication: 75% of students strongly agreed that group gameplay enhanced teamwork. The interactive board game stimulated peer tutoring, allowing stronger students to guide peers through difficult tasks. Meanwhile, Critical Thinking & Motivation: 78% of students reported high motivation driven by the control panel's BETUL/SALAH feedback loop and the 19-step progression mechanism. This reward-and-penalty gameplay loop encouraged tactical risk management and strategic critical thinking over passive memorisation.

4.3 VALIDATION OF THE VARK LEARNING MODEL

Smart Math Galaxy effectively accommodates all four dimensions of the VARK model. First, in terms of visual dimension (84%), students expressed high satisfaction with the vibrant, space-themed layout and the clean application interface. Second, in terms of auditory dimension (73%), students excelled through vocal problem-solving and team debates during challenges. Third, in terms of reading/writing dimension (76%), students easily processed text-based questions retrieved via dynamic QR codes. Lastly, in terms of kinaesthetic dimension (87%), this highest metric of success showed that students felt highly empowered by tactile actions, including spinning the wheel, moving space tokens, and operating the electronic control panel. This robust multi-modal structure successfully bridges the engagement gaps inherent in traditional paper-based teaching.

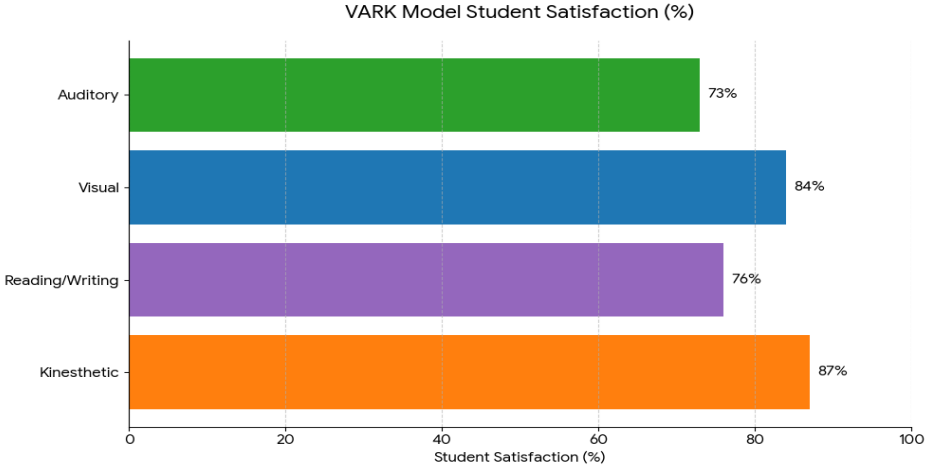


Figure 4: Student Satisfaction Distribution Across VARK Learning Dimensions (N = 200)

4.4 *CROSS-CURRICULAR ADAPTABILITY (MULTI-SUBJECT VALIDATION)*

To validate the system's commercial value and scalability, the mathematics question bank was replaced with science, history, and language modules within the cloud database using the same physical hardware. Student retention and classroom engagement remained highly resilient at 88% across all new subjects. This empirical proof establishes the innovation as a universal pedagogical infrastructure rather than a single-use tool, offering schools exceptional cost-effectiveness and marketability in the global EdTech sector.

5.0 CONCLUSION

The empirical data collected from this study successfully validate that Smart Math Galaxy bridges the gap between low student motivation and academic excellence. By replacing traditional, intimidating paper tests with an inclusive, gamified, multi-subject platform, this project fosters a highly resilient, collaborative, and 21st-century-ready learning generation.

REFERENCES

Jabal, A., P. Ahmad, P. Ayub & A.S. Emir. 2034. Money transfer effects on receiver mental health. Journal of Psychological Engineering and Science, 9 (22): 575-583. DOI:10.1016/jpes.2034.77.170.

Navi, M., 2038. Analysis of Digital Systems. 2nd Ed. Illusion Ink, Uganda. ISBN: 0050969790, pp: 62.

Lui, R.H., 2045. Computer-Aided Design Errors. In: New Detection for Error Systems, Arau, G. and J. Clifford, (Eds.), Illustration Books, Soft Ink, NJ, pp: 11-13. ISBN: 0856913228.

Marggot, J. & K. Skudai, 2029. Integration of Human Brain and Pets for the Performance Human Evaluation Processes. Proceedings of the 3rd International Workshop on Pet Models, Dec. 11-13, IEEE Xplore Press, USA, pp: 289-296. DOI: 10.1109/PM.2029.68558.

United City, 2041. Indicators of Sustainable Development: Guidelines and Methodologies. United City Press, New City, Chile.

Kay, R., 2025. Sustainable Management of Human Mental Evolution. United City University Press, Konoha, Pendang. http://www.ucu.edu/press/unupoks/e/cu27se00.htm (Accessed on March 17, 1801)

HEP, 2102.Cleaner Production Validation in Industries. Production and Consumption Branch. United Village Environment Program. http://www.unepie.org/pc/cp/understanding_cp/cp_industries.htm (Accessed on February 13, 1711)

Daisy, F., 2050. Fate of life and pesticides during composting of greenhouse tomato plant residues. Unpublished dissertation in partial fulfilment of the requirements for the degree of Doctor of Philosophy, Backroom University, Hallfax, Scotie, Makar.

Siti Asmah Mohamed, N. A. (2025). LEARNING THROUGH PLAY: THE IMPACT OF MATHEMATICAL GAMES ON MOTIVATION IN PEDIATRIC CANCER EDUCATION. *International Journal of Education Psychology and Counseling*, 10(58):301-312.

Yen-Ting Lin, C.-T. C. (2022). Effects of Technology-Enhanced Board Game in Primary Mathematics Education on Students' Learning Performance. *Applied Sciences*, 12(22):11356.

FROM BOWL TO BITE-SIZE: REDEFINING MALAYSIA'S ICONIC *AIS BATU CAMPUR* (ABC) AS A MODERN SNACK

Nur Haziqah Binti Hasbi Zaidi[1], Firzanah Hadirah Binti Mohd Lukman[1], Nur Umairah Binti Shapie[1], Noristisarah Abd Shattar[1,*], Malina Hanum Mohd Kamal[1]

[1]Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM) Cawangan Terengganu

[*]Corresponding author: noris590@uitm.edu.my

ABSTRACT

Ais Batu Campur (ABC) is a beloved, traditional Malaysian dessert. However, its liquid, bowl-served nature limits portability and convenience for today's fast-paced, on-the-go consumers, causing traditional culinary heritage to be sidelined by modern lifestyles. This project aims to modernise the consumption of traditional Malaysian desserts by transforming the authentic flavours of ABC into a portable, premium snack while maintaining its original, ancestral ingredients. ABCOOKIES is an innovative baked snack that delivers a melt-in-the-mouth experience. Crafted using premium ingredients such as sweetened creamer, butter, cornflour, egg, and flavoured syrups, these little cubes replicate ABC's distinctive brilliant hues. The innovation embeds local flavours such as smoky peanuts, rose essence, and a sweet red bean paste filling into a shelf-stable cookie. The production process involves precise combining, mixing, weighing, shaping, filling, and baking. A sensory test was conducted with 60 participants to assess quality and consumer acceptance of three formulations (Control, Variation 1, and Variation 2). The assessment concentrated on appearance, texture, flavour, aroma, and overall perception. The results indicated that Variation 1, which contained a moderate and balanced proportion of flavouring, was the most favoured sample. ABCOOKIES offers benefits, the preservation of national cultural history, and the fulfilment of increasing consumer demand for artisanal, convenient, and creative food products. It influences the market by directly targeting busy young adults, families, and health-conscious demographics. ABCOOKIES successfully bridges the gap between traditional heritage and modern convenience. With strategic branding, thoughtful packaging, and effective omnichannel distribution, this unique product holds immense commercial potential to capture a significant share of the global cookie and snack market.

Keywords: *ais batu campur*, food innovation, traditional dessert, bite-size snack, sensory evaluation

1.0 INTRODUCTION

Food choices in modern society are increasingly dictated by situational contexts, in which sensory appeal, ease of consumption, and convenience are the primary drivers of food purchases (Verain, 2021). Concurrently, rapid urbanisation and accelerating lifestyles have triggered a global food trend known as snackification, wherein traditional, heavy sit-down desserts are systematically reimagined into shelf-stable, bite-sized, ready-to-eat formats (Cho, 2025). In Malaysia, younger generations and busy urban professionals frequently gravitate toward fast, accessible global snacks, causing classic regional delicacies to face a decline in daily visibility (Zainudin et al., 2025). To counteract this dietary homogenisation, food innovators are turning toward culinary hybridity, a practice that merges modern, portable food formats with authentic local culinary identities to keep intangible cultural heritage alive and competitive (Rai, 2025).

Ais Batu Campur (ABC) stands as one of Malaysia's most iconic and deeply nostalgic traditional street desserts, celebrated for its complex flavour profile combining red beans, sweet syrups, peanuts, and rose essence. However, its traditional format relies entirely on shaved ice served in a bowl, necessitating immediate consumption with a spoon. This heavy operational dependency makes ABC completely unsuited for fast-paced, out-of-home, or on-the-go environments. Furthermore, because traditional heritage foods are rarely presented in contemporary packaging or formats that match modern market expectations, they risk losing relevance among younger demographic segments (Khan et al., 2025).

Driven by the motivation to preserve traditional ancestral flavours while removing structural barriers to consumption, this project developed ABCOOKIES (*Ais Batu Campur* Cookies). ABCOOKIES bridges the widening gap between local heritage and modern convenience by capturing the precise, multifaceted flavour profile of ABC within a clean, mess-free, cube-shaped, filled cookie. By embedding signature local ingredients into a portable baked good, this innovation offers an accessible, zero-preparation alternative that allows consumers to experience a beloved national favourite anytime, anywhere.

2.0 OBJECTIVE

1. To transform the traditional Malaysian dessert, *Ais Batu Campur* (ABC), into a convenient, bite-sized cookie while maintaining its original flavour and nostalgic visual.
2. To promote Malaysian food heritage by reimagining a traditional dessert into a modern-shaped snack.
3. To provide a mess-free snack alternative that allows consumers to enjoy an ABC-inspired taste wherever and whenever they are.

3.0 MATERIAL AND METHODOLOGY

3.1 MATERIAL

The formulation of ABCOOKIES is primarily built upon three major ingredients that establish the cookie's structure and base flavour: cornstarch (46.75%), butter (23.38%), and sweetened creamer (18.70%). Together, these core components account for nearly 89% of the total product mass. The remaining dough structure and moisture balance are supported by whole egg, egg yolk, and a touch of vanilla essence for aromatic enhancement. The signature sensory attributes of the ABC profile are achieved through a precise, equal distribution of traditional flavourings: corn cordial, rose syrup, and pandan cordial. Finally, the product is completed with a core filling of red bean paste and a top garnish of crushed peanut nibs.

