

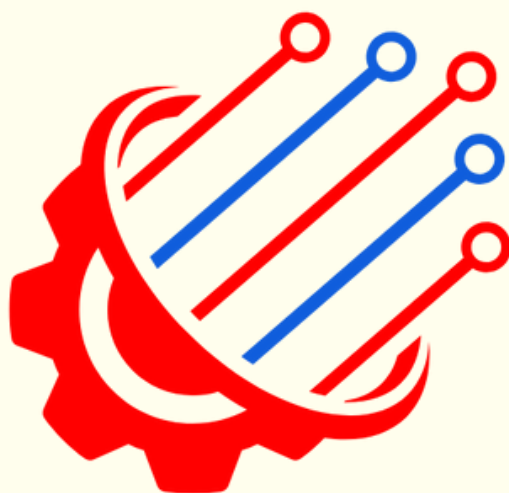


7TH IRCHST 2025

PROCEEDING:

**7TH INTERNATIONAL RESEARCH
CONFERENCE ON HUMANITIES, SOCIAL
SCIENCES AND TECHNOLOGY 2025
(7TH IRCHST 2025)**

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**GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD
2025**



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PREFACE

It is with great pleasure that I present the proceedings of the 7th International Research Conference on Humanities, Social Sciences and Technology 2025 (7th IRCHST 2025), held on 4th–5th October 2025 at Yannaty Hotel, Hat Yai, Thailand. This conference marks another significant milestone in our ongoing effort to provide a dynamic platform for scholars, researchers, academicians, and practitioners to exchange knowledge, ideas, and innovative research in the fields of humanities, social sciences, and technology.

Since its inception, the IRCHST series has aimed to foster academic collaboration and encourage interdisciplinary research that addresses the evolving challenges of the modern world. The 7th edition continues this tradition, featuring thought-provoking discussions, insightful presentations, and groundbreaking research findings that reflect the diversity and richness of global academic inquiry.

We are honored to have participants from various countries contributing their valuable research to this conference. Their work not only enriches our understanding of different cultural and academic perspectives but also strengthens the spirit of international cooperation in advancing education and research excellence.

On behalf of the organizing committee, I wish to extend my sincere appreciation to all presenters, participants, reviewers, and committee members who have dedicated their time and expertise to make this event a success. Special thanks are also due to our co-organizers, partners, and sponsors for their unwavering support and commitment to academic advancement.

It is our hope that the research presented in these proceedings will serve as a meaningful reference and inspiration for future studies in the areas of humanities, social sciences, and technology. May this collection of papers continue to encourage collaboration, critical thinking, and innovation among scholars and professionals around the world.

Congratulation and Thank You.

Sincerely,

Ts. Inv. Dr. Wan Azani Wan Mustafa

Chairman

*7th International Research Conference on Humanities,
Social Sciences and Technology 2025 (7th IRCHST 2025)*

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SERENIGUIDE: A MACHINE-LEARNING-POWERED SLEEP COMPANION APPLICATION

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Abstract: Sleep is one of the most important processes that the body goes through. Chronic sleep deprivation and untreated sleep disorders are linked to several diseases and disorders, some of which are life-threatening. Several studies and technologies have been conducted and developed to address sleep deprivation, improve sleep quality, and increase overall human well-being. However, such studies depend on the body's physiological functions to predict sleep quality. While technologies offer sleep-recommending capabilities, they are usually expensive and/or rely on body metrics. Thus, this study proposed, designed, and developed SereniGuide, a web application that combines machine learning models with empathic application principles to help assess sleep stages and educate users about several external factors affecting their sleep and their health. In this study, a Sleep Efficiency Dataset from Kaggle was acquired, preprocessed, and used as input data to compare eight classification machine learning models that underwent hyperparameter tuning. Results show that Multilayer Perceptron (MLP) exhibited the highest accuracy, precision, recall, and F1 score values of 87.50%, 87.60%, 87.50%, and 86.74%, respectively. A usability test was conducted via interviews with five participants to evaluate SereniGuide in terms of clarity, usability, and aesthetics, all of whom expressed interest in the application and the potential benefits that could be gained by using the application. Insights, limitations, and avenues for further development as a sleep-assisting technology, such as the presence of overfitting in the training performances of the models and the lack of clearer information in the deployed SereniGuide application, were also discussed, as well as potential applications in various fields like medical experiments that record sleeping habits and further research on cultural differences in sleeping patterns.

Keywords: Sleep Monitoring, Sleep Classification, Health, Machine Learning.

Introduction

Sleep is one of humans' most vital daily activities, influencing nearly all bodily functions and processes, including memory, learning, metabolism, tissue and muscle growth, mood



regulation, and immune system maintenance (Ravindra, 2012). However, chronic sleep deprivation and disruption are closely linked to a range of health disorders such as hypertension, arrhythmia, obesity, dementia, diabetes, and depression, and despite the well-documented benefits of good sleep and the adverse effects of poor sleep quality, modern lifestyles, and work cultures often prioritize productivity over adequate rest (Worley, 2018). This trend is reflected in alarming statistics across various regions. Approximately 46% of Southeast Asians report experiencing sleep problems weekly, with over half of the survey respondents in the Philippines indicating issues like insomnia and irregular sleep cycles—one of the highest rates in Southeast Asia (Abadilla, 2023). Sleep disorders are also prevalent in Western countries. In the United States, an estimated 50 to 70 million adults have been diagnosed with a sleep disorder. Similarly, in Australia and the Netherlands, around a fourth of the population is affected by sleep disorders (Tasnim, 2020). These statistics highlight the global nature of sleep problems and the pressing need for solutions addressing poor sleep's impact on health and well-being.

This study thus proposed a comprehensive sleep recommendation system that combines self-recorded body metrics with external factors. The system is designed to integrate seamlessly into users' daily lives, enabling them to easily input data they can comprehend while receiving clear and actionable feedback. By utilizing machine learning, the system identifies users' sleep types and provides personalized recommendations for optimal sleep. This project is part of the researchers' efforts to contribute to the 3rd United Nations Sustainable Development Goal: Ensuring healthy lives and promoting well-being for all.

Literature Review

Much effort has been made to leverage the power of empathic computing technologies as a response to this widespread problem of sleep deprivation, and hardware solutions that use sensors directly connected to the body make up the more generic form of sleep-monitoring technologies. The first prominent category for hardware solutions is wearable devices that help consumers conveniently track body metrics. Stone et al. (2020) discussed wrist-based wearable devices such as the Apple Watch, Fitbit, Garmin Vivosmart 4, and Polar A370. There is also the Sleep Profiler EEG Profile Monitor, which wraps around the head, and the Beddit Sleep Monitor, where users lie on top of a long, flat strip while on their bed. Sleep monitoring devices track duration and quality using body metrics, but they face three key issues: they overlook external lifestyle and environmental factors, they are often costly and financially risky for lower-income users, and their validity and reliability remain unclear while providing limited actionable guidance (Stone et al., 2020).

The second category of sleep-tracking technologies is integrated sleep monitoring systems typically stationed in hospitals or dedicated sleep centers. Polysomnography (PSG) is one of the best methods for assessing sleep quality and assessing sleep disorders. It combines a myriad of machines, such as electrooculograms, electromyograms, and electrocardiograms, to precisely measure sleep patterns and disturbances (Rundo et al., 2019). However, the high cost, limited machine availability, and lengthy duration of PSG mean patients wait a long time before being diagnosed, much less treated. Thus, Lin et al., (2017) proposed and developed an Internet-of-Things-based (IOT) Wireless Polysomnography System to provide patients with diagnoses of similar accuracy to clinical PSGs without leaving the comfort of their homes. This was achieved by building a small, battery-powered, and wireless module that measures a user's

bio-signals when worn. After comparing their device's results with laboratory-grade PSG machines, similar levels of accuracy and effectiveness were discovered. Unfortunately, battery problems, machine defects, and maintenance hindered the widespread adoption of this system.

Another variation of stationary sleep-monitoring devices comes from the work of Kay et al., (2012), Lullaby was developed to improve the existing sleep-monitoring technologies. It combines light, motion, and temperature sensors with cameras and microphones to record the user's bodily responses during sleep and how conducive their environment is. The simpler technological composition was implemented with the intention of letting people use this device in their homes. Though the plethora of sensors enhances the accuracy of Lullaby's analyses, this is also its biggest drawback, as the system is rather complex and cumbersome for the average consumer. The invasive and unrestricted surveillance of a user's body and environment may also carry privacy concerns, as this data could be used for malicious purposes. The main drawbacks to hardware solutions for sleep monitoring and analysis lie mostly with the limitations of physical materials. No matter how compact or comfortable these devices may become, they must be worn or attached to one's body. Peripherals may be lost or stolen, and while intricate machines may be accurate, they are expensive and cannot be distributed or used on a large enough scale.

To address the limitations of hardware solutions, mobile applications have been a popular avenue for assessing sleep quality. Personal informatics refers to tools that aid people in collecting metrics and data, both for internal and external factors, for self-monitoring and analytics (Daskalova, 2016). SleepTight by Choe et al. (2015) is an example of a personal informatics system created as a mobile application for the Android operating system. Users of SleepTight showed a much higher self-reporting rate (up to 92%) compared to users who tracked their sleep without the app (73%). The developers behind SleepTight were creative in taking advantage of Android's widgets system to reduce self-reporting friction. Other app features include a sleep summary feature tab to help visualize sleep patterns over a given time frame and a comparison tab that shows users which activities contributed to different aspects of their sleep. However, a limitation of this application is that users struggle to comprehend the significance of the data presented to them, and they cannot identify the various factors influencing their sleep patterns. The app merely presents data without deducing the cause of certain sleeping patterns, thus, leaving users to interpret results themselves.

Persuasive technologies focus on inciting change in a user's actions or attitudes through guidelines, suggestions, or recommendations. These suggestions may be generic and advised to several users or personalized depending on each user's conditions (Daskalova, 2016). Bauer et al., (2012) presented a simple design called ShutEye by focusing on a glanceable peripheral display on a smartphone's lock screen or notification center. Aside from the usual sleep habit-tracking features in other mobile applications, ShutEye also offers a variety of recommendations to help users improve their sleep quality, complete with explanations and statistics backed by published journals and articles. However, user input is still limited. ShutEye only analyses the user's sleeping behaviors without considering other external factors such as diet, nicotine consumption, or exercise.

Meanwhile, SleepCoach by Daskalova et al., (Daskalova, 2016) improves upon persuasive technology by integrating sleep monitoring with data-driven sleep recommendations. The system follows a closed feedback loop: user data is collected using raw mobile sensor data, this

data is communicated to clinicians, clinicians provide tailored suggestions, and then suggestions are sent to the user. Through iterative short experiments, SleepCoacher allows users to adjust various factors affecting their sleep, enabling the system to refine its recommendations over time. However, a notable drawback of SleepCoacher is its reliance on manual processes, requiring clinicians to review data and provide tailored feedback constantly. This bottleneck only increases as more users actively utilize the app, potentially overworking the clinician and leading to delays or discrepancies in feedback.

All the aforementioned technologies show that, despite the great strides made in both hardware and software-based sleep-recommending technologies, many improvements still need to be made. Specifically, there is a need for sleep-prediction technologies that combine the accuracy of physical devices, the convenience of personal informatics, and the actionable recommendations given by persuasive technologies.

Methodology

A dataset called *Sleep Efficiency Dataset* was used as a primary dataset for the machine learning stages of this study. The dataset was sourced from Kaggle and originated from an unpublished study conducted by a team of artificial engineering researchers from ENSIAS in Morocco, which intended to determine and explore the influence of caffeine, alcohol, and exercise on the sleep patterns and sleep quality of the participants. The dataset includes the following features listed in Table 1:

Table 1: Features of Sleep Efficiency Dataset

Feature	Description
Age	The age of the participant
Gender	If the participant is Male or Female
Bedtime	The time the participant went to bed each night
Wakeup Time	The time the participant woke up each morning
Sleep Duration	The total time in hours when the participant was in bed
Sleep Efficiency	A calculated proportion of time spent asleep
REM Sleep Percentage	The percentage of total sleep time spent in REM sleep
Deep Sleep Percentage	The percentage of total sleep time spent in Deep sleep
Light Sleep Percentage	The percentage of total sleep time spent in Light sleep
Awakenings	The number of times the participant woke up in between their sleep
Caffeine Consumption	The amount of caffeine in milligrams that the participant took before bedtime
Alcohol Consumption	The amount of alcohol in ounces that the participant took before bedtime
Smoking Status	Whether or not the participant smokes
Exercise Frequency	The number of times the participant exercises within the week of survey

This study chose the *Sleep Efficiency Dataset* because some of the listed features are closely related to human lifestyle and could be answered by participants to the best of their knowledge.