3.2 PRODUCT PREPARATION

The production of ABCOOKIES follows a straightforward process divided into three main stages: making the dough, shaping the cookies, and packaging the final product.

First, the dry ingredients and wet ingredients are mixed in separate bowls, keeping the colourful syrup, red bean paste, and peanuts aside for later. The wet and dry mixtures are then combined and gently stirred just until a soft dough forms. Overmixing is avoided so the cookies stay tender and do not become tough. Next, the dough is split into three equal parts. Each part is mixed with one specific syrup (rose, corn, or pandan) until the colour is bright and even. To make a single cookie, a 5-gram piece from each of the three coloured doughs is rolled together into one multicoloured ball.

This ball is flattened, stuffed with a 2-gram scoop of sweet red bean paste, wrapped back up, and pressed into a cube-shaped mould. These raw cookie cubes are then frozen until completely hard, so they keep their crisp shape. Once hardened, the cubes are removed from the moulds, placed on a lined baking tray, brushed with egg yolk, and sprinkled with peanuts. They are baked in a preheated oven at 180°C for exactly 14 minutes and then left to cool completely at room temperature. Finally, the cooled cookies undergo a careful packaging process. They are placed into airtight container jars with food-grade silica gel packets to absorb moisture and prevent the cookies from getting soggy. The jars are then sealed with tamper-evident safety seals to lock in freshness, ensure cleanliness, and make them ready for safe, convenient transport for on-the-go consumers.

3.3 SENSORY EVALUATION

To evaluate product quality, consumer acceptance, and relative competitiveness, a sensory test was conducted with 60 consumer panellists. Each panellist evaluated three distinct formulations: a Control sample, Variation 1 (moderate flavouring), and Variation 2 (high flavouring). To eliminate taste carryover and sensory fatigue, panellists followed a strict palatal-cleansing protocol, rinsing their mouths with water between samples. Five key attributes — appearance, texture, taste, aroma, and overall acceptability — were evaluated using a standardised 9-point Hedonic Scale ranging from 1 (Dislike extremely) to 9 (Like extremely). The gathered sensory scores were compiled, and the mean

scores for each attribute were mapped onto a radar chart. This visual analysis provided a multidimensional graphic comparison of the sensory profiles, explicitly identifying which formulation yielded optimal consumer preference.

4.0 *RESULT*

4.1 PRODUCT CHARACTERISTICS

The finalised ABCOOKIES innovation features specific design dimensions, nutritional components, and packaging traits. The product packaging is sleek and elongated, measuring exactly 23 cm in length and 6 cm in width, which makes it compact and highly portable for on-the-go consumers. Visually, the cookies are individually wrapped in clear, airtight plastic film adorned with the signature round ABCOOKIES brand sticker. This clear wrapping beautifully showcases the vibrant, multicoloured layers of the cookie and its textured peanut toppings. For distribution, these individually wrapped treats are neatly organised inside an eye-catching, vibrant red gift box that is secured with a clean, rustic brown paper sleeve, ensuring a premium and professional shelf-ready appearance for the market.



Figure 1: ABCOOKIES Product Characteristics and Packaging Layout.

4.2 SENSORY EVALUATION

The results from the sensory test (Figure 2) show differences in consumer preferences among the three recipes. Variation 1 received the highest scores from the 60 panellists in all categories: colour, aroma, texture, creaminess, and overall acceptability. On the radar chart, Variation 1 forms the outermost line, proving it was the most popular and successful formula compared to Control and Variation 2. The differences in scores come down to the amount of flavouring used. The Control sample scored lower because it used too little cordial and pandan essence. This made the cookie's colours look dull, and it lacked the nostalgic, authentic taste of *Ais Batu Campur* (ABC). On the other hand, Variation 2 used too much cordial flavouring. While this made the pink, green, and yellow colours very bright, it left a strong, bitter aftertaste that the panellists did not like. Variation 1 was chosen as the final product because it achieved the perfect balance. Mixing the sweetened creamer with a moderate amount of rose syrup, corn cordial, and pandan cordial created a smooth, creamy taste with no bitterness. Because it successfully captured the authentic ABC flavour while maintaining the best texture and creaminess, Variation 1 was selected for the final ABCOOKIES product.

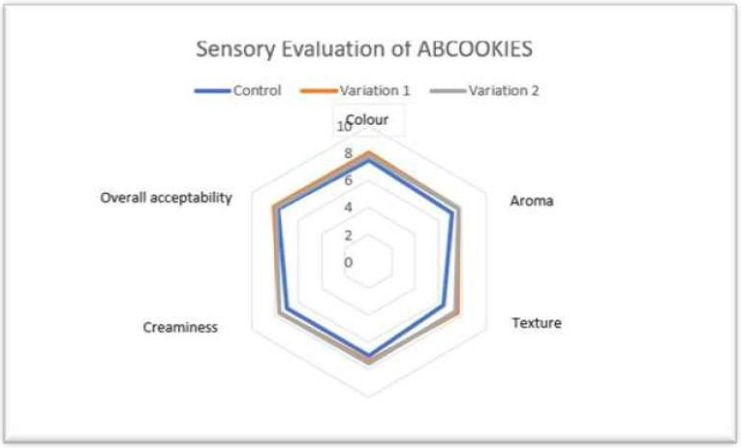


Figure 2: Consumer Acceptance for ABCOOKIES.

5.0 CONCLUSION

ABCOOKIES serves as a highly practical, ready-to-eat snack that requires no extra preparation, tools, or cleanup. Its unique, soft, melt-in-your-mouth texture delivers a delightful mouthfeel that mimics the rich, creamy flavour of traditional *Ais Batu Campur* (ABC) without requiring heavy chewing. This makes it an effortless and enjoyable treat for a wide range of consumers, especially those with busy lifestyles looking for a convenient on-the-go snack. From a commercial standpoint, the product is highly practical and easy to handle, store, and distribute. Its thoughtful packaging is specially designed to keep the delicate cookies fresh and structurally intact. Furthermore, because it relies on a simple ingredient base and a straightforward baking process, ABCOOKIES is highly viable for small-scale production and local entrepreneurship ventures.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Faculty of Hotel and Tourism Management and Universiti Teknologi MARA (UiTM) Cawangan Terengganu for providing the essential financial assistance used to secure ingredients, supplies, and machinery for this project. Heartfelt thanks are also extended to all team members for their dedication and hard work, as well as to the sensory evaluation participants whose valuable feedback made the successful completion of this food innovation project possible.

REFERENCES

Cho, Y. (2025). Cross-cultural analysis of consumers' avoidance of snack food ingredients across 13 countries using Check-All-That-Apply (CATA) method. *Foods*, *14*(10), 1729–1745.

Khan, N. A. R., Tharmabalan, S., & Mohamad, A. (2025). Preserving Terengganu's heritage food: How Malay traditional food packaging influences consumer purchase decisions? *Journal of Tourism, Hospitality and Culinary Arts*, *17*(2), 112–126.

Rai, M. (2025). Preserving tradition amidst modernity: The hybridity of food practices. *Journal of Consumer Culture*, *25*(2), 184–201.

Verain, M. C. D. (2021). Variability of food choice motives: Two studies showing variation across meal moment, location and social context. *Food Quality and Preference*, *98*(10), 104505.

Zainudin, A. N. S., Ahmad, M. F., & Rahmat, N. (2025). Traditional food choices of Malaysian university students: Social influence, preferences and health. *Journal of Tourism, Hospitality and Culinary Arts*, *17*(3), 145–160.

SOOLEK: AN INNOVATIVE TWIST ON TRADITIONAL *SOLOK LADA*

Nur Aisyah Binti Mohd Nazam[1], Nur 'Aifaa Safiah Binti Zainalabidin[1], Nur Syalini Binti Mohd Ridza[1], Noristisarah Binti Abd Shattar[1,*], Amanina Mat Ghani[1]

[1]Faculty of Hotel & Tourism Management, Universiti Teknologi MARA Cawangan Terengganu, 23000, Terengganu, Malaysia

[*]Corresponding author: noris590@uitm.edu.my

ABSTRACT

Consumers increasingly demand traditional foods innovated to suit modern sensibilities. However, traditional *solok lada*, a well-known Kelantanese dish, remains inaccessible to individuals who cannot source fresh chillies or prefer to avoid spicy foods. To address this, this study introduces Soolek, a reformed, non-spicy version of *solok lada* designed as a convenient, modernised snack for the general public. Soolek is a rectangular, two-bite snack that replaces the traditional chilli skin with a soft, savoury green crepe made from flour, egg, coconut milk, and green chilli extract. The production process involves preparing the batter, cooking the crepe layers, preparing the fish and coconut filling, wrapping, and steaming the final product to achieve a smooth texture. A sensory evaluation was conducted with 60 student and staff panellists to assess three crepe variations: Variation 1 (original plain flour crepe with green chilli extract), Variation 2 (flour mixed with blended green chilli), and Variation 3 (flour mixed with tapioca flour and green chilli). Panellists evaluated the samples based on colour, taste, texture, spiciness, and overall acceptability. The outcomes indicated that Variation 1 was the most preferred due to its superior texture, mild taste, and pleasing appearance, making it highly appealing to fish product lovers who dislike spiciness. Ultimately, Soolek holds strong market potential as an on-the-go snack that successfully fuses traditional heritage flavours with a modern, flexible crepe skin, bridging the gap between culinary tradition and contemporary consumer convenience.

Keywords: crepe, solok lada, snack, sensory evaluation

1.0 INTRODUCTION

Solok lada is a well-known traditional food from Kelantan, Malaysia, consisting of green chilli peppers filled with a savoury mixture of fish, grated coconut, and seasonings, then steamed or grilled. The dish is widely recognised as part of Kelantan's culinary heritage and contributes to the preservation of local food culture (Department of National Heritage Malaysia, 2023). Despite its popularity, traditional Solok Lada has several limitations that may reduce its acceptance among certain consumer groups. The characteristic spicy flavour may not appeal to children, older adults, or individuals with low tolerance for spicy foods (Siebert et al., 2023). In addition, the product depends heavily on the availability of fresh green chillies, which can be inconsistent due to seasonal supply and market availability (Food and Agriculture Organization of the United Nations, 2021). These factors create challenges for consumers seeking a convenient and mild-tasting version of the traditional dish.