Before the machine learning stages of this study, basic data preprocessing steps were conducted.

The research aims to classify what type of sleep is prevalent based on the features mentioned through the utilization of Machine Learning. Hence, the machine learning classification models must identify which feature(s) will serve as the model's target variable(s). Notice the relationship of the features 'RSP', 'DSP', and 'LSP' in Table 2. The values of REM Sleep Percentage (RSP), Deep Sleep Percentage (DSP), and Light Sleep Percentage (LSP) all accumulate to 1.0, meaning it could be viewed as the probability whether the instance's primary type of sleep is either REM Sleep, Deep Sleep, and Light Sleep.

Table 2: REM Sleep Percentage (RSP), Deep Sleep Percentage (DSP), and Light Sleep Percentage (LSP)

	RSP	DSP	LSP	Sum	is Sum = 1?
0	0.18	0.70	0.12	1.0	True
1	0.19	0.28	0.53	1.0	True
2	0.20	0.70	0.10	1.0	True
3	0.23	0.25	0.52	1.0	True
4	0.27	0.55	0.18	1.0	True
...	...	...	...	...	...
447	0.22	0.57	0.21	1.0	True
448	0.28	0.57	0.15	1.0	True
449	0.20	0.32	0.48	1.0	True
450	0.18	0.72	0.10	1.0	True
451	0.22	0.23	0.55	1.0	True

Number of Rows: 452

Number of True values in *is Sum = 1?* column: 452

Therefore, a new feature labeled *Sleep Type* is added to the set of features, where REM Sleep, Deep Sleep, and Light Sleep are categorized with discrete numerical values zero (0), one (1), and two (2), respectively. However, the number of REM-type sleep in the current dataset is at zero (0). Due to the supervised nature of the machine learning models, it is therefore implied that the model used in this research cannot learn the sleep type REM Sleep due to its absence in the current dataset. Because of this, the values of the target feature *Sleep Type* are converted to zero (0) for Deep Sleep and one (1) for Light Sleep.

The features *REM Sleep Percentage*, *Deep Sleep Percentage*, and *Light Sleep Percentage* were percentages with *int64* type (e.g. 97 instead of 97% or 0.97). These values were converted to *float64* type and divided by 100.0 to get its equivalent value in decimal. The values of *Smokes* feature were also converted from an *object* type to an *int64* type, with one (1) serving as True and zero (0) as False. On the other hand, the unit of measurement of feature *Alcohol Consumption* is different from the unit of measurement of feature *Caffeine Consumption*. As stated, the feature *Caffeine Consumption* has a unit of measurement of milligrams (mg), while the feature *Alcohol Consumption* is in units of ounces (oz), which are heterogenous data in nature (Wang, 2017). This is significant to notice because equal units of measurement are crucial for a fair and accurate comparison of the features in the machine learning training process, which, if done correctly, will result in higher prediction accuracy of the model. Hence, the values of either feature must be transformed to achieve such a goal. Feature scaling is an

essential step for almost all machine learning models as it helps increase the efficiency of the training and prediction processes. It involves rescaling each feature such that it has a mean that is closer to zero (0) and a standard deviation that is closer to one (1), which helps in accelerating calculations in machine learning models (Thara et al., 2019). Looking at the mean and standard deviation values of the features (except Sleep Type), it is evident that there is a need for feature scaling due to their values that are far from the standard mentioned. To achieve feature scaling, the Robust Scaler from Scikit was used since it scales features by removing the median and scales each data according to the interquartile range, or the range between the 1st Quartile and the 3rd Quartile, which is robust to outliers.

With the modified Sleep Efficiency Dataset preprocessed, this data is inputted in the following machine learning models based on the study of Sekkal et al., (2022): Multilayer Perceptron (MLP), Support Vector Machine RBF-Kernel (SVM-RBF), Random Forest, Linear Support Vector Machine, Logistic Regression, K-Nearest Neighbors, Decision Tree, and Naïve Bayes. These models are supervised in nature, where their approach is to train the algorithms to predict data using known labeled inputs and outputs Ayodele (2010). Since one of the goals of this research is to provide the most accurate machine learning prediction on which type of sleep is prevalent in each data, these models are compared for their performances using their Accuracy, Precision, Recall, and F-1 score values, where the best models are visualized using the confusion matrix (Yusof, et al., 2023). The hyperparameter tuning algorithm used in this study is called GridSearchCV from Scikit. It offers searching automation by trying out all the combinations of hyperparameters, cross validating each combination to the training set, and outputting the best set of hyperparameters at the end of its search. This ensured that the models deployed in this study provided the highest accuracy from its training/learning stage using the current dataset.

SereniGuide Web Application

The researchers developed a web application as the main interface to transform the algorithm into something users can interact with. The web application utilizes Vue.js for the front end and Python for the back end. Vue handles the application's design by asking users for vital sleep and health-related information to fill the input values needed by the algorithm. retrieval. Upon accessing the website, users are greeted with the starting page, as shown in Figure 3, which provides an overview of the website's purpose and functionality. This page is an entry point for users to initiate the data input process. When the Get Started button is clicked, users are directed to the data input field page, as shown in Figure 1, where they can input their data. This page is designed to be user-friendly, with intuitive input fields and clear instructions to guide users through the process. This self-reporting strategy follows a similar process to the aforementioned mobile applications in the literature review, such as *SleepCoacher* (Daskalova, 2016) and *Sleeptight* (Choe, 2015).

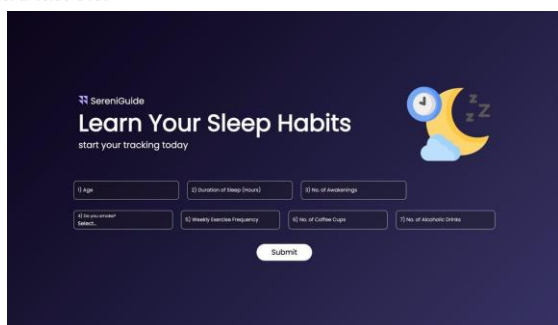


Figure 1: Data input page of SereniGuide web application

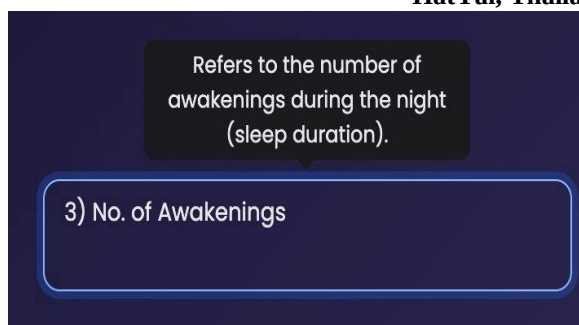


Figure 2: A sample description popup of a data input

The website provides descriptions for vague prompts to enhance user experience and ensure accurate data input, as seen in Figure 2. These descriptions help users better understand the type of information required and improve the quality of input data. In the backend, the machine learning algorithm with the highest accuracy is then exported and hosted on its server using Flask, which is a Python web framework. The Vue application and Flask server then communicate through a series of requests to process the user's input and output it back onto the Vue application after the algorithm's computation. Meanwhile, users in the front end are directed to the results page after submitting their data (see Figure 3), where they can view the outcomes of the machine learning analysis. The results are presented in a clear and concise manner, making it easy for users to interpret the findings. In addition to presenting the analysis results, as seen in Figure 4, the application provides lifestyle recommendations based on some of the user's input values based on research and related literature. The recommendations provided are based on sleep duration about age, alcohol and caffeine consumption, exercise frequency, smoking, and number of awakenings, as discussed by Hirshkowitz et al., (2015), Rubio-Arias et al., (2017), and e Silva et al., (2022). This feature resembles ShutEye's (Bauer et al., 2012) sleep recommendation feature, where users can learn more about their sleep patterns and behaviors.

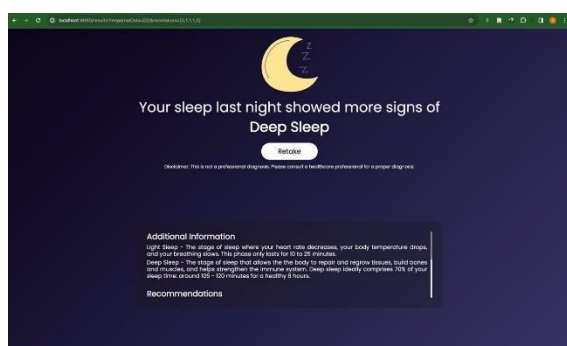


Figure 3: Result page of SereniGuide web application

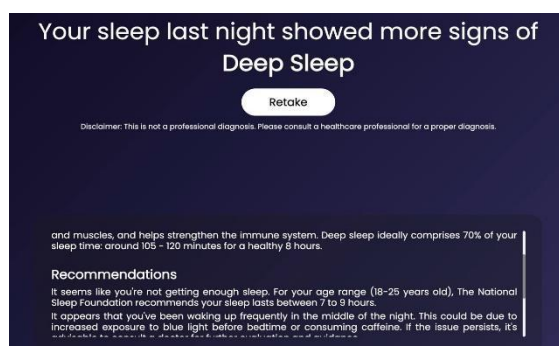


Figure 4: Lifestyle recommendations based on evaluation in data input

Ethical Considerations and Usability Testing

Five participants were gathered via Convenience Sampling to test the feasibility and effectiveness of the SereniGuide web application. Researchers of this study ensured that the participants' demographics include both male and female in gender, have an age of at least 18 years old, have a decent internet connection in their household, and are familiar with the use

of computers and the world wide web. All participants were then asked to sign an Informed Consent form voluntarily. The form contains the following sections: 1) The purpose and procedure of the study, 2) the potential psychological discomfort since their lifestyle is inputted to predict their sleeping stages, 3) the potential benefits of their data to the advancement of empathic computing, 4) the assurance on the confidentiality of their data, and 4) the clarification that their participation is entirely voluntary and that they can withdraw from the usability testing at any time. All participants were also informed that the output that the web application will display was only recommendations based on some research studies and does not represent any medical diagnosis that may be related nor reflect any negative connotations about the user. Due to this, the participants were also strongly encouraged not to over-rely on the web application's output and to seek a medical doctor to further consult for professional advice. Once signed, all participants were made aware of the SereniGuide web application and what type of life-aspect factors are needed, ensuring that their personal information, such as name, contact number, and e-mail addresses, are not included in the study. All questions raised by the participants before usability testing were also answered and clarified, and a piece of contact information was given to them in case of follow-up inquiries and concerns.

As stated, this study utilized Usability Testing to test whether the SereniGuide web application is effective as a sleep-recommending system. In the testing process, all participants were asked to use the application at least five times before giving feedback about the application in terms of three criteria: Clarity, Usability, and Aesthetics. The Usability Testing of all participants was done via interviews through online meetings in the participants' preferred schedule. The researcher also noted the participants' responses in detail as the testing session proceeded. The results of both machine learning and usability testing of SereniGuide were discussed in the next section of this study.

Results and Discussions

This section details the results from performing the machine learning stage and deployment evaluations of this study, which contains the model performances after the hyperparameter tuning of eight classification machine learning models, as well as the usability evaluation of the SereniGuide web application. As shown in Table 3, all eight classification machine learning models produced quality performances on all evaluation metrics, Accuracy, Precision, Recall, and F1 score, where the lowest percentage value is 77.35%, and the highest percentage value is 100.00 for both training and testing sets of the modified Sleep Efficiency Dataset. However, looking at the Multilayer Perceptron (MLP) as an example, the performance of this model using the testing set is lower than the training set. This observation is visible to all eight models, especially on Random Forest and Decision Tree where the training performances are all 100.00% but lowered by more than 10% when the testing set is used. Hence, it is noticeable that all models decreased in performance when it comes to predicting the testing data when trained using the training data, possibly indicating overfitting in the training stage of machine learning. Yet, although this is the case, all the metric values on the testing set are still of high quality, where the highest is at 87.60%. This performance value makes the dataset reliable for usage and deployment to predict sleeping types, Deep Sleep and Light Sleep.