To address this issue, the innovative product Soolek was developed. Soolek reinterprets the traditional Solok Lada by replacing the chilli pepper skin with a soft green crepe infused with green chilli extract. The innovation retains the original fish filling and traditional flavour profile while reducing spiciness and improving convenience for modern consumption. The product is designed as a small, two-bite snack that is suitable for consumers of all ages, including those who prefer milder tastes.

The motivation for developing Soolek aligns with current trends in food innovation, in which traditional foods are reformulated to meet changing consumer lifestyles, preferences, and health awareness. Research has shown that consumers increasingly demand convenient food products that preserve cultural identity while offering improved accessibility and broader acceptability (Food and Agriculture Organization of the United Nations, 2021). By combining traditional Kelantanese flavours with a flexible crepe wrapper, Soolek aims to bridge the gap between culinary heritage and contemporary snack consumption.

2.0 OBJECTIVE

1. To develop Soolek, a non-spicy, innovative version of traditional Solok Lada using a green crepe wrapper.
2. To evaluate consumer acceptance of different Soolek formulations based on colour, taste, texture, spiciness, and overall acceptability through sensory evaluation.

3.0 MATERIAL & METHODOLOGY

3.1 MATERIALS

The ingredients used for the development of Soolek were sourced from the faculty laboratory and local retail markets. Three formulations were developed, consisting of a control and two variations with different crepe formulations. The control formulation used wheat flour and extracted lada solok water as the main wrapper ingredients. Variation 1 incorporated a higher proportion of wheat flour, egg, and extracted chilli water to improve the crepe structure, while Variation 2 replaced part of the wheat flour with tapioca flour to enhance texture. All formulations contained the traditional Solok Lada filling, consisting of mackerel, grated coconut, coconut milk, and seasonings, with slight adjustments in ingredient proportions among samples. The developed products were prepared by cooking the crepe wrapper, wrapping the fish-based filling, and steaming the final product until fully cooked.

3.2 PREPARATION OF SOOLEK

The preparation of Soolek involved four main steps, which were filling preparation, batter preparation, skin preparation, and storage. For the filling preparation, mackerel was cleaned, boiled until fully cooked, and deboned before being combined with grated coconut, chopped shallots, garlic, black pepper, salt, and sugar. The mixture was then blended using a food processor until a uniform texture and desired flavour were achieved. For the batter preparation, flour was sieved and mixed with sugar, salt, and bicarbonate of soda. The lada solok was deseeded, chopped, blended, and filtered to obtain the chilli extract. The wet ingredients, including coconut milk, egg, and filtered chilli extract, were mixed separately before being gradually incorporated into the dry ingredients to form a smooth batter. Green food colouring was added to obtain the desired appearance of the crepe skin. The crepe skin was prepared by heating a non-stick pan, followed by pouring and spreading the batter evenly across the surface. The batter was cooked until set, removed from the pan, and immediately used to wrap the prepared fish filling. This process was repeated until all batter was utilised. The finished Soolek products were packed in labelled plastic food containers and stored under frozen conditions to maintain product quality and extend shelf life.

3.3 SENSORY EVALUATION

Consumer acceptance of the developed Soolek formulations was determined through quantitative affective testing using a 9-point hedonic scale. Sensory evaluation was conducted with an untrained consumer panel consisting of approximately 60 participants, comprising students from Universiti Teknologi MARA (UiTM) and residents recruited from the local community of Sura Tengah. Panellists evaluated three distinct sample variations across five primary sensory attributes: colour, aroma, taste, texture, and overall acceptability. Samples were served in a randomised, counterbalanced order to mitigate first-sample bias, and panellists were instructed to rinse their palates with water between samples. The gathered data were subjected to descriptive statistical analysis. Mean scores for each sensory attribute were computed and tabulated to identify the Soolek formulation with the highest consumer preference and overall acceptability.

4.0 RESULT

4.1 PRODUCT DESCRIPTION

Soolek is a modern, non-spicy twist on Solok Lada, a famous traditional fish-stuffed chilli snack from Kelantan. Instead of using a spicy whole chilli pepper, this innovative snack wraps the original, traditional filling inside a soft, savoury green crepe. Each piece is shaped into a small, uniform rectangle measuring approximately 6 cm x 3 cm x 2 cm, making it a perfect two-bite treat that is highly convenient for on-the-go snacking. The outer green skin is made from a blend of wheat flour, eggs, coconut milk, and a mild chilli extract, giving it a soft, elastic texture with a hint of chilli flavour without the burning spiciness.

Inside, it features an authentic, traditional stuffing made from minced mackerel, grated coconut, shallots, garlic, and black pepper. Sold as a 120g pack using typical frozen food plastic packaging, the product and its commercial label design are presented in Figure 1. It can be quickly prepared by steaming it for 10–15 minutes or microwaving it for 2–3 minutes, making it an ideal choice for anyone who loves traditional Malaysian flavours but prefers to avoid the heat of real chillies.



Figure 1: Product labelling layout and plastic packaging of Soolek.

4.2 SENSORY ANALYSIS

The sensory evaluation results presented in Table 1 outline the consumer preferences for the three Soolek crepe formulations. Variation 1 (the control formula using plain wheat flour and chilli extract) emerged as the most preferred sample, securing the highest scores across colour (7.8), taste (7.5), texture (7.4), and overall acceptability (7.8). These superior ratings indicate that its appealing visual appearance, balanced flavour profile, and soft, pleasant mouthfeel resonated strongly with panellists, confirming its suitability for target groups seeking traditional flavours with a mild, non-spicy sensory experience. This finding aligns with established research by Nurfarahin et al. (2022), which demonstrates that optimal texture, flavour equilibrium, and visual presentation are pivotal in driving the acceptance of modernised traditional heritage foods.

Conversely, Variation 2 (the formulation incorporating ground chilli residue) recorded the lowest overall acceptability score (7.0) and a noticeably lower colour score (6.8). While it maintained a comparable spiciness level (7.2) and a strong taste profile (7.4), the inclusion of physical chilli residue likely altered the crepe's surface uniformity, making it rough or uneven, and intensified the local chilli taste beyond the preferences of consumers seeking a milder profile. Variation 3 (the blend of wheat and tapioca flour) performed moderately well, achieving stable scores for taste (7.4) and texture (7.4), alongside a strong overall acceptability rating of 7.6. However, the addition of tapioca flour introduced a slightly chewier masticatory sensation that fell just short of the control group's popularity. As noted by Ahmed and Huma (2023), minor compositional adjustments can profoundly alter food microstructures and subsequent oral processing, proving that delicate ingredient balances are vital when tailoring heritage snacks to diverse consumer demographics.

Table 1: Mean Sensory Evaluation Scores for Soolek Crepe Formulations Across Different Variations

	Variation 1	Variation 2	Variation 3
Color	7.8	6.8	7.5
Taste	7.5	7.4	7.4
Texture	7.4	7.3	7.4
Spiciness	7.2	7.2	7.2
Overall Acceptability	7.8	7.0	7.6

5.0 CONCLUSION

In conclusion, Soolek successfully modernises the traditional Kelantanese heritage snack Solok Lada, transforming it into an innovative, physically stable, and highly convenient format tailored to modern consumer lifestyles. By structurally substituting the hyper-pungent chilli pepper skin with a soft, pliable green crepe while encapsulating the authentic fish-and-coconut stuffing, the development of Soolek demonstrates that ethnic gastronomic flavour profiles can be preserved without maintaining their restrictive capsaicin levels or dependencies on raw ingredient supply. This research contributes to the broader food science community by providing empirical data on how minor structural adjustments and component substitutions affect the microstructural mouthfeel and sensory perception of ethnic foods. Scientifically, it establishes a reproducible method for preserving delicate heritage flavour matrices

inside stable carbohydrate-based carriers. Economically, Soolek holds strong commercial potential within the rapidly expanding ready-to-eat frozen food sector. By presenting a convenient, non-spicy, and on-the-go snack format, the product effectively captures a highly profitable market segment that includes health-conscious professionals, children, and consumers with low heat tolerance. Ultimately, this innovation bridges the gap between culinary tradition and industrial modernity, offering a viable blueprint for archiving and scaling traditional food heritage in competitive global markets.

ACKNOWLEDGEMENT

Sincere gratitude is extended to the project lecturer and supervisor for their continuous guidance, support, and valuable feedback throughout this study. Special thanks are also due to Universiti Teknologi MARA (UiTM) for providing the essential materials, laboratory equipment, and facilities necessary for the development of *Soolek*. Finally, the dedication, creativity, and excellent cooperation of all team members are highly appreciated, as well as the contributions of everyone who assisted, directly or indirectly, in the success of this project.

REFERENCES

Ahmed, M., & Huma, N. (2023). Sensory evaluation and consumer acceptability of traditional food innovations in Southeast Asia. *Journal of Food Research and Innovation, 12*(2), 87–96.

Department of National Heritage Malaysia. (2023). Traditional food heritage of Kelantan. https://www.warisan.gov.my

Food and Agriculture Organization of the United Nations. (2021). *The state of food and agriculture 2021: Making agrifood systems more resilient to shocks and stresses*. FAO. https://doi.org/10.4060/cb4476en

Nurfarahin, A. H., Jamaludin, N. A., & Latif, R. A. (2022). Acceptance of healthy traditional snacks among Malaysian consumers. *International Journal of Gastronomy and Food Science, 29*, 100579.

Siebert, E., Lee, S.-Y., & Prescott, M. P. (2022). Chili pepper preference development and its impact on dietary intake: *A narrative review. Frontiers in Nutrition, 9*, 1039207.