Amongst all models, Multilayer Perceptron (MLP), Support Vector Machine with RBF-Kernel (SVM-RBF), and Random Forest produced the highest performances on the testing dataset. MLP has an accuracy of 87.50%, precision of 87.60%, recall of 87.50%, and F1 score of

86.74%, which are the highest values recorded during the machine learning process of this study. Meanwhile, the performances of SVM-RBF and Random Forest are close to each other. These models both have an accuracy and recall of 86.03%, but SVM-RBF has a precision of 86.67%, which is higher than the 85.89% of Random Forest, while Random Forest has an F1 score of 85.18%, which is higher than the 85.75% of SVM-RBF. Nevertheless, these three models performed most accurately compared to the rest, as shown in Table 3.

Table 3: Performances of Eight Models under Accuracy, Precision, Recall, and F1 score metrics

Model	Accuracy (%) of Training Set	Accuracy (%) of Testing Set	Precision (%) of Training Set	Precision (%) of Testing Set	Recall (%) of Training Set	Recall (%) of Testing Set	F1 (%) of Training Set	F1 (%) of Testing Set
MLP	95.25	87.50	95.26	87.60	95.25	87.50	95.15	86.74
SVM-RBF	87.34	86.03	87.09	86.67	87.34	86.03	86.46	84.75
Random Forest	100.00	86.03	100.00	85.89	100.00	86.03	100.00	85.18
Linear SVM	81.01	80.15	79.76	79.39	81.01	80.15	78.35	77.97
Logistic Regression	81.33	78.68	79.93	77.35	81.33	78.68	79.34	77.38
KNN	89.56	81.62	89.52	80.76	89.56	81.62	88.94	80.50
Decision Tree	100.00	82.35	100.00	82.68	100.00	82.35	100.00	82.50
Naive Bayes	80.70	81.62	79.41	81.21	80.70	81.62	79.68	81.37

Figure 5, 6, and 7 show the confusion matrix of the three best-performing models, MLP, SVM-RBF, and Random Forest, when predicting the testing set of the preprocessed Sleep Efficiency dataset. Discussing Figure 8, MLP has a precision of 87.27% and a recall of 96.97% when predicting class 0 or Deep Sleep and a precision of 88.46% and a recall of 62.16% when predicting class 1 or Light Sleep. Meanwhile, as calculated from Figure 9, predicting Deep Sleep using SVM-RBF produces a precision of 85.09% and a recall of 97.98%, while predicting Light Sleep produces a precision of 90.91% and a recall of 54.05%. Lastly, in Figure 10, using Random Forest to predict Deep Sleep has a precision of 86.36% and a recall of 96.94%, while Light Sleep prediction has a precision of 84.62% and a recall of 59.46%.

Based on these models' precision and recall values, it is evident that Random Forest performed the lowest compared to SVM-RBF in terms of precision when predicting Deep Sleep and Light Sleep. It is also lowest on recall in Deep Sleep prediction and was only second to MLP in terms of recall under Light Sleep Prediction. On the other hand, although SVM-RBF has the highest recall when predicting Deep Sleep, it only performed 1.01% better than MLP, and when predicting Light Sleep, MLP still has the highest recall value. Furthermore, MLP has the highest precision when predicting Deep Sleep and was only 2.45% lower than SVM-RBF when predicting Light Sleep. Therefore, among the three models, MLP proved to be the best-performing model for predicting both Deep Sleep and Light Sleep.

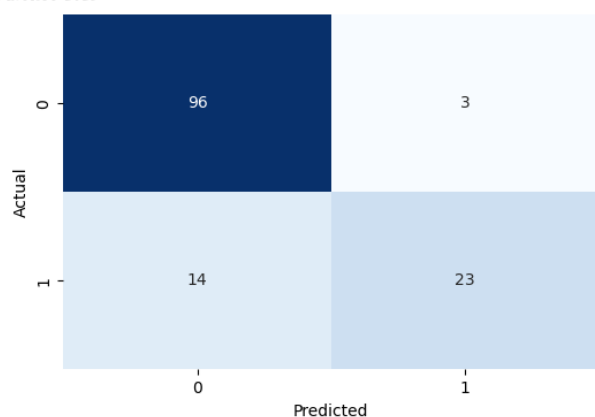


Figure 5: Confusion Matrix for MLP

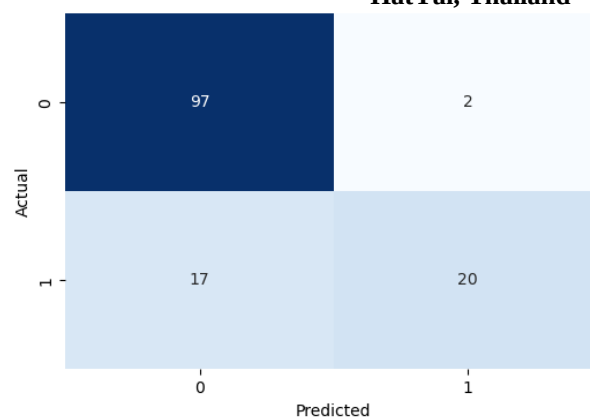


Figure 6: Confusion Matrix for SVM-RBF

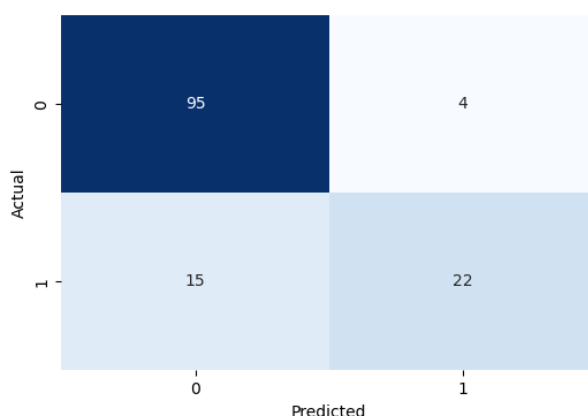


Figure 7: Confusion Matrix for Random Forest

Due to MLP being the best performing classification machine learning model for sleeping type prediction, it is therefore used as the model deployed in the SereniGuide web application. The following section discusses the results of the usability testing of SereniGuide.

Usability Testing Evaluation of SereniGuide

Five participants were interviewed to discuss and give feedback on the website. Under the Usability Testing, each participant was asked about the website's clarity, usability, and aesthetic. Their responses are tabulated in Table 8 and discussed in the subsequent paragraphs.

Participant 1 (P1) provided valuable insights into the system's user interface design and analytical depth during the evaluation process. P1 emphasized the need for enhanced descriptions accompanying each data input field to ensure users grasp the information collected effectively. Furthermore, P1 highlighted the importance of clarifying the significance of different sleep stages, advocating for a more apparent distinction between light sleep and deep sleep to aid users in interpreting their sleep patterns accurately. Regarding the results page, P1 suggested incorporating more in-depth insights in the section, including trends over time and comparisons to recommended sleep patterns. P1 also recommended implementing a weekly trend tracker, as it would provide users with a comprehensive overview of their sleep patterns and progress over time. P1 stressed the importance of prominently displaying relevant information, such as recommendations, to enhance user experience and facilitate ease of access.

Organizing different analyses into separate blocks in a dashboard-style layout was also recommended to improve user navigation and engagement. P1 further suggested incorporating visual elements to present data effectively, minimizing scrolling and enhancing the overall aesthetics of the interface. Adjusting metrics to present data weekly was proposed to offer users clearer insights into their sleep patterns and progress. Lastly, P1 recommended incorporating messages to affirm healthy sleep habits and providing clear indications of progress to motivate users to maintain positive behaviors.

Meanwhile, Participant 2 (P2) emphasized the need for clearer instructions and more specific information regarding sleep-related factors. P2 noticed a deficiency in emphasis regarding the required content for the input fields, particularly realizing that the data to input is from only last night. Despite a lack of personal interest in sleep tracking, P2 found the interface simple enough for general use. On the other hand, Participant 3 (P3) provided insights from a user with challenging sleep patterns, emphasizing the need for clear instructions and improved presentation of sleep data. P3's suggestions included specifying recent input days and advocating for backend implementation to track sleep types over time. Additionally, P3 wants more emphasis on what the results mean.

Participant 4 (P4) provided feedback that while the website is straightforward and helpful, areas could be improved for clarity. P4 suggested that with the metric of awakenings, a more accurate description is necessary, recommending a better term and implementing a hovering explanation feature. Despite the simplicity of the website, P4 noted areas where additional clarity could enhance user experience. Lastly, Participant 5 (P5) highlighted the interactive nature and conciseness of the questionnaire but pointed out a need for clearer instructions, particularly visible without hovering. P5 suggested using yellow highlighting to improve visibility, especially in low-light environments like a dark room. In addition to these, P5 also recommended providing more context on how each feature affects predictions and enhancing interactivity for a more engaging user experience.

Conclusions

The researchers exhibited SereniGuide, a machine-learning powered sleep companion web application that helps users assess the quality of their sleep through several metrics such as hours of sleep, number of awakenings, caffeine intake, and alcohol intake. These sleep criteria were then fed into the MLPClassifier machine learning model from SciKit to attain classifications through a neural network algorithm. The GridSearchCV hyperparameter tuning was then used to produce eight classification machine learning models, with the best-performing model being the Multilayer Perceptron (MLP) with an accuracy of 87.50%, precision of 87.60%, recall of 87.50%, and F1 score of 86.74%. The next two top-performing models were Support Vector Machine with RBF-Kernel (SVM-RBF) and Random Forest. After conducting usability testing, it was found that SereniGuide helps participants improve their sleep habits and avoid sleep deprivation. Participants found that the research-backed information shown on the web application compelled them to learn more about the importance of sleep. Despite the positive feedback and results, there were still several application features that participants expected to be present in the application. Some of these were: a weekly habit tracker, visual summaries, and options for more in-depth recommendations.

Overall, using the Sleep Efficiency Dataset for machine learning and developing the SereniGuide web application are acceptable as foundation blocks of knowledge on providing a sleep-recommending system based on machine learning predictions using human lifestyle-related factors. SereniGuide further contributes to the body of research surrounding sleep-assistive technologies by determining the type of sleep of the user. It can also serve as an avenue for further exploration of more software products that utilize machine learning algorithms to classify user sleep quality. Through further research and advancement, the application can help alleviate certain physical, mental, and psychological burdens of the users through the visualization of sleep patterns and recommendations for improving sleep quality. This study can also be used as the basis for laboratory experiments and clinical trials surrounding sleep habits, especially when measuring habits over an extended time. The model can also be applied to local datasets from the Philippines or ASEAN countries to highlight and distinguish the cultural differences between their sleeping patterns. The application can be improved to incorporate better analytical depth by tracking daily, weekly, and monthly sleeping patterns and providing accessible results and visualizations.

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IMPACT OF 3D PRINTED SCIENCE MODELS ON STUDENTS' ACADEMIC PERFORMANCE IN ELEMENTARY SPACE SCIENCE

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Abstract: *Three-dimensional (3D) printing is recognized as a powerful tool for enhancing science education because it creates tangible and interactive models that help students better understand complex scientific concepts and improve scientific literacy. This study investigated the impact of integrating 3D printed science models as educational materials on students' academic performance in Space Science. It also explored students' perceptions of the utilized models. The study employed an embedded mixed-method design and purposive sampling. The quantitative phase used total enumeration and classroom action research with pre-and post-test assessments to gauge academic performance. The embedded qualitative phase consisted of semi-structured interviews with a few students. The study involved 32 Grade 6 students from Tinoc Central School (TCS), Tinoc, Ifugao, Philippines. Quantitative results revealed a significant improvement in students' academic performance after integrating 3D printed models into science lessons. Qualitative findings disclosed five main themes: models' physical attributes, learning benefits, challenges experienced, personal preference, and suggestions for improving the models. Students found the models engaging, had reasonable sizes, were visually appealing, presented concrete objects, and were interactive. However, they indicated that the models were fragile, had unpleasant smells, and were insufficient. They suggested that more models with articulated parts will be printed in bigger sizes in future lessons. These results and findings affirm that 3D printed models impacted students' academic performance, made science learning engaging, provided tangible representations of complex concepts, and promoted hands-on learning experience. It also implies considering the models' characteristics in future preparations to support students' scientific learning effectively.*

Keywords: *3D printing, 3D printed science models, Educational materials, Science academic performance, Space Science education*

Introduction

The world is changing fast, and technology is opening up new possibilities. Nowadays, technology helps teachers teach, and students learn better than traditional methods (Chenrai, 2021). One of the emerging technologies is three-dimensional (3D) printing, opening up new learning opportunities (Leinonen et al., 2020). Initially emerging as a tool for industrial purposes, 3D printing has found its place in classrooms, enabling teachers to create customized

learning experiences. As 3D printing technology becomes accessible, its integration into educational environments expands, fostering innovation and enriching students' learning experiences.