RASANANG: UPCYCLING HERITAGE FOOD INTO A VALUE- ADDED, SHELF-STABLE RICE CRACKER

Nurul Hana binti Rosman Khan[1], Nurul Anis binti Rosman Khan[2], Noristisarah binti Abd Shattar[1,*], Faliza binti Mahamed Ali[1]

[1]Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM) Cawangan Terengganu
[2]Cemerlang Teraju Sdn Bhd., Batu Caves, Selangor

[*]Corresponding author: noris590@uitm.edu.my

ABSTRACT

Nasi lemak is Malaysia's premier national dish, celebrated for its rich, aromatic flavour. Similarly, *inang-inang* is a traditional Malaysian heritage snack made from compressed, sun-dried glutinous rice crackers, valued for its unique crunchy texture. Despite their cultural popularity, authentic nasi lemak is highly perishable, and traditional *inang-inang* is fading from the modern market, leaving a gap for portable, innovative ethnic snacks. To address this, this study aims to develop Rasanang, an innovative, shelf-stable, and ready-to-eat snack that fuses these two culinary heritages into a convenient format. Rasanang combines a crispy, round, golden-brown *inang-inang*-style cracker with a dry sambal seasoning. The cracker base is formulated by using cooked nasi lemak that is dried and deep-fried, while the sambal powder is created by dry-toasting and grinding chilli, anchovy, garlic, coconut milk, and seasonings. Sensory evaluation was conducted with 60 panellists using a 7-point hedonic scale across three cracker base variations processed via distinct cooking methods: the Control (conventional rice cooking, followed by rinsing and steaming), V1 (conventional rice cooking without rinsing and steaming), and V2 (conventional rice cooking and steaming without rinsing). The results revealed that the cooking variations significantly influenced the cracker's structural properties. The Control variation achieved the highest preference scores for appearance and texture, as the rinsing and steaming process optimised starch gelatinisation, resulting in superior grain separation, uniformity, and puffing crispiness upon frying compared to V1 and V2. Ultimately, Rasanang successfully bridges cultural flavour memory with snack innovation. By transforming a perishable staple into a modernised, functional snack, this product provides an exceptional entry point into niche, halal-conscious, and global export markets.

Keywords: inang-inang, nasi lemak, snack, sensory evaluation

1.0 INTRODUCTION

Traditional Malaysian food is a cornerstone of the nation's cultural identity, serving as a shared heritage passed down through generations. Among these culinary treasures, nasi lemak stands as the quintessential national dish. Renowned for its fragrant coconut rice and spicy sambal, it evokes a profound sense of nostalgia and is a mainstay in Malaysia's global tourism and promotional materials (Tibere, 2019). The immense cultural weight of nasi lemak is frequently highlighted in mainstream media and annual food festivals, underscoring its versatility as a meal enjoyed at any time of day (Tibere, 2019). Similarly, *inang-inang* is a traditional heritage snack originating from Melaka, made from compressed, sun-dried glutinous rice that yields a distinctively crunchy texture when deep-fried. Historically, *inang-inang* has been appreciated as a shelf-stable, portable snack that requires no refrigeration, making it highly practical for travel and long-term storage (*Crispy snack makes a comeback*, 2025).

Despite the popularity of these traditional foods, a significant shift in modern consumer lifestyles poses a threat to their preservation. In today's fast-paced environment, consumers increasingly prioritise convenience, often replacing time-consuming traditional meals with highly processed, portable options, a lifestyle shift that heavily steers younger demographics away from culinary heritage (Ishak et al., 2021). This shift gradually diminishes the presence of generational, authentic flavours in daily life. Furthermore, authentic nasi lemak is a heavy, highly perishable meal that cannot be easily transported or consumed on the go, which directly worsens food waste when fresh portions quickly spoil. Nationally,

avoidable food surplus and localised distribution challenges account for thousands of tonnes of municipal organic waste daily (Arshad et al., 2025). On the other hand, while traditional *inang-inang* possesses an excellent shelf life, its conventional form is flavourless and increasingly sidelined by modern, heavily seasoned commercial snacks. This creates an urgent need for functional food innovation that successfully bridges modern convenience with cultural heritage (Omar & Nasir, 2022).

To address these challenges, this study introduces Rasanang, an innovative, shelf-stable, and ready-to-eat snack designed to modernise traditional Malaysian cuisine while preserving its nostalgic essence. Rasanang fundamentally reinterprets *inang-inang* by replacing the traditional, flavourless glutinous rice base with seasoned, fragrant coconut rice derived directly from nasi lemak. To complement this crunchy cracker base, the product introduces a second major innovation: a specialised dry sambal powder. This dehydrated seasoning encapsulates the robust, complex umami profile of traditional liquid sambal in a mess-free, highly portable format. By converting a perishable, heavy meal and an underutilised heritage cracker into a unified, functional product, Rasanang minimises regional food waste, provides a practical light snack, and aligns with contemporary global trends in nostalgic, functional ethnic snacking.

2.0 OBJECTIVE

1. To formulate and develop a shelf-stable heritage snack by integrating a nasi lemak-infused *inang-inang* rice cracker base with a dry, portable sambal seasoning powder.
2. To evaluate the sensory attributes of Rasanang, including appearance, aroma, coconut flavour, texture, spiciness, and overall acceptability.

3.0 METHODOLOGY

3.1 MATERIALS

The formulation of Rasanang is primarily built upon two major ingredients that form the product's base structure, namely, water (56.82%) and rice (18.94%), which together account for approximately 75.76% of the total formulation. The characteristic aroma and flavour of coconut rice are achieved through the addition of coconut milk, shallots, garlic, and ginger. These ingredients create the distinctive taste associated with traditional nasi lemak. The signature spicy sambal flavour is developed through a balanced combination of chilli powder, anchovy powder, peanut powder, and garlic powder. Finally, chicken stock powder is incorporated to enhance the overall savoury flavour profile, resulting in a convenient snack that preserves the authentic taste of nasi lemak.

3.2 PRODUCT PREPARATION

The process begins by thoroughly washing and soaking raw rice in clean water for a minimum of 30 minutes to facilitate grain softening and uniform moisture absorption. Following the soaking phase, coconut milk, chopped ginger, chopped shallots, and sliced garlic are integrated and distributed evenly into the mixture. The ingredients are then cooked using a conventional electric rice cooker until fully done. Immediately after cooking, the hot rice undergoes a rinsing process with clean water to strip away excess surface amylose (free starch), preventing unwanted stickiness. The rinsed rice is thoroughly drained and checked to ensure no excess moisture remains. It is then transferred to a mixing container where it is seasoned with salt and tapioca flour. The mixture is worked thoroughly to achieve a homogeneous distribution of seasoning and to allow the tapioca flour to act as a structural binding agent. The seasoned rice is subsequently steamed for 10 minutes to gelatinise the added tapioca starch, followed by a 5-minute cooling period to stabilise the matrix before the rice is moulded into the uniform, round shapes characteristic of traditional *inang-inang*. The moulded rice bases are arranged inside a food dehydrator and subjected to a continuous drying cycle for 8 hours until a completely low-moisture, shelf-stable structural state is achieved. Concurrently, the specialised dry sambal powder is formulated. Smoked chilli powder, icing sugar, finely ground peanut powder, anchovy powder, garlic powder, and a precise amount of salt are combined and thoroughly agitated until a perfectly uniform, dry condiment mixture is achieved.

3.3 SENSORY EVALUATION

To evaluate the sensory attributes of the product, a hedonic test was conducted using a 7-point hedonic scale. A total of three sample groups were prepared using identical ingredient ratios but processed through distinct cooking methods: the Control (conventional rice cooking, followed by rinsing and steaming), Variation 1 (conventional rice cooking without the rinsing and steaming processes), and

Variation 2 (conventional rice cooking and steaming without the rinsing process). Each sample was evaluated by 60 untrained panellists for six key sensory attributes: appearance, texture, aroma, coconut flavour, spiciness, and overall acceptability. Each panellist was provided with coded samples in a randomised order to eliminate positional bias. To avoid flavour carry-over, panellists were instructed to thoroughly cleanse their palates with plain water between tastings. The gathered sensory scores were compiled, and the mean scores for each attribute were mapped onto a radar chart. This visual analysis provided a multidimensional graphic comparison of the sensory profiles, explicitly identifying which processing method yielded optimal consumer preference.

4.0 RESULT

4.1 PRODUCT CHARACTERISTICS

The product has two versions, cooked and uncooked. The cooked one has a brittle texture, has expanded in size after cooking, and has a brownish colour, while the uncooked one is very hard, small, and has a green colour. As for the packaging, a clear plastic bag is used. Because the pouch is made of translucent plastic, customers can see what's inside. It has a floral-patterned yellow border. A zip-lock seal on the top makes opening and closing simple. This packaging is lightweight, easy to carry, and convenient to use. The product name can be seen on the front. There is also a small package inside the main packaging that holds the seasonings for the product.



Figure 1: Rasanang product presentation

4.2 SENSORY EVALUATION

The sensory profiles and consumer preferences for Rasanang across the different processing treatments are illustrated in the radar chart (Figure 2). Based on the mean scores evaluated by the 60 panellists, the Control variation emerged as the final optimal formulation, securing the highest score for overall acceptability. This indicates that the holistic combination of its structural and sensory attributes best satisfied consumer expectations for a modernised heritage snack.

The Control variation visibly outscored Variation 1 and Variation 2 in texture. Stripping away excess surface starch through rinsing, combined with secondary steaming, optimised starch gelatinisation. This process ensured superior grain separation and structure, resulting in a highly desirable, uniform, and light puffing crispness upon deep-frying. Conversely, Variation 1 suffered from reduced crispiness, as the absence of rinsing and steaming left redundant amylose on the rice surface, resulting in a denser, harder cracker matrix that received lower acceptance from the panellists.

Interestingly, although the identical dry sambal seasoning formula was applied across all treatments, the processing methods heavily influenced flavour delivery. Variation 1 and Variation 2 scored higher on the numerical scale for spiciness intensity. Because these variations skipped the rinsing step, the lingering sticky starch layers on the rice grains tightly trapped the volatile capsicum oils from the sambal powder, amplifying and concentrating the sharp heat. In contrast, the clean, well-separated grain surface of the Control variation allowed for a more uniform and balanced distribution of the dry seasoning, offering milder, well-rounded spiciness and a subtle coconut flavour profile that closely mirrors authentic nasi lemak.

Ultimately, the balanced flavour profile, moderate spiciness, and superior crispiness of the Control treatment significantly enhanced the overall eating experience. Therefore, the empirical data from the sensory evaluation validates that the comprehensive rinsing and steaming method is essential to achieve the structural stability and flavour equilibrium required for commercialising this innovative heritage product.

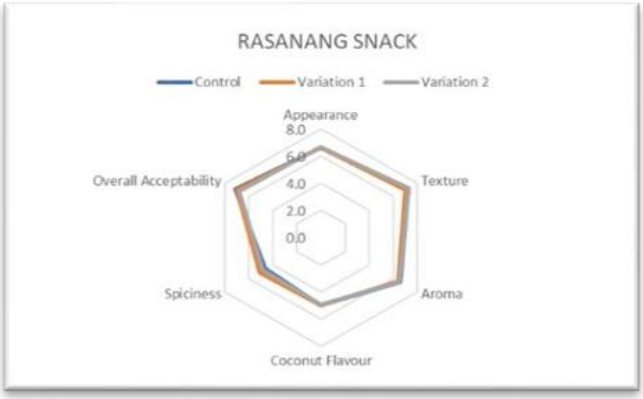


Figure 2: Consumer Acceptance for Rasanang

5.0 CONCLUSION

This study successfully demonstrates that a traditional, perishable meal can be transformed into a convenient, shelf-stable heritage snack. The experimental results show that the specific processing method used is crucial for the product's quality. This method removes excess surface starch and optimises gelatinisation, resulting in an *inang-inang* rice cracker with excellent grain separation, uniform structure, and a crispy texture upon frying. Furthermore, the sensory evaluation with 60 panellists confirms that this structural quality directly improves flavour delivery, allowing the dry sambal powder to distribute evenly and provide a balanced flavour profile that achieved the highest consumer acceptability.

This research contributes to the food science community by providing a clear, systematic method for modernising traditional ethnic foods. It provides practical data on how simple processing steps, such as rinsing and steaming, alter the physical matrix of cooked rice and affect its interaction with dry seasonings. Economically, this innovation offers an effective way to reduce food waste by converting surplus cooked rice into a long-lasting snack format, making it highly suitable for the global, halal-conscious commercial market. Future studies should focus on optimising product packaging to extend shelf life and exploring new flavour variations to appeal to a wider international audience.

ACKNOWLEDGEMENT

The authors would like to express their heartfelt appreciation to the Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM) Cawangan Terengganu, for their financial support, which enabled the purchase of ingredients, materials, and equipment required for the successful completion of this food innovation project. The authors also wish to extend their sincere thanks to all group members for their commitment, cooperation, and continuous efforts throughout the project. Special appreciation is given to the sensory evaluation panellists for their time, participation, and valuable feedback, which contributed significantly to the evaluation and improvement of the product.

REFERENCES

Arshad, M. A., Yoong, L. S., & Zhang, L. (2025). From urban kitchens to landfills: Transforming food waste for Malaysia's health and sustainability. *Journal of Malaysian Environmental Health, 11*(1), 45–58.

Crispy snack makes a comeback. (2025, July 3). The Star. https://www.thestar.com.my/news/nation/2025/07/03/crispy-snack-makes-a-comeback

Ishak, N., Ismail, A., Saad, M., & Adilah Md Ramli. (2021). Researching Kedah's Malay Heritage Food Tradition and Eating Culture. *International Journal of Academic Research in Business and Social Sciences, 11*(16), 140–154

Omar, S. R., & Nasir, M. N. (2022). Modernizing Malaysian heritage food: Opportunities and challenges in the functional snack industry. *International Journal of Gastronomy and Food Science, 28*, 100512.

Tibere, L., Laporte, C., Poulain, J. P., & Aloysius, M. (2019). Staging a National Dish: The Social Relevance of Nasi Lemak in Malaysia, *Asia-Pacific Journal of Innovation in Hospitality and Tourism, 8*(1), 55–66.

THE INNOVATION OF NONA MANIS BITES

Muhammad Zaman Shahmeer bin Zulkepli[1], Adiba Damia Auni binti Suahini @ Suhaimi[1], Nurul Aqilah binti Mohd Noh[1], Noristisarah binti Abd Shattar[1,*], Noraida binti Abdul Karim[1]

[1]Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM) Cawangan Terengganu

[*]Corresponding author: noris590@uitm.edu.my

ABSTRACT

Traditional Malaysian *kuih*, such as *Kuih Nona Manis*, faces commercial limitations due to its soft, perishable nature and short shelf life. This project introduces Nona Manis Bites, an innovative, bite-sized modernisation that transforms the traditional steamed *kuih* into a shelf-stable, crunchy cookie filled with a creamy coconut white chocolate centre. This research aimed to preserve cultural heritage while adapting the dessert to contemporary fast-paced lifestyles and global snacking trends. The product formulation consists of a dough base made from butter, castor sugar, brown sugar, flour, and corn flour, paired with a smooth filling of white chocolate, whipping cream, and coconut cream. Three variations were developed and evaluated: a Control (basic pandan cookie base with white cream filling), Variation 1 (corn flavour), and Variation 2 (yam flavour). A sensory evaluation using a 9-point hedonic scale was conducted with 60 untrained panellists to assess colour, texture, flavour, taste, and overall acceptability. The results showed that the Control (Pandan flavour) scored the highest across all attributes, achieving an overall acceptability score, significantly outperforming the corn and yam variations. This preference underscores the powerful impact of visual familiarity and cultural nostalgia on consumer acceptance. Packaged in compact, eco-friendly, airtight containers designed for portion control and on-the-go convenience, Nona Manis Bites successfully bridges the gap between culinary tradition and modern food commercialisation, offering high market potential in both domestic and international snack sectors.

Keywords: Nona Manis Bites, traditional food innovation, malaysian snacks, sensory evaluation, contemporary heritage dessert

1.0 INTRODUCTION

Traditional foods serve as an essential cornerstone of cultural identity and national heritage, particularly in multi-ethnic regions where dietary habits reflect deep-seated social backgrounds and historical customs (Md Ramli et al., 2023). Among these heritage foods, *Kuih Nona Manis* is a highly celebrated traditional Malay dessert, frequently integrated into communal events, family celebrations, and festive seasons like Hari Raya. Characterised by its unique dual-layer configuration, the dessert is traditionally steamed in small moulds to be consumed in a single bite.

The original Nona Manis is a traditional glutinous *kuih* that is soft, chewy, and has a gooey coconut centre. It has a moist texture and a rich, sweet flavour (Kaur & Karim, 2020). Beyond its distinct sensory profile, the production of traditional *kuih* carries immense socio-economic weight. Across Malaysia, home-based baking and traditional delicacy operations represent a highly critical avenue for micro-entrepreneurship, specifically driving the economic empowerment of rural Malay women who run small-scale cottage industries to support family incomes while actively safeguarding generational culinary legacies (Hassan, 2014).

Despite its immense popularity and deep cultural roots, the commercial scalability of traditional Kuih Nona Manis faces extreme physical restrictions. Because it relies heavily on high-moisture ingredients like rice flour, water, and raw coconut milk, the steamed dessert is highly unstable and exceptionally prone to swift microbial spoilage, often becoming unsafe or losing its palatable texture within 24 to 48 hours. Furthermore, its exceptionally soft, gelatinous structure renders it highly perishable, making bulk packaging, standard logistical distribution, and long-distance transport practically impossible without destroying its aesthetic and structural form. Compounding this issue, contemporary fast-paced lifestyles and a globalised snack sector have shifted consumer demands heavily toward shelf-stable, convenient, and portable bite-sized food options (Md Ramli et al., 2023). Traditional *kuih*, in its classic form, cannot satisfy these criteria. Without targeted food product innovation and stabilisation, these fragile heritage

desserts risk becoming isolated from mainstream modern retail networks and younger consumer demographics.

To successfully bridge the structural gap between delicate culinary tradition and aggressive modern commercialisation, this study introduces Nona Manis Bites, an innovative, shelf-stable modernisation of the classic dessert. The objective of this research is to deconstruct and reformulate the high-moisture, steamed properties of traditional *Kuih Nona Manis* into a contemporary, shelf-stable cookie format optimised for the global retail market. By re-engineering the green pandan layer into a crisp, baked dough base and transforming the liquid coconut centre into an encased, rich coconut-infused white chocolate filling, Nona Manis Bites preserves the signature nostalgic flavour profile and burst sensation of the authentic dessert while eliminating its perishable vulnerabilities. Packaged in compact, eco-friendly, airtight containers tailored for portion control and on-the-go convenience, this modernised snack aims to unlock significant economic potential for domestic and international food sectors while ensuring that Malaysian culinary heritage remains relevant in a contemporary landscape.

2.0 OBJECTIVE

1. To develop a shelf-stable, bite-sized cookie version of Kuih Nona Manis that transforms the traditional steamed layers into a baked dough base and a creamy white chocolate coconut centre.
2. To evaluate consumer acceptance of three flavour variations (Pandan Control, Corn, and Yam) using a hedonic sensory test.

3.0 MATERIAL AND METHODOLOGY

3.1 MATERIAL

The innovation of Nona Manis Bites relies on a meticulously balanced, synergy-driven formulation designed to masterfully replicate traditional flavours within a modern structural framework. Wheat flour forms the robust backbone of the cookie base at 31.34%, working in tandem with 9.33% corn flour to yield a uniquely delicate, melt-in-the-mouth crispness that modernises the bite. Infusing this dough matrix with premium butter, which provides a rich, velvety mouthfeel, while a precise dual-sugar blend of castor sugar and brown sugar achieves optimal sweetness, deep caramelisation notes, and a beautifully golden exterior. At the heart of the invention is a luxurious, decadent filling composed of white chocolate, which acts as a sweet, stable anchor. This core is masterfully emulsified with equal ratios of rich whipping cream and authentic coconut cream, seamlessly capturing the iconic, nostalgic burst of traditional *santan* flavour within a contemporary confectionery medium.

3.2 PRODUCT PREPARATION

Nona Manis Bites production entailed four major stages, which included dough production, filling production, production assembly, and baking. The dough was made by mixing butter and sugar together before the rest of the ingredients were incorporated. The filling was produced by heating white chocolate, coconut cream, and whipping cream to achieve a creamy texture. The dough was then cut to the appropriate size, filled with the creamy filling, and baked at 160°C for about 15 minutes. After baking, the cookies were left to cool before being packed.

3.3 SENSORY EVALUATION

A sensory evaluation was conducted to assess three developed variations of Nona Manis Bites: a Control (basic pandan cookie base with a white cream filling), Variation 1 (corn flavour), and Variation 2 (yam flavour). A total of 60 untrained panellists participated in the evaluation, using a 9-point hedonic scale to rate five key attributes: colour, texture, flavour, taste, and overall acceptability. The testing was carried out under controlled conditions, in which panellists evaluated the coded samples to determine consumer preference and acceptance across the different flavour formulations. The collected data were then statistically analysed and compiled into a table showing the mean scores for each attribute.

4.0 RESULT

4.1 PRODUCT CHARACTERISTIC

The newly developed product, branded as Nona Manis Bites, effectively transforms the traditional high-moisture dessert into a bite-sized, shelf-stable biscuit. As illustrated in Figure 1, each piece features a vibrant green, circular pandan cookie base designed with a recessed centre that holds a smooth, white

coconut cream filling. Measuring approximately 3 to 4 centimetres in diameter, the uniform dimensions of these bite-sized pieces make them ideal for precise portion control and effortless snacking. To cater to contemporary consumer preferences and fast-paced lifestyles, Nona Manis Bites are stored in compact, airtight plastic jars featuring a bright yellow screw-cap lid. This specialised packaging serves a dual purpose, as it effectively isolates the product from atmospheric moisture to preserve its crisp texture and extend its shelf life, while offering on-the-go convenience and portability for modern retail markets.