Additive manufacturing (AM), commonly known as 3D printing, uses digital computer-aided design (CAD) modeling to construct 3D objects and 3D printers to assemble materials layer-by-layer (Jayswal & Adanur, 2022; Shahrubudin et al., 2020). 3D modeling and printing may create sturdy copies that are nearly exact reproductions of the original items. 3D printing has become very popular in the past years because it is a printing technique that makes it possible to turn a digital model into a tangible 3D object. This makes it a potential educational tool and material at schools and is now also used in classrooms (Arvanitidi et al., 2019). As 3D printers become commercially available, schools adapt and use them more to help students learn new ways (Fokides & Lagopati, 2024). With their education technological potential, it is becoming more accessible, improving the teaching and learning process (Budinski et al., 2019). Depending on the subject and the desired outcome, 3D printing can create models, tools, spare parts, or even functional prototypes, offering a versatile approach to teaching (Thyssen & Meir, 2023). It can make learning more engaging in any subject. It allows for hands-on experiences from observing real objects (Chen & Cheng, 2021), fostering student collaboration and communication (Akyol et al., 2022; Chen & Cheng, 2021).

While more research is needed, it is evident that 3D printing can improve students' learning (Eldebekey, 2021). The tactile experience of the students using 3D printed models can improve comprehension and retention, especially for visual and kinesthetic learners. With 3D objects, students can understand the lessons better because they can touch and move what they are learning about (Abu Khurma et al., 2023). 3D objects benefit young children, allowing them to think critically and solve problems (Aslan, 2023). This supports students' self-guided inquiry and the conceptual comprehension of many concepts (Budinski et al., 2019).

In science education and the Science, Technology, Engineering, and Mathematics (STEAM) curriculum, 3D printing has the potential to foster students' creativity, collaboration, problem-solving, higher-order thinking skills (HOTS), impact their interests, engagements, beliefs, and careers toward STEAM learning (Kit Ng et al., 2022). It could be an excellent tool for achieving the goals of STEAM (Nazha & Szabolcs, 2022) and to help students develop competencies like inquiry and critical thinking (Budinski et al., 2019). It can accommodate diverse teaching and learning styles, such as the capacity to identify solutions, learn from their mistakes, and solve challenges, which is enhanced by the design experience affected by 3D printing.

Literature Review

Theoretical Framework

A theory that strongly supports the use of 3D printing in science education is constructivism. It emphasizes that learners use internal sense-making to construct knowledge from their experiences (Eldebeky, 2021; Özeren et al., 2023). It suggests that education should focus on empowering students to create their knowledge rather than simply passing it down (Bagheri Noaparast, 2022). Constructivism, which emphasizes active, hands-on engagement and knowledge construction through experience, aligns well with 3D printing in science education. Students can visualize scientific concepts by incorporating 3D printing into science lessons, fostering a more profound understanding. This hands-on approach allows students to visualize



abstract concepts and experiment with real-world applications, reinforcing their learning. 3D printing encourages creativity, collaboration, and problem-solving, as students can explore and refine their ideas, key components of constructivist learning environments. It empowers students to take ownership of their learning and connect theoretical knowledge with practical, tangible results.

Another theory supporting the use of 3D printing in science education is experiential learning. It involves a cyclical process of doing, reflecting, thinking, and applying, making learning more meaningful and engaging for students to apply their understanding to solve problems or make predictions (Kong, 2021). It is a dynamic, student-driven approach to learning that emphasizes direct engagement with experiences, followed by analysis and reflection (Habib et al., 2021; Levy & Moore Mensah, 2021). Experiential learning is effectively enhanced by 3D printing in science education. Engaging students in designing, creating, testing, and using 3D printed models gives them hands-on experience that deepens their understanding of scientific principles. Through this, students may be encouraged to hypothesize, experiment, and problem-solve, fostering critical thinking and allowing them to reflect on their actions and results. The ability to iterate on designs and immediately observe the effects of changes further reinforces experiential learning, helping students connect theoretical knowledge with practical application while building their creativity and technical proficiency skills.

3D Printing Technologies in Education

Fokides and Lagopati (2022) determined that integrating 3D printers in primary education has been shown to improve students' knowledge and skill development. Avinal and Aydin (2022) found that students were thrilled with the activities created using 3D printing technology. Students' expectations of the lessons and their expectations have increased positively. They participated actively in the activities and remarkably assimilated these activities. They were not bored or distracted during the activities created with 3D printers. The students tried to provide great desire and participation in the activities. Because of the intense focus and with the aid of 3D printing, the students did not face many dire circumstances or issues during their classes.

Arslan and Erdogan (2021) indicated that most students were optimistic about the impact of 3D objects on their learning. They claimed that the 3D objects transformed abstract concepts into concrete visual representations, facilitated learning, made lessons enjoyable, provided learning retention, encouraged them to learn more about the lesson, increased their interest, and assisted them in developing creative thinking and design skills, allowing them to create various content-specific educational materials.

Elementary Earth Science Education in the Philippines

Elementary Science Education in the Philippines has undergone significant transformations in recent years, particularly with the implementation of the Kindergarten to Grade 12 (K to 12) Curriculum by the Department of Education (DepEd). The curriculum aims to equip students with the knowledge and skills needed to be informed citizens who can make responsible decisions about science-related issues impacting society, health, and the environment. In addition, it focuses on producing well-rounded individuals who are knowledgeable about science, technology, and the environment. These individuals should be able to solve problems

creatively, care for the environment, make informed decisions, communicate effectively, and contribute positively to society. To foster this development, the curriculum uses different teaching methods, such as interdisciplinary learning, connecting science to society, and encouraging students to explore and question actively. The curriculum offers a captivating portal for learners to explore and creates a classroom environment where children feel comfortable asking questions and expressing their curiosity about space (DepEd, 2016, 2019).

The specific Space Science topic covered in this study was “The Solar System.” It was based on the K to 12 Science Curriculum for Grade 6 level. This topic identifies the following content standard, “the students can demonstrate an understanding of the physical characteristics of planets in the solar system.” It had the following learning competencies: 1) “compares the eight planets of our solar system” and 2) “constructs models of the solar system that show the relative sizes of each planet and the relative distances between the planets” (DepEd, 2016).

Research Gap

3D printing allows for the creation of tangible and interactive models to help students better understand complex concepts, improving academic performance. It can also increase student engagement by making the learning process more hands-on and engaging. Despite the potential of 3D printing to enhance teaching and learning, there is a knowledge gap exploring its many applications in science education. Also, there is a lack of awareness and understanding among many teachers regarding how 3D printing can help students learn. Similarly, there is a lack of knowledge about 3D printing in the locality.

Research Aim and Research Questions

This study aimed to investigate the impact of integrating 3D printed science models as educational materials into elementary space science education. The study also aims to determine students' academic performance as affected by the integration of 3D printed science models and their perceptions towards it. The following questions have guided the study:

1. What are students' academic performances in space science before and after integrating the 3D printed science models as educational materials?
2. Is there a significant difference in students' pre-and post-test results after integrating 3D printed science models?
3. What are the perceived benefits and concerns of the students regarding integrating 3D printed science models in teaching science lessons?

Methodology

Research Design

The study employed an embedded design mixed method and classroom action research. In embedded design, quantitative and qualitative data were collected simultaneously, with the qualitative data embedded within the quantitative data (Yu & Khazanchi, 2017). This design proved most suitable for focusing on quantitative data while gaining a deeper understanding through qualitative data. A quasi-experimental design utilizing pre- and post-tests was employed for quantitative data gathering and analysis, offering an efficient and pragmatic approach to evaluate a group undergoing an intervention (Stratton, 2019). Thematic analysis



was used to analyze, interpret, and determine patterns or themes to uncover the qualitative data's underlying meanings, ideas, and perceptions (Maguire & Delahunt, 2017).

The study primarily focused on assessing the effectiveness of 3D printed science models as educational materials and interventions in elementary space science. This involved gathering students' academic performance as quantitative data. To gain a richer understanding of the quantitative results, qualitative data was embedded in the study through interviews and observations of the students. This captured students' perceptions and experiences of the 3D printed science models when used as educational materials during science lessons. While the pre-and post-tests were conducted at the beginning and end of the lessons, the interviews and observations were conducted during the lesson proper, where the 3D printed science models were utilized in teaching science.

Classroom action research is a reflective, systematic process where educators examine their teaching practices, assess the effectiveness of instructional strategies or interventions, and make data-informed decisions to improve student learning outcomes (Meesuk et al., 2020). The goal was to enhance student engagement, understanding, and achievement within the classroom environment and refine teaching methods. This study utilized the four stages of action research by Mertler (2021): planning, acting, developing, and reflecting. These stages were cyclical.

The planning stage involved identifying problems, gathering background information, developing a plan related to students' academic performance in science, and integrating 3D printed science models as educational materials and interventions. The acting stage involved the actual conduct of the study, where 3D printed science models were utilized as educational materials in teaching space science lessons. It included the conduct of pre-and post-tests to determine students' academic performance and embedded observations and interviews to determine students' perceptions and experience of using models. The developing stage involved analyzing the collected quantitative and qualitative data to understand the impact of the 3D printed science models as interventions, making revisions and changes, and refining the approach for improvement and future actions. All of these were developed into an action plan. The reflecting stage consisted of summarizing the study's results, assessing the effectiveness of the 3D printed science models as interventions, and making decisions for future action. It also involved finalizing data for presentation, planning for dissemination, and holistic reflection on the action research study.

Using embedded design and classroom action research, the study yielded a rich data set that informed whether the 3D printed science model interventions improved students' academic performance in science and how students felt about its integration into science lessons. This provided a well-rounded view of the intervention's success and areas for improvement, offering a robust, flexible, and comprehensive approach to the study's conduct. This combination proved highly suited to the study's context, considering the specified duration of science lessons on the curriculum and the need to prioritize quantitative data and analysis over qualitative data collection.

Participants

The participants in this study were 32 Grade 6 students from Tinoc Central School (TCS), Tinoc, Ifugao, Philippines. The student population comprised 46.88% ($N = 15$) males and

53.13% ($N = 17$) females. These students were selected using total enumeration as recommended by the School Head and Class Adviser and based on the grade section where one of the researchers was teaching. The quantitative data involved a total enumeration of students' academic performances. They were designated with pseudonyms from S1 to S32. The qualitative phase only involved 13 students who volunteered for the interviews. Their pseudonyms for the quantitative and qualitative phases remained the same. The study was conducted from February to April 2025, the last quarter of the academic year 2024 - 2025.

Materials and Instruments

The study utilized 3D printed models of Earth, the Solar System, and various rockets (see Figure 1). Because of the 3D printer's restrictive specifications, the models were created in a single color. The models were printed in several sets but in smaller sizes due to the availability of filaments and time limitations. To get rid of undesirable smells, the models were exposed to the sun to air dry. The models were edge-trimmed and sanded to eliminate any possible risks and dangers.