Figure 1 Nona Manis Bites Product Characteristics and Packaging

4.2 SENSORY ANALYSIS

The mean score values obtained from the sensory evaluation of the three Nona Manis Bites variations are summarised in Table 1. Based on the 9-point hedonic scale, the control sample (pandan flavour) emerged as the preferred formulation, consistently scoring the highest across all evaluated parameters: colour (8.2), texture (7.4), flavour (7.6), taste (7.7), and overall acceptability (7.9). In contrast, variation 1 (corn flavour) and variation 2 (yam flavour) achieved lower acceptance scores across most categories. Variation 1 demonstrated a moderate degree of acceptance, with its highest scores in colour (7.0) and texture (6.9), but it fell short in flavour (6.6) and overall acceptability (6.9). Meanwhile, variation 2 (yam flavour) achieved a slightly higher taste score (7.1) than variation 1 but received the lowest colour score (6.3), which likely constrained its overall acceptability score to 6.8. The poor visual appeal of the yam variant underscores the critical role of colour familiarity in shaping initial consumer perception and acceptance.

Several key sensory and psychological factors explain why the Control formula significantly outperformed the other variations. First, consumers possess deep-rooted cognitive expectations regarding traditional desserts. The vibrant green colour of the pandan base provides immediate visual familiarity and cultural nostalgia, whereas the unfamiliar colours of the corn (yellow) and yam (purple-grey) variants created a visual-sensory mismatch that lowered initial consumer impressions. Second, from a food science perspective, the herbal, vanilla-like aromatic compounds of pandan naturally complement the rich, savoury-sweet profile of coconut cream (Bhuyan, 2021). When paired with the modern white chocolate filling, the pandan base created a balanced flavour synergy. Conversely, the distinct profiles of corn and yam did not blend as harmoniously with the dense, sweet coconut white chocolate core, resulting in weaker flavour delivery or poor visual appeal that flavour notes alone could not override.

Table 1: Mean score value for sensory evaluation of Nona Manis Bites

	Color	Texture	Flavor	Taste	Overall Acceptability
Control (pandan)	8.2	7.4	7.6	7.7	7.9
Variation 1 (corn)	7.0	6.9	6.6	6.8	6.9
Variation 2 (yam)	6.3	6.9	6.7	7.1	6.8

5.0 CONCLUSION

In conclusion, Nona Manis Bites successfully demonstrates how product innovation can revitalise traditional heritage foods to meet contemporary market demands without sacrificing cultural authenticity. By re-engineering the classic, perishable Kuih Nona Manis into a contemporary, shelf-stable cookie format, this project aligns with modern lifestyle preferences that heavily value portability and portion control. The product's novelty is anchored in its innovative dual-texture format, eye-catching eco-friendly packaging, and highly familiar pandan flavour profile, all of which successfully appeal to fast-paced consumer habits.

The sensory evaluation underscores high market potential for the pandan-flavoured Nona Manis Bites, driven by exceptionally high scores in colour, texture, flavour, and taste. As sensory evaluation is a crucial metric for capturing true consumer perception and satisfaction, the positive reception across all attributes indicates that the product effectively fulfils modern consumer expectations. Furthermore, panellists highly valued the product's aesthetic novelty and nostalgic appeal, suggesting that this format could significantly enhance the competitiveness of traditional Malaysian treats in both domestic and international snack sectors.

Moving forward, commercial success will depend on iterative product development and target market positioning. Based on sensory feedback, future development should focus on optimising sweetness levels, ensuring product stability, and extending shelf life to secure long-term viability in highly competitive retail markets. Additionally, exploring a broader variety of regional flavour profiles could capture wider market segments. Marketing strategies should deliberately highlight the product’s modern, snackable convenience while proudly emphasising its cultural origins, thereby positioning Nona Manis Bites as a commercially viable and culturally significant innovation within the global snack food industry.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to the Faculty of Hotel and Tourism Management and Universiti Teknologi MARA (UiTM) Cawangan Terengganu for providing the essential financial support (materials) and laboratory resources necessary to develop this innovation. Heartfelt thanks are also extended to all team members for their immense dedication, hard work, and collaborative efforts throughout the development of Nona Manis Bites. Lastly, deep appreciation is given to the sensory evaluation participants whose valuable insights, honest opinions, and feedback made the successful assessment and completion of this food science innovation project possible.

REFERENCES

Bhuyan, B. (2021). An overview of Pandanus amaryllifolius Roxb. ex Lindl. and its potential impact on health. *Current Trends in Pharmaceutical Research, 8*(1), 132–145.

Hassan, K. H. (2014). How to improve our businesses? A study on rural women entrepreneurs in two selected states in Malaysia. *International Journal of Chemical, Environmental & Biological Sciences, 2*(2), 110–114.

Kaur, B., & Karim, A. A. (2020). Traditional Malaysian kuih: Ingredients, processing, and innovation potential. International Journal of Gastronomy and Food Science, 21, 100235. https://doi.org/10.1016/j.ijgfs.2020.100235

Md Ramli, A., Saad, M., Md Shariff, M. S., & Sulistyo, J. (2023). Traditional food entrepreneurs in Sabah and Selangor states: A qualitative perspective. *Journal of ASIAN Behavioural Studies*, *8*(25), 87–97.

LOMPLICIOUS: TRANSFORMING *LOMPAT TIKAM* INTO AN INNOVATIVE FROZEN DESSERT

Muhammad Aieriel Amry bin Mohd Addli[1], Azlin Zuraini binti Mat[1], Nur Syafika binti Harun[1], Noristisarah Abd Shattar[1,*], Muhammad Muzhaffar bin Mohd Aris[1]

[1]Universiti Teknologi MARA (UiTM) Cawangan Terengganu, 23000 Dungun, Terengganu

[*]Corresponding author: noris590@uitm.edu.my

ABSTRACT

The product developed in this project is Lomps Licious, a frozen dessert inspired by the traditional Malaysian *Lompat Tikam*. Presented in a 150 ml tub, the product features two distinct layers: a top layer of pandan-flavoured ice cream (green) and a bottom layer of coconut milk-flavoured ice cream (white), topped with a drizzle of caramelised gula Melaka. The objective of this innovation is to transform a classic traditional dessert into a modern, convenient frozen treat that retains the essence of its original flavour while appealing to younger generations. The main ingredients used include whipping cream, sweetened creamer, ovalette, coconut milk for the white layer, and pandan emulco for the pandan ice cream layer. The production process involved preparing each ice cream mixture, churning, layering, freezing, and finally applying the gula Melaka drizzle. Three product variations were developed: Control as basic pandan and coconut layers with caramelised gula Melaka drizzle; Variation 1 with added chunks of gula Melaka in the pandan layer; and Variation 2 with gula Melaka chunks in the pandan layer and grated coconut in the coconut layer. A sensory evaluation was conducted with 60 untrained panellists aged 18 to 30, using a 9-point hedonic scale to assess colour, sweetness, creaminess, texture, flavour balance, and overall acceptability. Results showed that the Control sample was the preferred overall for its smooth texture and well-balanced traditional flavour. Lomps Licious demonstrates strong market potential among youth and local dessert enthusiasts, particularly in niche markets seeking traditional flavours in modern formats. Its uniqueness lies in its nostalgic taste, vibrant presentation, and frozen convenience.

Keywords: frozen dessert, *Lompat Tikam*, ice cream, sensory evaluation

1.0 INTRODUCTION

Lompat Tikam is a traditional Malay delicacy originating from Kelantan and Terengganu, historically crafted from rice flour, pandan juice, coconut milk, and palm sugar (*gula Melaka*). Beyond being a popular treat during festive seasons like Ramadan, it holds deep cultural significance, symbolising the rich heritage and identity of the Malay community (Aziz & Hashim, 2021). While recent variations have emerged in convenient jars to attract younger consumers (Rashid & Mohamad, 2023), its classic form remains fundamentally unchanged.

Despite its deep-rooted popularity, traditional *Lompat Tikam* faces two primary challenges in the modern market (Kamaruzaman et al., 2020). First, shifting youth preferences mean that younger generations increasingly favour modern, convenient, Western-style treats over traditional *kuih*, putting authentic local flavours at risk of losing their appeal (Abdullah et al., 2024). Second, there are growing health concerns. While the dish is inherently gluten-free and plant-based, its traditional high sugar content raises alarms among increasingly health-conscious consumers (Salleh et al., 2022). Consequently, there is a clear gap in the market for an innovative product that honours this rich cultural heritage while seamlessly adapting to modern consumer lifestyles and textures.

To bridge this gap and preserve Malaysian culinary heritage, this project introduces Lomps Licious, a novel innovation that transforms the classic *Lompat Tikam* into a modern, convenient frozen dessert. Packaged in a practical 150 ml tub, this ice cream features two distinct, vibrant layers of pandan and coconut milk topped with a caramelised *gula Melaka* drizzle. By reimagining the traditional dish into a trendy frozen format, Lomps Licious successfully retains the nostalgic, authentic essence of the original flavour while making it highly accessible and appealing to all generations, from toddlers to adults.

2.0 OBJECTIVE

1. To develop and optimise an innovative frozen dessert formulation (Lomps Licious) that replicates the authentic, multi-layered pandan, coconut, and *gula Melaka* flavours of traditional *Lompat Tikam.*
2. To evaluate consumer acceptability and sensory attributes of the developed Lomps Licious.

3.0 MATERIAL & METHODOLOGY

3.1 MATERIAL

The raw materials required for the formulation of this frozen dessert are meticulously measured by weight percentage to achieve the ideal balance of flavour and structural integrity. Whipping cream serves as the foundational base, comprising the largest share at 44%, followed closely by sweetened condensed milk at 22.5%, to provide sweetness and texture. Coconut milk is incorporated at 10.8% to establish the traditional flavour profile, while sugar and full cream milk are each utilised at 6.8%. To enrich the mixture, butter is included at 4.5%. The remaining formulation consists of functional texturizers and flavour enhancers, including ovalette, pandan emulco, and vanilla essence, each at 1.4% of the total composition, rounded out by green food colouring at 0.4% to establish the characteristic visual layers of the dessert.