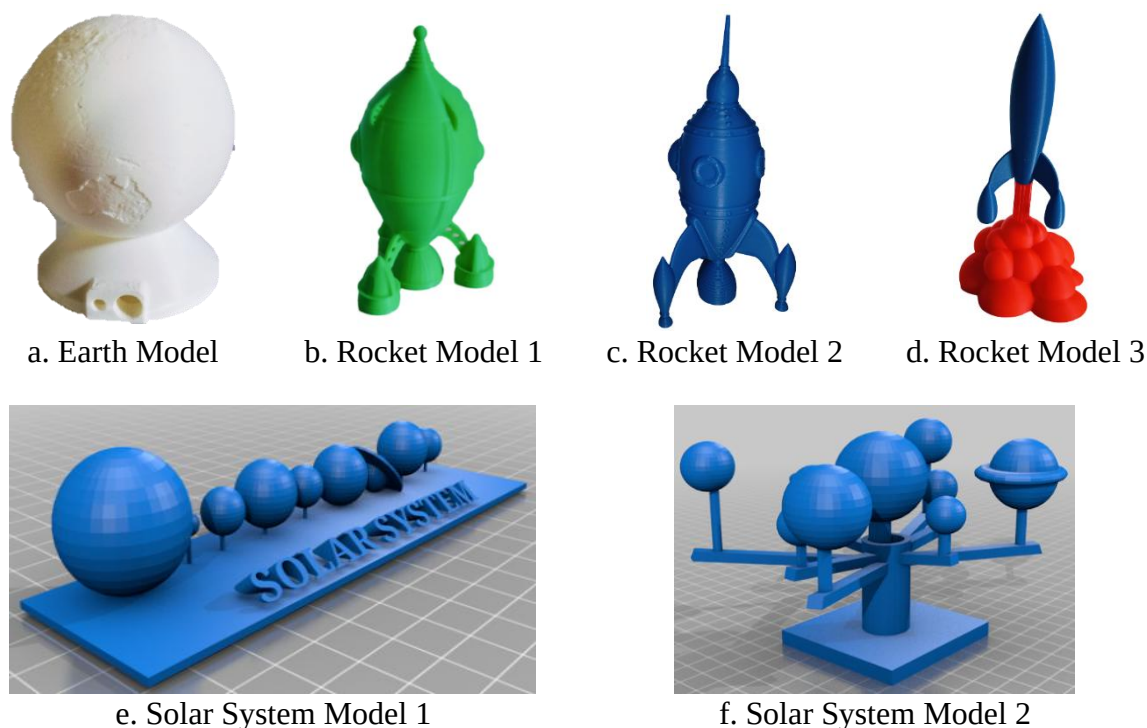


Figure 1: Examples of Some of the 3D Printed Space Science Models Used in the Study

The researchers did not develop any models. Instead, the models were carefully chosen and acquired from reputable open online sources. This was due to time constraints, a restricted number of 3D printers, and the need for extensive printing times. They were gathered from several makers or designers (see Appendix A). The researchers resized the models and printed them. The researchers make no claim to ownership or intellectual property for any of the 3D model designs. Their respective makers or designers own them. Though there were several identical model designs, the researchers chose the ones that were the easiest to print.

The materials for this study included the A1 Mini Desktop 3D printer, plastic filaments, and Bambu Studio slicing software. The A1 Mini Desktop 3D printer is a high-quality, user-friendly 3D printer featuring a user-friendly interface for easy operation. It is a compact and feature-rich 3D printer that can provide a compelling blend of sophistication and simplicity of use thanks to its automatic calibration, multi-color printing, and silent operation. This makes it an exceptional choice for both novice and expert users. It can print 3D models with a maximum build volume of 180 x 180 x 180 mm³. It adopts an open-source technology, making it simple to link with a home network, and lets one remotely monitor and control printing from a digital device (Bambu Lab, 2025b).

Bambu Studio is the compatible slicing software for the A1 Mini. A slicing software in 3D printing is a tool that converts a 3D model into a series of thin, horizontal layers, or 'slices,' that the 3D printer can understand and print (McClements, 2022). The Bambu Studio offers a range of advanced features tailored to optimize print quality and efficiency, such as automatic support generation, customizable print settings, and real-time print monitoring. The software supports various filament types and specialty materials, allowing users to fine-tune print parameters like layer height, infill density, print speed, and temperature. It allows seamless integration with the A1 mini hardware, providing a smooth user experience with print preview, queue management, and cloud-based functionality. Whether for beginners or advanced users, Bambu Studio provides a comprehensive suite of tools to ensure high-quality 3D prints with minimal hassle (Bambu Lab, 2024a).

This study used polylactic acid (PLA) and acrylonitrile butadiene styrene (ABS) filaments. These two are the most common plastic filaments used in 3D printing. PLA filament is a biodegradable thermoplastic polymer known for its ease of use and durability (Budinski et al., 2019). PLA is unique because it is good for the environment (Polygenis, 2024). It is made from plants and can break down naturally in special composting facilities. It is also safe because it does not release harmful chemicals while printing. It has a low printing temperature and adheres well to various print surfaces, reducing the likelihood of warping. PLA is known for its smooth finish and ability to produce detailed prints with sharp edges and vibrant colors. It is ideal to create educational models (Polygenis, 2024). Alternatively, ABS is a widely used thermoplastic in 3D printing known for its durability, strength, and heat resistance. It is commonly used for functional parts, mechanical components, and prototypes that require robustness and the ability to withstand higher temperatures. ABS has a higher printing temperature than PLA and often requires a heated print bed to reduce warping and ensure good adhesion during printing. It is more flexible and impact-resistant than PLA, making it ideal for producing items that need to endure stress or rough handling. However, ABS can emit fumes during the printing process, so it is recommended to print in a well-ventilated area or with an enclosed 3D printer. While it offers strong performance, its tendency to warp and its sensitivity to environmental factors make it less beginner-friendly than PLA. Despite these issues, ABS remains popular for producing tough, functional, high-quality 3D prints.

For quantitative data collection, the test items that were used in the pre-and post-test assessments were adopted from the teacher's science module for the grade level. This ensured that the test items were standardized, validated, and undergone reliability testing by DepEd. The assessments consisted of ten multiple-choice questions designed to measure students' understanding of space science concepts. The same set of test questions was used for the pre-and post-tests. Guide questions were used to gather qualitative data. It went through construct

validity from three professional elementary science teachers in the same school. The purpose of this validation was to precisely assess the constructs of the study, specifically focusing on students' experiences and perceptions of the 3D science models used. The teachers' feedback was integrated into the final design of the guide questions.

Procedures

The study was conducted using the embedded design and the four steps of action research. Classroom observations were conducted during the planning stage. This provided a glimpse into the design, selection, printing, and preparation of 3D science models for teaching space science lessons. Lesson planning was undertaken, integrating the 3D printed science models as educational materials and interventions. A pre-test assessment among the students was also conducted in this stage, serving as the initial data for students' academic performance.

In the acting stage, 3D printed science models were integrated into the science lessons. During the delivery of lessons, observations and documentation of any visible changes in students' perceptions and engagement before and after the integration of 3D printed science models were undertaken. The students were asked open-ended questions regarding the models' utilization. The questions were incorporated while students were handling the models or at the end of the lessons to avoid confusing the students with their learning process and study conduct. A video recording of the whole lesson was done to help the researchers document actions and responses regarding using models. The video recordings captured complex interactions that might be missed in real-time observations. The footage could be replayed multiple times to ensure important details were not overlooked. After completing the lesson incorporating 3D models, a post-test assessment was conducted to measure changes in students' academic performance.

In the developing stage, the quantitative data on students' performances was tallied on a spreadsheet and statistically computed and analyzed. Students' papers were returned immediately after recording. The students' interview responses were transcribed. Translations into English were done based on their responses, which were stated in their local language. The pre- and post-test scores were compared to determine if there was a significant improvement in students' academic performance after integrating the 3D printed science models. Thematic analysis of student responses was done to identify key benefits and concerns. Recurring themes were identified, which aided in understanding whether a change in students' scores was linked to their perception and experience of the models. Based on these results, the action plan was modified and improved, especially on the interventions.

Finally, in the reflecting stage, the overall effectiveness of using 3D printed science models on students' academic performance was evaluated. The research questions and the results were reflected upon. Based on this, the intervention was refined for future use. This stage also involved evaluating the action research process and finalizing the data for presentation and dissemination.

Before conducting the study, the researchers obtained permission from the School Principal of TCS and the students' Class Adviser for data collection and video recording. Once approved, informed consent was solicited from the target students' parents or guardians. The consent reflected the study's objectives, scope, methodology, and possible student benefits. The informed consent also indicated the voluntary withdrawal of their child or ward's participation

in the data collection process without penalty. The study encompassed all target students during the science lessons and class hours. The withdrawal only applied to the data collection from the students. After obtaining consent, the students were also oriented about the study's purpose, procedures, and potential hazards.

Data Analysis and Management

The researchers were in charge of data gathering and analysis for embedded design and classroom action research, as well as integrating 3D printed science models as educational materials and interventions. The conduct of pre-and post-tests was managed, checked, and appropriately recorded. Means (M), standard deviation (SD), and percentages were used for data computation on students' academic performance. Further, a paired t -test was used to determine significant differences in students' academic performances. Cohen's d was calculated to determine the effect size between the mean groups. Transcription and translation of students' interview responses were done. Each student was assigned codes, and their personal information was removed for anonymity and confidentiality. To ensure the credibility of the translations, help from an English language expert, who was also fluent in the students' local language, was sought. The researchers solely conducted thematic analysis. The video recordings, transcriptions, translations, and spreadsheets were appropriately stored and used for the study only. Results and findings for quantitative and qualitative data were presented accordingly.

Ethical Considerations

This research prioritized the safety and well-being of the students. Informed consent was obtained from parents or guardians, ensuring they understood the study's purpose, procedures, and the benefits and potential risks their child or ward would undergo. The researcher informed the students about the study's purpose, provided clear step-by-step instructions, and established guidelines to ensure a safe and productive learning environment. Strict measures were implemented to safeguard student information and maintain confidentiality, ensuring anonymity throughout the study. All 3D-printed science models were inspected for sharp edges or loose parts that could cause injuries. They were prepared and cleaned to eliminate potential contamination or dirt. The researcher observed energy conservation in printing the models and minimized waste and energy consumption, promoting environmental responsibility.

Results and Findings

Quantitative Results

Students' Academic Performances in Space Science

The results of the students' academic performances in space science before and after integrating 3D models are shown in Table 1. Results indicate an increase in the students' scores from the pre-test ($M = 48.75\%$) to the post-test ($M = 77.50\%$) after integrating the models.

Table 1: Space Science Academic Performances of the Students

Students	Pre-test Scores		Post-test Scores	
	Scores	%	Scores	%
S1	4	40	7	70
S2	5	50	5	50

S3	4	40	8	80
S4	0	0	7	70
S5	5	50	9	90
S6	6	60	6	60
S7	5	50	8	80
S8	5	50	10	100
S9	6	60	8	80
S10	5	50	10	100
S11	6	60	9	90
S12	3	30	8	80
S13	4	40	6	60
S14	5	50	10	100
S15	9	90	10	100
S16	4	40	9	90
S17	5	50	6	60
S18	5	50	9	90
S19	5	50	6	60
S20	8	80	9	90
S21	2	20	5	50
S22	3	30	7	70
S23	6	60	6	60
S24	5	50	9	90
S25	4	40	6	60
S26	7	70	8	80
S27	5	50	8	80
S28	6	60	8	80
S29	4	40	10	100
S30	5	50	6	60
S31	5	50	9	90
S32	5	50	6	60
Mean	4.88	48.75	7.75	77.50

Only S4 acquired 0% scores during the pre-test. S21 got 20% correct items. Two students, particularly S12 and S22, garnered 30%. Six students, S1, S3, S13, S16, S25, and S29, obtained 40%. Fourteen students, specifically S2, S5, S7, S8, S10, S14, S17, S18, S19, S24, S27, S30, S31, and S32, gained 50%. Five students, S6, S9, S11, S23, and S28, attained 60%. One student earned 70%, especially S2, while S20 got 80%, and student 15 attained the highest passing rate of 90%. This indicates that the pre-test results show very low academic performance in science for the Grade 6 students.

However, the post-test result showed an overall increase in students' academic performance. Five out of 32 students had 100% perfect scores, notably S8, S10, S14, S15, and S29. Twenty-five students, including S6, S13, S17, S19, S23, S25, S30, S32, S1, S4, S22, S3, S7, S9, S12, S26, S27, S28, S5, S11, S16, S18, S20, S24, and S31, achieved above minimum passing rate of 60% to 80% correct scores. However, the remaining two students, S2 and S21, attained 50%, below the minimum passing rate of 60%. In general, the post-test results show increased academic performance in science for the students after integrating 3D models in teaching space science.

Table 2 indicates a significant difference in students' academic performance [$t(31) = -8.6534$, $p = .0001$] during and after the 3D science models interventions. The pre-test results ($M = 4.88$, $SD = 2.63$) significantly increased compared to the post-test ($M = 7.75$, $SD = 2.52$). This signifies significant progress in the academic performance of the students. Additional examination shows that Cohen's effect size ($d = 1.11$) indicates a large effect between the performance scores.