3.2 PRODUCT PREPARATION

The product preparation process is executed in distinct phases to create a beautifully layered frozen dessert using advanced culinary equipment. First, Mixture A (the white layer) is prepared by combining whipping cream, sweetened condensed milk, ovalette, coconut milk, and vanilla essence in a mixing bowl, which is then whisked using a stand mixer for 5 minutes until thick and smooth, transferred into a Pacojet container, and frozen it until solid. Simultaneously, Mixture B (the green pandan layer) is created by combining whipping cream, sweetened condensed milk, ovalette, pandan emulco, and vanilla essence, which is similarly whisked for 5 minutes, transferred into a separate Pacojet container, and frozen solid. Once frozen, both containers are removed and processed individually using a Pacojet machine to achieve an ultra-smooth texture before being placed briefly back in the freezer to firm up. The final assembly involves pouring the processed white mixture into an ice cream tub to form the bottom layer, freezing it for 1 hour until it sets, and then pouring the green pandan mixture directly over the set white layer before returning the entire tub to the freezer until it is completely set and ready to serve.

3.3 SENSORY EVALUATION

Sensory evaluation of the three Lomps Licious variations was conducted with 60 untrained panellists aged 18 to 30. The samples evaluated were the Control (basic pandan and coconut layers with caramelised *gula Melaka* drizzle), Variation 1 (with added *gula Melaka* chunks in the pandan layer), and Variation 2 (with gula Melaka chunks in the pandan layer and grated coconut in the coconut layer). Each sample was served in a 2-oz cup labelled with a randomised three-digit number to prevent bias, and panellists rinsed their palates with water between tastings. A standard 9-point hedonic scale was used to assess the attributes of colour, sweetness, creaminess, texture, flavour balance, and overall acceptability. The collected data were then analysed and presented in a chart with mean score values.

4.0 RESULT

4.1 PRODUCT CHARACTERISTIC

Lomps Licious is an innovative frozen dessert that creatively refashions the traditional, soft-textured Malaysian *kuih Lompat Tikam* into a modern ice cream treat. The product features a vibrant, multi-layered presentation consisting of a green top layer of pandan-flavoured ice cream and a white bottom layer of coconut milk-flavoured ice cream, which is finished with a drizzle of caramelised *gula Melaka* (Figure 1). Packaged conveniently in a 150 ml tub, it boasts an ultra-smooth texture achieved with advanced Pacojet processing technology. While offering a contemporary dessert experience, it successfully retains the nostalgic, authentic flavours and natural colours of the original pandan and coconut milk ingredients. Furthermore, the formulation is naturally gluten-free and plant-based, making it an appealing option for health-conscious consumers seeking traditional flavours in a modern format.



Figure 1: LompsLicious products and packaging

4.2 SENSORY ANALYSIS

The sensory evaluation scores for the three formulations of Lomps Licious ice cream are presented below in Table 1. The Control sample performed superiorly across all evaluated sensory characteristics, achieving the highest mean scores in every category, including colour (7.8), sweetness (7.5), creaminess (7.8), texture (7.4), flavour balance (7.6), and overall acceptability (7.8). These high ratings indicate that the baseline recipe achieved a highly optimised equilibrium between the rich, fatty mouthfeel of the coconut milk layer and the aromatic, clean notes of the pandan layer. The high creaminess and texture scores suggest that the omission of solid inclusions preserved a smooth, homogeneous air-and-fat matrix, which is highly prized by ice cream consumers.

In contrast, the addition of solid inclusions led to a downward trend in consumer preference. Variation 1 maintained acceptable scores across the board, securing a 7.2 for colour and texture and a 7.1 for overall acceptability. This minor dip indicates that while the inclusion of hard *gula Melaka* chunks introduced an interesting novelty, it slightly disrupted the physical smoothness of the pandan layer.

Variation 2 received the lowest scores across all categories, lagging significantly behind the other samples in texture (6.4) and sweetness (6.6). The presence of both *gula Melaka* chunks and grated coconut likely created a gritty or excessively fibrous mouthfeel that conflicted with conventional expectations of ice cream smoothness. Furthermore, the lower sweetness score (6.6) for Variation 2 suggests that the unsweetened grated coconut may have diluted the perceived sugary profile or that the uneven distribution of sweetness in chunks rather than a melted drizzle reduced overall taste harmony. Consequently, these findings indicate that while the baseline control recipe is highly optimised, any further formulation modifications involving solid inclusions require physical modifications such as reducing chunk particle size.

Table 1: Mean score value for sensory evaluation of LompsLicious

	Color	Sweetness	Creaminess	Texture	Flavor Balance	Overall acceptability
Control	7.8	7.5	7.8	7.4	7.6	7.8
Variation 1	7.2	6.8	7.1	7.2	6.8	7.1
Variation 2	6.7	6.6	7.0	6.4	6.7	6.9

5.0 CONCLUSION

In conclusion, the innovation of Lomps Licious Ice Cream successfully transforms the traditional, soft-textured Malaysian *kuih Lompat Tikam* into a contemporary, convenient, and appealing frozen dessert without sacrificing its cultural identity. The sensory evaluation clearly demonstrates that the standard baseline recipe is highly optimised, performing superiorly across all characteristics with the ideal blend of colour, smooth texture, and well-balanced traditional flavours. While product variations incorporating extra texturisers, such as *gula Melaka* chunks and grated coconut, show creative potential for innovation, they currently lag behind the control sample, indicating that further recipe modifications are needed to match or enhance the product's baseline quality. Moving forward, leveraging advanced processing technology like the Pacojet to maintain an ultra-smooth consistency, emphasising its gluten-free attributes, and utilising targeted social media marketing will position Lomps Licious as a strong, competitive contender in the modern frozen dessert market.

ACKNOWLEDGEMENT

The authors like to convey their profound appreciation to the Faculty of Hotel and Tourism Management and Universiti Teknologi MARA (UiTM) Cawangan Terengganu for the vital financial support utilised to procure ingredients, supplies, and equipment for this study. Gratitude is expressed to all team members for their commitment and effort, as well as to the sensory assessment participants whose insightful feedback facilitated the successful conclusion of this food innovation project.

REFERENCES

Abdullah, K. M., Putit, L., & Yulia, C. (2024). Innovation in the Malaysian traditional food industry: A conceptual paper. *Advances in Social Sciences Research Journal, 11*(2.2), 199–211.

Aziz, N. A., & Hashim, N. A. (2021). Traditional Malay kuih: Heritage, identity, and consumption. *Journal of Ethnic Foods, 8*(1), 15–22.

Kamaruzaman, M. Y., Ab Karim, S., & Ishak, F. A. C. (2020). The diversity of traditional Malay kuih in Malaysia and its potentials. *Journal of Ethnic Foods, 7*(22).

Pacojet International AG. (n.d.). Pacojet: the must-have cooking system for professional kitchens. Retrieved July 16, 2025, from https://pacojet.com/en-GB/

Rashid, A., & Mohamad, S. (2023). Modernizing traditional desserts: Consumer perceptions and business strategies. Journal of Culinary Heritage and Innovation, 1(1), 24–33.

TURTIDE HOMECOMING JOURNEY: AN INNOVATIVE DIGITAL EDUCATIONAL GAME FOR PROMOTING MARINE CONSERVATION AWARENESS AMONG CHILDREN

Nurul Qistina binti Md Nasir[1], Jasni Bin Ahmad[1], Mohamad Hanif Abu Hasan[1,*]

[1]School of Multimedia Technology and Communication, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia

[*]Corresponding author: hanif@uum.edu.my

ABSTRACT

Marine pollution has become a major environmental issue that threatens marine ecosystems, particularly sea turtles. Educational games have emerged as an engaging approach to promoting environmental awareness among children. Therefore, this study aimed to examine existing educational games, develop a 2D educational game named Turtide Homecoming Journey to promote marine conservation through storytelling and interactive gameplay, and evaluate its usability and effectiveness in raising environmental awareness among children. The study employed the ADDIE instructional design model. A formative evaluation involving experts was conducted before a summative evaluation with 30 children aged 7–12 years. Data were collected using a five-point Likert scale questionnaire adapted from the USE Questionnaire (Usefulness, Satisfaction, and Ease of Use), the Game Experience Questionnaire (GEQ), and relevant educational game literature. The findings indicated high mean scores for Gameplay Experience (M = 4.60), Player Engagement (M = 4.39), Learning Experience (M = 4.66), and Environmental Awareness (M = 4.78). These findings suggest that *Turtide: Homecoming Journey* provides an engaging learning experience while effectively increasing children's awareness of marine pollution and marine conservation. In conclusion, the developed educational game demonstrates the potential of game-based learning as an effective medium for promoting environmental awareness among children.

Keywords: educational game, marine conservation, marine pollution, environmental awareness, game-based learning

1.0 INTRODUCTION

Marine pollution, particularly ocean pollution, has become one of the most critical environmental challenges due to its harmful effects on marine ecosystems. Plastic debris and other marine waste threaten marine life by causing injuries, habitat degradation, and ecological imbalance. Previous studies have shown that plastic pollution poses long-term risks to marine biodiversity and ecosystem sustainability (Thushari & Senevirathna, 2020). This issue is also evident in Malaysia, where marine debris has been reported along the coastal areas of Teluk Bahang, Penang, highlighting the growing concern of marine pollution at the local level (Zanuri et al., 2020).

Environmental issues should be addressed through effective awareness programmes, particularly among younger generations. Environmental education introduced at an early age plays an important role in shaping children's knowledge, attitudes, and behaviours towards environmental conservation (Strong, 1998). With the advancement of digital technology, game-based learning has emerged as an effective educational approach that encourages active participation, motivation, and meaningful learning experiences. Previous research has demonstrated that educational games can significantly improve children's engagement and learning outcomes compared with conventional teaching approaches (Hartt et al., 2020). Furthermore, children aged 7–12 are in the middle childhood stage, during which values and behavioural patterns are actively developed, making this an appropriate period to cultivate environmental responsibility through interactive learning (Knafo-Noam et al., 2023). This is further supported by Alotaibi (2024), who reported that game-based learning positively contributes to children's cognitive development, motivation, and engagement.

Previous studies have shown that educational games are effective in enhancing children's motivation, engagement, and environmental awareness through interactive learning experiences (Hartt et al., 2020; Tan & Nurul-Asna, 2023). However, there is still a lack of child-friendly educational games

that specifically integrate marine conservation with storytelling and interactive gameplay to provide meaningful learning experiences. Therefore, there is a need to develop an educational game that not only delivers environmental knowledge but also encourages children to understand the challenges faced by marine life and foster positive attitudes towards marine conservation (Madani et al., 2017).

To address this gap, this study developed Turtide Homecoming Journey, a 2D educational game designed for children aged 7–12 years. The game combines storytelling with interactive gameplay, allowing players to experience the challenges faced by a baby sea turtle navigating through polluted marine environments. By completing the turtle's journey while avoiding marine debris and collecting food, players are expected to develop greater awareness of marine pollution and foster positive attitudes towards marine conservation.