Table 2: Comparison Between the Student's Space Science Academic Performances

Tests	<i>M</i>	<i>N</i>	<i>SD</i>	<i>df</i>	<i>t-value</i>	<i>p-value</i>	Cohen's <i>d</i>
Pre-test	4.88	32	2.63	31	-8.6534	.0001	1.11
Post-test	7.75	32	2.52				

Note: * = significant ($p < .05$); ns = not significant ($p > .05$); Cohen's $d = .20$ is small effect; $d = .50$ is moderate effect; $d = .80$ is large effect

Qualitative Findings

Based on the students' interview responses, there are five emerging main themes in the study, as summarized in Table 3. These include 1) Physical Attributes of the 3D Models, 2) Learning Benefits from Using the 3D Models, 3) Challenges Associated with Using the 3D Models, 4) Personal Preference in Using the 3D Models, and 5) Suggestions for Improving the 3D Models.

Table 3: Themes and Sub-themes Derived from the Students' Responses

Main Themes	Sub-themes
1. Physical Attributes of the 3D Models	a. Reasonable Sizes b. Subtle Smells c. Appealing Colors
2. Learning Benefits from Using the 3D Models	a. Enhanced Learning b. Interactive Learning c. Concrete Representations and Realism
3. Challenges Associated with Using the 3D Models	a. Fragility b. Insufficient Quantity c. Unpleasant Smell
4. Personal Preference in Using the 3D Models	a. Individual vs. Group Use b. Articulated Movement of the 3D Models
5. Suggestions for Improving the 3D Models	a. Augmented Quantity b. Increased Size

Physical Attributes of the 3D Models *Reasonable Sizes*

Students generally found the sizes of the models reasonable. While some preferred a larger size for better visualization, most students felt the size was good enough. One student indicated that both the small and big sizes were fine, suggesting that the variety in size did not pose issues for them. They shared,

S5: "The sizes of the models are good enough."

S23: "The small and big sizes of the models are okay."

S21: *"The sizes of the model are just right."*

Subtle Smells

While the smell of the models appeared to be a negative factor for some students, a few found the smell pleasant or acceptable. A student mentioned that they do not mind the smell and even noted that some models smell good. Another further reinforced this by stating that the models have a pleasant smell. They commented,

S7: *"I do not mind the smell. Some models even smell good."*

S15: *"The models have a pleasant smell."*

Appealing Colors

Students generally found the colors of the models to be pleasing and appealing. They appreciated the models' colors, finding them good and pleasant to the eyes. Several students mentioned that the models' varying colors made them more appealing. They mentioned,

S31: *"The colors are good and are pleasant to the eyes."*

S5: *"The models are good since it has different colors."*

S23: *"I like the light and dark colors used in the models."*

S21: *"The colors are appealing and easy on the eyes."*

Learning Benefits from Using the 3D Models Enhanced Learning

Students consistently felt that the models enhanced their understanding of the lessons. They emphasized that the models helped them understand science concepts deeply. They would not have understood the lesson better without the models to aid the discussion. They remarked,

S31: *"The models help us understand deeply our lesson."*

S27: *"I understood the lessons because models were used to explain it further."*

S23: *"I understood the lessons well since models were involved during the discussions."*

Interactive Learning

Students highlighted the interactive nature of the models, finding them engaging and contributing to their interest in the lessons. They particularly appreciated the models' articulated movements and manipulative nature, and they could hold them. Students expressed that they could visualize at least the objects' movement with the help of the models. A student added the realism of the models' movement. They conveyed,

S13: *"Some models have moving parts, and we can hold them to learn their characteristics."*

S21: *"The models can sway and are manipulative."*

S20: *"Aside from the appearance, the models can move when I touch them."*

S23: *"The models' movement is good because it looks real."*

Concrete Representations and Realism

Students emphasized the importance of realism in the models, finding them valuable for their resemblance to real objects. A student mentioned that some models closely resemble the real

ones, highlighting the importance of authenticity. Another echoed this sentiment by noting that the models closely looked like what they saw in objects' pictures. They indicated,

S27: *"Some models closely resemble the real ones."*

S20: *"The models closely resemble what I saw in pictures."*

Challenges Associated with Using the 3D Models

Fragility

Several students commented on the fragility of the models, highlighting their tendency to break or be easily damaged. They mentioned the models' thinness as a contributing factor to their fragility. A student noted that the Earth model is too thin and may easily break if dropped. Others echoed this concern with the other models, highlighting the model's susceptibility to damage when stepped on or since it is fragile. A student generalized these concerns, stating that some models are thin and small and could easily be bent. They pointed out,

S31: *"The Earth's model is too thin. If it is dropped, it will easily break."*

S30: *"It is easy to break since it is thin, and if we step on it, it will get damaged."*

S13: *"Some models are not durable because they are thin."*

S7: *"Some models are thin and small. It could easily be bent."*

Insufficient Quantity

Students consistently expressed that the number of available models was insufficient. This limited individual interaction time, as students were forced to share models, creating a sense of competition and frustration. A student expressed this frustration, mentioning wanting to hold the model longer, but their seatmate took it immediately. Others indicated that there were not enough to be passed around due to the few available models, and they had to share them with classmates or other groups. They remarked,

S31: *"The models provided are insufficient. I wanted to hold it longer, but my seatmate took it immediately."*

S13: *"The models provided are not enough."*

S20: *"I have to share the models with other groups because the number of the models is lacking."*

S30: *"The models given are not enough for individual use. I have to share them with my classmates."*

Unpleasant Smell

Though some students were not troubled by the models' odor, some associated the models' odor with an unpleasant plastic smell. The model's smell is similar to that of a cellophane or trash bag, as described by a student. Another indicated their negative sensory experience with the models' smell. They observed,

S6: *"The models are smelly. It smells like plastic, and I do not like it."*

S3: *"Some models smell like cellophane or trash bags."*

Personal Preference in Using the 3D Models

Individual vs. Group Use

Students overwhelmingly preferred receiving models individually, primarily to avoid conflict and to have more time to explore the models without pressure. They believed individual access would allow them to focus on learning without competition or time constraints. They shared the desire to avoid fighting over the models and emphasized the importance of individual access to prevent conflicts. A student proposed a system where models are initially given individually before being shared with the group, suggesting a balance between individual and group exploration. Another highlighted the benefit of individual access, where they could hold the models longer, emphasizing the increased time for exploration and interaction. They shared,

S27: *"It is better to receive models individually so we will not fight over it."*

S23: *"I prefer to hold the models on my own."*

S21: *"The models can be given individually and shared through the group later."*

S15: *"I wanted to hold the models on my own so we can touch it for a longer minute."*

Articulated Movement of the 3D Models

Though students generally enjoyed the moving parts of the models, some preferred the models with moving parts to those that were stationary. One student shared their sentiment, noting that moving parts made the models more attractive. They mentioned,

S7: *"I like most models with moving parts more than those that do not move."*

S30: *"The models are more attractive with moving parts."*

Suggestions for Improving the 3D Models Augmented Quantity

Students strongly advocated for printing more models to ensure everyone could have an opportunity to interact with them. They mentioned the need for more models to prevent students from fighting over it, highlighting the issue of limited access. One suggested that more models available would allow for a deeper understanding of the lessons. Another noted that more models will make the class less boring. They suggested,

S13: *"More models should be produced so we will not fight over it."*

S27: *"We need more models to be available for use in future lessons to help us to understand them fully."*

S3: *"We want more models because the class will be less boring when we have models to see and touch."*

Increased Size

Some students emphasized the need for larger-sized models to improve the visibility of details and enhance their overall learning experience. They expressed a desire for bigger sizes because the current models were small. A student agreed that larger models would be more motivating. One student highlighted the importance of size in clearly seeing the objects' characteristics. They recommended,

S31: *"Some models are small. I want bigger sizes."*

S12: *"Next time, can the models be in bigger sizes?"*

S20: *"I need bigger models so that I can enjoy holding them."*

S7: *"The small models need to be available in bigger sizes so I can be motivated further."*

S13: *"It would be better to make the models bigger so their physical features will be seen clearly."*

Discussion

The students' academic performance in science increased after integrating 3D models as educational materials in science lessons on Earth and their characteristics. The scores attained during the pre-test and post-tests revealed that the 3D models have positively affected the student's academic performance. It means that they have understood the lessons well. This aligns with Abu Khurma et al. (2024) study, which states that with 3D objects, students can understand the lessons better because they can touch and manipulate what they are learning about. This finding is also consistent with the study by Eldebekey (2021), which suggests that 3D printing can enhance students' learning. The 3D models have benefited the students by allowing them to think critically, as Aslan (2023) indicated. Using 3D models in science classes can help students understand difficult concepts better and learn more interactively. This finding reveals the potential of 3D printing to improve science education and make learning more enjoyable for students.

Most students found the models' size reasonable, indicating that the chosen dimensions were suitable for them. However, some students preferred larger models for clearer details and overall engagement. This aligns with the concept of scalability in 3D printing, which allows for the creation of models with different sizes to suit different learning needs, as stated by Budinski et al. (2019), especially for visual and kinesthetic learners, as indicated by Abu Khurma et al. (2023). The mixed opinions about the model smell advocate the need to consider the materials used in 3D printing. This emphasizes the importance of selecting safe and non-toxic materials to ensure student comfort. The positive responses regarding the colors of the models stress the significance of appealing colors in creating engaging and effective learning experiences. This implies that educators should consider using vibrant colors and designs in 3D printed models to enhance the learning experience. This also suggests choosing appropriate model sizes for different learning styles.

The students have consistently expressed a positive impact from using the 3D models. They shared that these tangible tools have enhanced their learning. The students liked using the 3D models and said they helped them learn in several ways. They said the models made it easier to understand complicated ideas, kept them interested in the lesson, and made it easier to picture what they were learning about, aligning with the study of Arslan and Erdogan (2021). The students consistently stated that the models helped them understand the lessons profoundly and that they would not have understood the lessons without the models. This reflects the models' interactive nature and ability to represent concrete examples. This implies that 3D models are significant tools for teaching complex science concepts. This also suggests that hands-on learning with tools like 3D models can improve student understanding and engagement, as claimed by Fokides and Lagopati (2022).

While the students expressed positive experiences with the 3D printed models, their feedback also revealed challenges associated with their use. These challenges primarily revolved around the durability and accessibility of the models, which require improvements in future implementations. Several students commented on the fragility of the models. They noted their proneness to breakage due to their thinness. This suggests that the chosen materials may not be

durable enough to handle and manipulate the students. This aligns with the observation of Budinski et al. (2019) that 3D printed objects can be fragile and prone to damage. This finding draws attention to the importance of designing sturdy models. The students' consistent expression of insufficient model quantity, leading to sharing and limited interaction time, calls for adequate access to these resources. This aligns with the need for increased accessibility of 3D printing in education, as Chen and Cheng (2021) indicated. The students further identified an unpleasant smell that was distinctly synthetic and irritating for certain students, leading to a negative sensory experience. Student comments reflect an apparent similarity to the plastic-like scent. This may be attributed to the materials used in the models, such as ABS, which produces a strong plastic-like smell compared to the milder smell of PLA filaments. This indicates a need for more significant consideration in material selection to minimize these challenges and ensure a smooth integration of 3D printed models.

Understanding the students' preferences for how the 3D printed models were used in the classroom provides further insight into how to optimize their integration. Students preferred individual access to the models to avoid conflict and explore them for longer. This preference indicates the importance of having sufficient models to ensure individual learning opportunities, especially in larger classrooms. The students strongly appreciated models with dynamic features and articulated movements. This aligns with the research findings of Arvanitidi et al. (2019) and Habib et al. (2021), which suggest that 3D printing can promote student collaboration and communication and that individual opportunities for learning can be highly effective. The students' positive responses to models with dynamic features and movement confirm the principle of experiential learning, where students learn best by doing, reflecting, and applying their knowledge, as stated by Kong (2021). This implies that educators should prioritize individual access to models. This also suggests incorporating design elements with dynamic features and movements to enhance engagement and interactive learning.