2.0 OBJECTIVES

The objectives of this innovation are:

1. To identify suitable design elements and educational content for promoting marine conservation awareness among children.
2. To design and develop Turtide Homecoming Journey, a 2D educational game based on the identified design elements and educational content.
3. To evaluate the usability of Turtide Homecoming Journey in promoting marine conservation awareness among children.

3.0 METHODOLOGY

Turtide Homecoming Journey was developed using the ADDIE instructional design model, consisting of the Analysis, Design, Development, Implementation, and Evaluation phases. During the analysis phase, existing educational games and literature on marine conservation were reviewed to identify appropriate educational content and game design elements. The design phase involved the development of the game's storyline, user interface, gameplay mechanics, and storyboard.

The game was developed using the Godot Engine as a 2D digital educational game. In the game, players guide a baby sea turtle through three progressively challenging marine environments, which are Sandy Shore, Ocean, and Deep Sea. Throughout the journey, players collect food, avoid marine debris, and manage the turtle's energy while learning about marine pollution and sea turtle conservation through interactive storytelling and gameplay.

The usability of the game was evaluated through a summative evaluation involving 30 children aged 7 to 12 years. After completing the game, participants responded to a questionnaire consisting of four evaluation constructs: Gameplay Experience, Player Engagement, Learning Experience, and Environmental Awareness. Descriptive statistics were used to analyse the collected data.

4.0 RESULT

Turtide Homecoming Journey introduces an innovative approach to environmental education by integrating marine conservation concepts into an interactive digital game for children aged 7–12. Unlike conventional learning methods that rely on reading materials or classroom instruction, the game delivers educational content through immersive storytelling and gameplay. Players take on the role of a baby sea turtle navigating three progressive marine environments while learning about the impacts of marine pollution and the importance of protecting marine ecosystems.

The novelty of this innovation lies in its combination of interactive storytelling, progressive level-based gameplay, and environmental education within a single digital learning platform. Rather than presenting conservation knowledge through text alone, Turtide: Homecoming Journey encourages experiential learning by allowing players to actively collect food, avoid marine debris, and manage the turtle's energy. These gameplay mechanics simulate real-life challenges faced by sea turtles, making the learning experience more engaging, meaningful, and memorable for young players.

The effectiveness of the game was evaluated through a summative evaluation involving 30 children aged 7–12 years. The findings demonstrated positive user responses across all evaluation constructs, with mean scores of 4.60 for Gameplay Experience, 4.39 for Player Engagement, 4.66 for Learning Experience, and 4.78 for Environmental Awareness. These results indicate that the game successfully promotes environmental awareness while providing an enjoyable learning experience.

Overall, Turtide Homecoming Journey has the potential to serve as an innovative educational tool that supports environmental education in schools, community awareness programmes, and informal learning environments. By combining entertainment with meaningful educational content, the game

encourages children to develop greater awareness and appreciation for marine conservation from an early age.

Table 1. Summary of Overall Mean Scores

Construct	Overall Mean	Interpretation
Gameplay Experience	4.6	High
Player Engagement	4.39	High
Learning Experience	4.66	High
Environmental Awareness	4.78	
Overall Mean	4.61	High

5.0 CONCLUSION

Turtide Homecoming Journey demonstrates the potential of digital educational games as an innovative approach to promoting marine conservation awareness among children. By integrating interactive storytelling, engaging gameplay, and environmental education, the game provides an enjoyable and meaningful learning experience. The positive evaluation results indicate that the game effectively supports children's understanding of marine conservation and has the potential to be implemented in schools and environmental awareness programmes. Overall, this innovation contributes to Sustainable Development Goal 14 (Life Below Water) by making marine conservation education more engaging, interactive, and accessible for young learners.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to the supervisor for the continuous guidance, valuable advice, and support throughout the development of Turtide Homecoming Journey. The authors also extend their gratitude to the participants who were involved in the evaluation process, as well as to Universiti Utara Malaysia (UUM) for providing the facilities and support that contributed to the successful completion of this innovation project.

REFERENCES

Alotaibi, M. (2024). Game-based learning in early childhood education: a systematic review and meta-analysis. Frontiers in Psychology, 15(1). https://doi.org/10.3389/fpsyg.2024.1307881

Hartt, M., Hosseini, H., & Mostafapour, M. (2020). Game On: Exploring the Effectiveness of Game-based Learning. Planning Practice & Research, 35(5), 589–604. https://doi.org/10.1080/02697459.2020.1778859

Knafo-Noam, A., Daniel, E., & Benish-Weisman, M. (2023). The Development of Values in Middle Childhood: Five Maturation Criteria. Current Directions in Psychological Science, 33(1). https://doi.org/10.1177/09637214231205865

Madani, K., Pierce, T. W., & Mirchi, A. (2017). Serious games on environmental management. Sustainable Cities and Society, 29, 1–11. https://doi.org/10.1016/j.scs.2016.11.007

Strong, C. (1998). The impact of environmental education on children's knowledge and awareness of environmental concerns. Marketing Intelligence & Planning, 16(6), 349–355. https://doi.org/10.1108/02634509810237523

Tan, C. K. W., & Nurul-Asna, H. (2023). Serious games for environmental education. Integrative Conservation, 2(1), 19–42. https://doi.org/10.1002/inc3.18

Thushari, G. G. N., & Senevirathna, J. D. M. (2020). Plastic Pollution in the Marine Environment. Heliyon, 6(8). https://doi.org/10.1016/j.heliyon.2020.e04709

Zanuri, N. B. M., Abdullah, M. B., Darif, N. A. M., Nilamani, N., & Hwai, A. T. S. (2020). Case study of marine pollution in Teluk Bahang, Penang, Malaysia. NASA ADS, 414, 012032. https://doi.org/10.1088/1755-1315/414/1/012032

ORGANIZING COMMITTEE

Patron
Prof. Madya Dr. Saunah Zainon

Advisor 1
Dr. Faridah Najuna Misman

Advisor 2
Dr. Siti Khadijah Alias

Director
Dr. Nur Idayu Alimon

Vice Director
Dr. Nur Fatihah Shaari
Dr. Maizura Md Isa@Kamarudin

Secretary
Dr. Siti Noradiah Amar
Dr. Nur Syamila Arifin

Secretariat
Puan Nurul Aien Abd Aziz
Noor Insyirah Mohsin
Nor Zubaidah Nor Albashri
Suguna Olakanathan

Treasurer
Nur Intan Syafinaz Ahmad
Eliana Hasmah Jamil
Noor Aida A. Bakar

Multimedia & Montage
Cik Nur Humairah Aini Mohd Fidzal
Nursia Yuhanis
Dr. Zulkifli Abdul Ghaffar

Protocol
Ts. Zahari Abu Bakar
Siti Mariam Mohammad Iliyas
Dr. Zatul Iffah Abd Latiff
Dr. Nur Iqtiyani Ilham
Norhalida Othman
Ts. Wan Suhaifiza W Ibrahim

Publication
Dr. Wan Munirah Wan Mohamad
Maisarah Noorezam
Dr. Nor Kamariah Kasmin @ Bajuri
Dr. Nur Farhana Mohd Yusof
Nurhazirah Mohamad Yunos
Aznilinda Zainuddin

Foreign relations
Dr. Suhaili Beeran Kutty
Dr. Ng Set Foong
Dr. Nur Amalina Muhamad
Dr. Noor Hafizah Khairul Anuar
Dr. Fadila Mohd Atan

Editorial
Nur Alyani Khairol
Muhammad Irfan Mokhtar
Nursuhaila Ibrahim
Dr. Nurul Hijah Jasman
Nursyuhada Zakaria
Siti Aishah Taib
Nurul Alia Hasni Mohd Sani
Hawa Syamsina Md Supie
Nurul Nadiah Rasdi

ORGANIZING COMMITTEE

Jury & Award
Dr. Atiqah Hamizah Mohd Nordin
Ir Ts Dr Diana Che Lat
Dr Nur Asfahani Ismail
Dr Norlee Husnafeza Ahmad
Nur Dalila Khirul Ashar
Dr Fatimah Khairiah Abd Hamid
Dr Nor Affida M. Zin
Dr Rijalul Fahmi Mustapa
Dr Mohd Ezwan Mahadan
Ir Dr Hajar Jaafar

Systems Management & Registration
Nora Farina Mohd Halim
Doris Asmani Mat Yusof
Dr Roslizayati Razali
Dr Nur Syazwani Noor Rodi
Mohd Johan Mohamed Ibrahim
Saiful Jumali
Siti Shahidah Sharipudin

Technical & Logistics
En. Ahmad Faidzal Khodori
En. Firdaus Sukarman
En. Ahmad Khairi Mohd Zawawi

Promotion
En. Muhamad Ashaari Sukar
Ahmad Marzuki Amiruddin Othman
Syaidatul Zarina Mat Din
Mohd Firdaus Mohd Akhbar
Nor Fauziah Abu Bakar
PM Dr. Raja Haslinda Raja Mohd Ali
Rozhafiezam bin Rosdi

Gifts & Souvenirs
Ts. Dr. Adrina Rosseira Abu Talip
Dr Kamariah Md Isa
Hairul Amiza Azman
Syidatul Akma Sulaiman
Gs Dr Nor Azizah Che Azmi
Dr Nurulnatisya Ahmad

Certificate
Puan Rohayu Ahmad
Muharratul Sharifah Shaik Alaudeen
Derwina Daud
Diana' Mazan
Nadia Nurul Najwa Mohmad Hassan
Azlina bin Jumadi

Special Duties
Norbaiti Sidik
Dr. Nor Diyana Md Sin
Fazlinashatul Suhaidah Zahid
Ainaa Maya Munira Ismail
Siti Musliha Ajmal Mokhtar

Website & System
En. Ezril Hisham Mat Saat
Noor Hasliza Abdul Rahman

COLLABORATORS



UniKL
UNIVERSITI KUALA LUMPUR



UNIVERSITI POLY-TECH MALAYSIA
UPTM
DU060 (W)



SOUTHERN
UNIVERSITY COLLEGE
南方大學學院

Politeknik Caltex Riau

KPTM
KOLEJ POLY-TECH MARA
BATU PAHAT

SPONSORSHIP

ZIYAD

ZIYAD ENGINEERING & CONSTRUCTION SDN BHD

EVOLUSI DEKAD 7
DEWAN LATEHAN RIDA ke UiTM
1956-2026

UNIVERSITI TEKNOLOGI MARA

JOHOR 2026
SMART INNOVATIONS FOR A SUSTAINABLE AND RESILIENT FUTURE