Students' suggestions for improving the 3D printed models provide valuable feedback for the future development and implementation of this technology in educational settings. Their recommendations centered on increasing the quantity and size of the models, demonstrating a clear desire for greater access and improved visibility of details. The students emphasized the need for more 3D printed models to ensure everyone has access and can engage with the technology without competition. This aligns with the notion that 3D printing can be a valuable tool for achieving the goals of STEAM, but only if sufficient resources are available to support these goals, as claimed by Nazha and Szabolcs (2022). They also requested larger models, particularly for those with visual learning styles. This emphasized the importance of seeing the models' characteristics clearly, which can help them understand the lesson better. This aligns with the principle of constructivism, where learners construct knowledge through their experiences (Eldebeky, 2021), and suggests that larger models can facilitate a deeper understanding of the subject matter. These findings imply that future implementations of 3D printed models should prioritize increasing the number of models and consider adjusting model sizes to make the lessons more engaging. Addressing these factors will make students more eager to participate in class.

Based on the observed challenges and the students' suggestions, the researchers have decided to improve the 3D printed models for future use. The researchers will use more sturdy materials to produce the next model batch to prevent breakage during handling. Furthermore, to address the issue of limited model quantity, the researchers will print a larger quantity of the models to

ensure that each student can interact with them individually. Additionally, the researchers will add more movements and interactive features to the models to make learning more fun and engaging. The upgraded models will be donated to TCS to support the continuous use of 3D printed science models as effective and engaging learning tools in their classrooms. Students will be more eager to participate in class.

Conclusions, Implications, and Recommendations

3D printing is increasingly recognized as a powerful tool for enhancing science education. It improves students' academic performance and offers them interactive learning experiences. The study aimed to explore the potential impact of 3D models on students' academic performance. The study investigated whether the 3D printed models could improve students' understanding of space science concepts and provide a more interactive learning environment. The quantitative results revealed that using 3D models as educational materials positively affected students' academic performance in science. The qualitative results affirmed that using 3D models made the learning engaging, provided tangible representations of complex concepts, and promoted hands-on learning experience. This study proves that 3D printing is a valuable tool for enhancing science education. The findings also imply that integrating 3D models in the classroom can boost student understanding, engagement, and overall academic performance in science, particularly when teaching complex concepts.

While the study's findings suggest that 3D printed models can enhance science education in elementary schools, particularly in subjects like space science, it is important to acknowledge the limitations of this research and consider its implications for future studies. This study was limited by its sample size. It only included students from a single school, limiting the generalizability of the findings to a broader population. The 3D models used have a limited number, and some can easily be destroyed. However, the researchers still recommend integrating 3D models as educational materials in science classrooms. Producing more sturdy and larger models is also suggested. Lastly, conducting related research involving a more significant number of participants is encouraged.

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Appendix A. The Makers or Designers of the 3D Printed Models used in the Study

3D Models	Makers/Designers	Sources
solar system	yliu1581 Yingtao Liu July 01, 2021 edBlue75	https://www.thingiverse.com/thing:4898013
Solar System, Sistema Solar	Eduardo Feijoo Madrid November 27, 2019	https://www.thingiverse.com/thing:4003014
Earth Globe Lamp	DoctorWh0 Doctor Who March 08, 2019 bld	https://www.thingiverse.com/thing:3475736
Textured Earth	Ben Diedrich Huntsville, Alabama February 10, 2012	https://www.thingiverse.com/thing:17336
gCreate Official Rocket Ship	gCreate gCreate Brooklyn, NY August 14, 2014 vandragon_de	https://www.thingiverse.com/thing:427789
An old retro rocket	vd print Germany November 10, 2017 ZeKazz	https://www.thingiverse.com/thing:2636131
Fusée Tintin / Tintin Rocket	Nico Kazz France March 13, 2018	https://www.thingiverse.com/thing:2823726
Modelling the Solar System with OnShape	SpoonUnit Spoon Unit UK August 28, 2016 rweaving	https://www.thingiverse.com/thing:1739983
Our Solar System	Ryan Weaving Atwater, CA May 18, 2012	https://www.thingiverse.com/thing:23324

GEOSPATIAL INTEGRATION WITH AI: A CASE STUDY OF MELAKA RIVER BASIN

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Abstract: *This study presents a comprehensive framework integrating geospatial technologies with Artificial Intelligence (AI) to monitor and predict hydrological dynamics in the Melaka River Basin, Malaysia. The basin, facing increasing flood risks due to rapid urbanization and climate variability, demands a robust system for real-time water level prediction and land use analysis. Leveraging data from remote sensing platforms such as Sentinel-1 and Sentinel-2, the study employs the Google Earth Engine (GEE) for land use and land cover (LULC) classification and time-series analysis. Artificial neural networks, including Radial Basis Function models, are applied to predict river water levels using eight years of meteorological and hydrological data. The integration of AI and GIS facilitates the development of spatial flood prediction models and decision-support systems, enhancing local capacity for disaster management and sustainable urban planning. Results indicate a significant transformation of agricultural areas into urban zones, contributing to increased flood susceptibility. The developed AI models demonstrate high accuracy in forecasting river levels, offering a scalable and adaptive tool for early warning systems. This framework not only aids in flood risk mitigation but also supports ecological and water quality assessments. By synthesizing environmental, technological, and socio-economic dimensions, this study provides a replicable model for other urban river basins facing similar challenges. It contributes to the advancement of data-driven environmental governance, emphasizing the critical role of AI-powered geospatial integration in addressing contemporary hydrological and urban resilience issues.*

Keywords: *Geospatial Integration, Artificial Intelligence, Melaka River Basin, Flood Prediction, Remote Sensing Applications*

Introduction

Proper quantification of surface water extent and timely monitoring of water bodies is critical for a broad variety of hydro-environmental applications. Particularly, up-to-date spatial data about the distribution of inland water bodies are vital for assisting decisions regarding water resources management, disasters management, hydrology modeling, climate change research, and water quality assessment, among others. For surface water mapping, satellite remote sensing imagery is a valuable data source for the generation of robust earth surface observations. Satellite imagery from optical sensors has been widely used for surface water mapping (Ghosh et al., 2022). However, optical sensors have limitations regarding weather conditions and light availability that hinder their ability to provide reliable observations. On the other hand, Synthetic Aperture Radar (SAR) is capable of capturing earth surface observations independently of daylight condition and cloud coverage, thus it is potentially more useful for the generation of long-term optical-independent surface water observations.

Climate, geology, topography, land cover, and land use are key controlling factors of the hydrology of river basins. Future climate change is expected to alter rainfall patterns and meltwater regimes in many areas. Changes in land use and land cover also significantly affect hydrological processes. The development of rapid urbanization, land reclamation, and land conversion significantly alters land covers, land use categories, and their distributions in sub-basins. These changes alter topography, geology, vegetation types, and other controlling factors in such sub-basins. Understanding the current hydrology of a river basin is crucial for assessing impacts of future changes on river runoff and flood-drought regimes. Hence a comprehensive geospatial integration framework is developed that can systematically utilize datasets from multiple open-access earth observation satellites to understand current, past, and future hydrological processes within a river basin.

The research hypothesis for this study is elaborated upon. It is aimed at facilitating the generation of basin-wide time-series datasets of parameters controlling surface hydrology. Methodologies are described for geospatial data extraction, preprocessing, and analysis. A case study of the Melaka River Basin is presented to demonstrate the use of the framework in a complete workflow for geospatial data extraction to hydrology modeling. The results exhibit the variability of parameters controlling surface hydrology currently and in the past. All datasets extracted from this geospatial framework for the Melaka River Basin, including those from other river basins, along with the relevant geospatial processing scripts, are shared to assist use, modification, and extension of the methods presented in this study.

Background and Rationale

The Mahkota Watershed is the main source of clean water for the people of Melaka, Malaysia. However, it is considered a critical watershed as the vegetation/catchment area and bamboo plantation area is decreasing. In addition, Melaka experiences severe land-use transformations from agriculture land, jungle, and rice fields to industrial and residential lands. These changes cause floods in Melaka. The basin is located in the equatorial region with a tropical climate. Rainfall occurs throughout the year and its rainfall volume accounts for 1.5 to 25×10^9 m³/Anno, averaging 7.2×10^9 m³/Anno with a return period of 10 to 50 years (Ghosh et al., 2022). The reservoir capacity is about 2.8×10^9 m³ and 98% of rainfall runoff come to the river network system. The rivers are the Melaka River, Kesang River, and Muar River. They are 14.5 km, 16.74 km, and 40 km long respectively. The Melaka River is the main river in this study area and has 87.46 km² of catchment area. Thus, the river basin is inundated even if rainfall excess of 100 mm caused the river's flowing toward the sea becomes low. It happened for the flood occurred on December 9, 1990 but it less severe than flood happened on October 25-26, 2006. Widespread inundation for the entire basin (902.747 km²) level and 10 km away from the river banks were detected for October 2006 flood from satellite images.

By combining Geographical Information Systems (GIS) and remote sensing technologies, integration of a knowledge-based spatial decision support system to improve flood management capabilities, which consists of flood predisaster, disaster management, and postdisaster vision. Pre-disaster evaluation, modeling and remote sensing technologies were used to predict the likely causes of flooding disaster and assist in the assessment of flood probability maps. In flood disaster management, it is necessary to dynamically classify flooding based on the updates of the latest news. The integration of the big data filtering system

and the graphical display was proposed to provide real-time updates of the status of the flood to civil defense departments.

Another consideration is effective communication at the recovery stage following a flooding disaster. An integration of a spatial decision support system and an online forum system provide a channel for stable and continual communications in the aftermath of a flood. It enables public discussions to increase awareness of the flooding disasters and their aftermath and improve risk communication, so that social hazard management can be achieved.

Literature Review

Artificial Intelligence (AI) is a rapidly growing area of research, with a diverse range of applications across various fields. AI and its applications have burgeoned significantly over the past few decades. This meteoric rise has led to a burgeoning interest in AI applications. Subjective surveys and systematic literature reviews in this field are gradually increasing; however, a comprehensive analysis of AI in GEOSCIENCES, incorporating the latest research publications, is lacking (Jiang et al., 2022). To fill this gap, citing records from 22,807 publications and 618,337 citations from 2003 to 2023, the present study performed a large-scale and systematic analysis of the geographical distribution, research contents, collaboration network, and future directions of AI in GEOSCIENCES. Research on AI in GEOSCIENCES started around 2003 and underwent rapid growth after 2018. Three research fronts, i.e., six research hotspots in different subjects and fields, and four interdisciplinary frontiers, were discovered.

Geoinformatics is a burgeoning discipline requiring an understanding of a vast array of subject-specific terminologies. The use of artificial intelligence (AI) techniques and its myriad branches remain unexplored in this disciplinary area. Literature-based discovery is not only an effective means of information retrieval but also a source of knowledge discovery to help researchers determine unexplored areas of research. While the use of AI techniques in Geoinformatics has been prevailing, such publications have not yet been reviewed. A review of AI techniques used in Geoinformatics is attempted here. A bibliometric study is also conducted to examine the leading countries, institutions, authors, and journals. In this literature-based semi-automatically discovered work, 182 papers are mined, and a measure of similarity between against them is calculated to help researchers understand and categorize this vast pool of papers. More importantly, gaps in the literature have been discovered and discussed, which can pave the path for further research in this discipline.

Geospatial Technologies

Geospatial technologies have seen rapid advancement in the past few decades. New hardware technologies provide for enhanced aerial and satellite based observations of the Earth's surface. Extensive new software developments facilitate the integration and exploitation of these observations (Blaschke et al., 2011). These advances combine to provide unprecedented opportunities to see 'invisible' data, to uncover patterns, and produce derived data products. As a result of these recent advancements, geospatial technologies provide more powerful tools for spatial problem solving, based on more comprehensive spatial data sets in combination with more processing that, in turn, enables the production of outputs that generate insights and improve understanding of a system. Based on these recent advances were the development of

a variety of novel products and applications in the fields of Operational Geographic Information Systems, Spatial Data Infrastructures, and a myriad of mapping mash-ups and user-generated content applications including Virtual Globes.

Currently interactive geospatial technologies are entering a new stage of spatial data and services provision with a noticeable departure of products and services that see a wider use of geospatial. New technology is bringing collective senses of contemporary spatial information to provide collective assessments of cities. Common users are actively exploring their cities in very sophisticated ways. Such a collective sensing of urban planning is bringing profound changes to the understanding of urban processes and their monitoring. City/region inhabitants get half or a few hours of a real-time, comprehensive, and consistent sense of various processes in their cities at different scales. The established collective sense is then stored online for future exploration. During this stage of Rapid Geospatial Technologies Upgradation, online unstructured geo-information is abundant, but the geo-information is usually open question. Effective methods/algorithms need to be developed and implemented to derive the filtering and standardization functions.

Geospatial technologies have accumulated a trove of the history of human activity on the Earth's surface. It is envisioned that they will provide new scientific insights as well as practical decision making references for our sustainable urbanization (Muhammed Al-Mahdi & Lawan Maina, 2013). However, due to the limitations of present geospatial technologies, research and development on this vast collection of data is currently lacking. Novel research and technology innovation are thus highly desired in filtering, reconstructing, and acquiring useful knowledge from this heap of information that would assist human beings in understanding all aspects of the urbanization.

Artificial Intelligence in Environmental Studies

Artificial Intelligence (AI) tries to replicate human intelligence through the processing and analysis of datasets using algorithms and software. Environmental science may be one of the areas where AI has the most potential applications. By detecting changes in the environment and translating numerous changes in the biodiversity of the ecosystem, AI can contribute to environmental protection efforts worldwide. However, some problems arise from the use of AI in environmental studies. AI relies heavily on trained Dataset and digital tools. The availability and trustworthiness of training datasets are their poor quality and scarcity (Pachot & Patissier, 2022). Indeed, bias in the data or the model can lead to discrimination against a subpopulation, which lowers the generalization capability of the model. AI has great potential for application in environmental studies, but data scarcity, noise, and incomplete information can severely limit its performance. This paper focuses on the progress made in using AI in environmental studies and the challenges and needs for future work in this field.

AI can analyze satellite images and data from sensors such as those mounted on drones or collected with conventional sampling. AI algorithmic classifications of satellite images can help understand environmental changes in terms of land areas assigned to special land covers. This information is complementary to some environmental indicators derived from national statistics, such as the Human Development Index and the Urban Indicators as proxies for the sustainable urban transition. AI can also be used to develop a Water Ephemeral Systems Model in a smart aquaculture system, which establishes a smart sensor network and water collection

system. AI models were developed to realize automatic monitoring and forecasting of water quality indicators, which differ from conventional models that do not adapt, leading to acceptable development costs. Therefore, adaptive AI will be the focus of future work, especially in the field of environmental science.

Previous Case Studies

Geospatial technology refers to methods that acquire or manage spatial data. This technology covers a wide range of methods from GPS-based data logging to satellite-based imaging and provides data types such as LiDAR point clouds and images. A subset of this technology is used to parse raw data retrieved from devices into formats that are easily accessible. The parsing and cleaning software converts point clouds and images into bathymetric surfaces and contours, enabling their integration with GIS tools for further analysis. Geographic information systems (GIS) are a set of tools based on computer programs or related frameworks. GIS is a system designed for capturing, storing, analyzing, and managing spatial and geographic data. GIS tools model reality and enable visualizing the impact of changes over time through mapping. Geospatial data are acquired through GIS and other devices such as on-board GPS or cameras. GIS data formats such as ESRI Shapefile or JPEG are available in the public domain and are commonly used (Ghosh et al., 2022). The integration of geospatial data with other disciplines, commonly referred to as x-GIS, differentiates these technologies from other fields or sub-disciplines. Recently, there has been notable interest in the integration of geospatial data with artificial intelligence (AI) techniques. AI techniques are capable of automatically replicating human expertise or knowledge, enabling them to be seamlessly integrated with GIS tools to analyze the vast amounts of spatio-temporal data collected via geospatial technologies. With this integration, processes traditionally performed manually can easily be accomplished, enabling inference of changes over large areas and vast time periods (Noelle Young, 2015). Three pertinent sub-topics of this integration pertaining to the impact on the Earth and its systems are considered: (i) geospatial integration via computer vision; (ii) geospatial integration via time series forecasting; and (iii) domain knowledge, which enhances deeper understanding of geospatial integration. A case study pertaining to the Melaka River basin is presented in Section 4 to exemplify these methods.

Methodology

In general, a holistic framework based on Integrated Systems Model (ISM) was developed for the assessment and planning of marine geo-data infrastructure across multiple jurisdictions and degrees of development and standards with requirements that vary substantially. The ISM was designed to allow researchers and decision-makers to objectively carry out cost/benefit analyses of the alternative options available using comprehensive criteria that tie into organizational objectives and incisively answer the ‘why’ questions regarding the options under consideration. The framework itself is merely a facilitator of the process of obtaining reliable and meaningful information that is crucial for the proper evaluation of some credentials of existing technologies. Overlaying ISM with Fuzzy Sets (FS) theory, Data Enveloping Analysis (DEA), scenario analysis was formulated to handle the subjective and uncertain relationship between the alternatives and selection criteria and thus better assess candidate technologies (Adekunle Hamid-Mosaku, 2014). A new understanding is generated through the binding of the sophisticated models, reasonably accurate interpretations of results could be formulated, the credibility of the imposed constraints could be examined, and thus direct

insights on the overall issues could be obtained. Scale up of components would represent extrapolation beyond the parameters values that were envisioned during construction. For example, the refinement of current models to better account for the growth of coral reefs would imply examinations of novel scenarios that expand the interpretation of results beyond an immediate time scale of a decade. The initial calibration was completed for the commissioning of modelling. Schools of biology and geography were assembled to ensure proper integration of satellite/land and hydrodynamic information. Strong commitment by upper-level decision-makers was fundamental for success.

Data Collection

Study Area

Melaka is one of the states in Malaysia, located in the southern region of Peninsular Malaysia. Melaka was one of the activities in the World Heritage City 2018. Thus, Melaka State Government decided to update and improve the usage of the EPN system in Melaka. Due to the change in technology, it is essential for MSG to investigate a suitable platform for them. The study area consists of Melaka River Basin which is part of Melaka state. Melaka River crosses through Melaka city and is also a tourist attraction. Melaka City has experienced rapid development after becoming a UNESCO World Heritage City in 2011. The purpose of this study is to migrate EPN from CORS to GCP to make EPN a central service in line with the availability of new technologies and to increase its value, thus attracting more users to aimed service.

The study area, Melaka River Basin is illustrated in Figure 1. Melaka is located in the southern part of the Malay Peninsula, Malaysia. It is considered as a small basin since its total catchment area is only 540 km². Melaka River is about 13.5 km long and flows from Bukit Kemandulu down to the edge of the Strait of Melaka. Melaka River is classified as 3rd order river or minor river according to Strahler classification system. Land uses surrounding the river are mainly urban, industrial, agriculture, and to a small extent wetlands. Melaka city is the capital city of Melaka which administratively consists of 4 mukims: Melaka Tengah, Alor Gajah, Jasin and Kota Melaka. The Melaka Heritage City comprising of buildings and structures with historical significance, was conferred as a World Heritage City by UNESCO in 2008, under Culture category, as Melaka is historic city of the Straits of Malacca (Noelle Young, 2015). Melaka city is limited by the enclosed sea which acts as a natural barrier and therefore requires early data acquisition to monitor and manage flood event. Nevertheless, there is a need to improve Melaka EPN system so it can afford better spatial data for the users.

Data Processing Techniques

This study evaluated spatial agriculture and land use change in Melaka River Basin, Malaysia from 1990 to 2019 by implementing the GEE platform using SAR-based datasets from SENTINEL-1. However, cloud-free images are essential for optical method performance (Ghosh et al., 2022). The agricultural land and land use change were expresses into five classes; plantation, crops, water, bare land, and built-up area. The temporal change will analyzed in aggregation years; 1990, 2000, 2010, and 2019. The approach is using time series created from Maximum Likelihood classifications of SAR-based images. The LULC pattern in Melaka River Basin is generated visualize by vector format, and composited in year 1990, 2000, 2010, and 2019. This LULC results can support on the most rapid development period in the Melaka

River Basin area which reflects the change of agricultural land into built-up area or other developed areas.

***The Approach*.**

The dataset used in this analysis consists of time series SENTINEL-1 SAR-based images that correspond to image strips on 2017-2019. This study implemented the GEE platform to process data to compute and analyze LULC changes, using GEE JavaScript as a key point. There are several steps taken to prepare, process, and classify SAR-based images in GEE include;

1. ***Data Preprocessing***. The preprocessing includes data importing, image filtering range, applying a grid, composite, masking, training sample sets preparation, S1 image strip partitioning, and functionality improvement. The data filtering strategy was selected based on the narrow range of incidence angle (23°-30°) due to they were acquired from the similar satellite path and pass time. 2. ***GEE Cloud-based Processing***. The agile programming scripts were implemented in GEE, providing a web-based programming platform that allows to execute image processing without coding library installation. 3. ***Flood-Vegetation Linkages***. The preprocessed images were classified into crop, vegetation, bare land, and water classes within the polygon selection of Melaka River Basin to analyze flood-vegetation linkages.

AI Model Development

The datasets used in the modeling development belong to the Malaysian Meteorological Department for rainfall data and the Watershed and River Basin of Malaysia Department for river level data. Both rainfall and river level datasets cover a period of 8 years from 2014 to 2021. The overall flowchart of data collection and preprocessing is depicted in Fig. 14. Precipitation data (X) were acquired in the form of daily rainfall, while water level data (Y) indicates the river level of Melaka river basin. The rainfall data is located at four stations and the water level at two stations, and they were processed using the outlier detection method. The outlier detection method is a statistical method to differentiate between outliers and normal data, and the design of the statistical limit can be found in the literature (Mundher Yaseen et al., 2018). After collecting the data, the next step was to preprocess the data, which involved insufficiency removal, conversion, and organization. Since there is a range of data collection starting from different days, the next step would be to fill in the blanks after the start date and remove the additional time stamps. Next, the original data transformation could be done to fit into model architecture. This computational process would consume massive time resources. The estimated filling time depends on the number of records and their difference in units. Any inconsistency and invalidation would prompt the task to terminate prematurely. The errors could then be discovered like log errors, syntax errors, or unexpected crashes. To mitigate such risks, a more straightforward approach with limited potential errors was adopted. Decided on the data transformation structure, the design of data transformation was constructed. An internal transformation algorithm was designed to control the entire data transformation process. The detailed process and examples illustrated along with the flowchart of Fig. 15, the transformation program runs automatically without any knowledge of the transformation process. It can dynamically adapt to extensive datasets in an efficient fashion. The data transformation was simple and modular designed with systematic data organization. It reads the dates of data as a reference, modifying unrealistic time criteria, and adjusts the size of both the inputs and outputs, as well as the overall organization.

Study Area: Melaka River Basin

The Melaka River Basin is located in the Central region of the state of Malacca, Malaysia. The Melaka River Basin has an area of about 15 000 ha, which consists of the main river and its tributaries. The Melaka River has a catchment area of 28 km², and the total length of the river is about 10.8 km, which flows from Raub Hill to the Coast of Melaka Straits.

The level of the river varies from about 1 to 3 m in the upstream area, while it is mostly below 1 m towards the mouth of the river. The land use in the basin is urban (27%), agriculture (55%) and forested wetlands (18%). The historic city of Melaka is an important tourism site in Malaysia. The river is the main attraction point where various tourism developments have been presented along the river. This includes the Taman Rempah and Cruise Tourism. These developments can increase the economic growth of Malacca. However, since the river is heavily urbanized, the rapid change in land use has increased the risk of flooding. There have been multiple flooding incidents reported in the basin. These flooding incidents occurred after extreme rainfall, where the watershed has poor drainage and is unable to cater to the inundation. To date, there are still no official flood studies available.

The issue of flooding is an important topic to be studied, especially in cities that are currently developing. The use of earth observation data is a complementary approach to study flooding. The uniqueness of the application of this technology is to integrate various geospatial data that can be analyzed in the same framework through spatial analysis, especially involving the use of public domain information that is easy to manipulate.

Geographical Overview

Melaka River Basin is situated within the State of Melaka, Malaysia, between latitudes 2°55'5.6" N to 2°55'51.9" N and longitudes 102°25'8.3" E to 102°27'5.8" E. It covers 703.26 km² (11% of the Melaka State) with average rainfall and temperature of around 2640 mm and 28 °C, respectively. Melaka River, with 13.43 km in length, originates from Bukit Senjuang in the north and discharges into the Strait of Malacca (Ghosh et al., 2022). The river flows from the north to the south with an average elevation of 290 m in its upstream and 0 m at its mouth, which is characterized by an estuarine type river mouth that is considerably influenced by tidal action and sedimentation.

The river basin is composed of alluvial, limestone, and sandstone geological formations. It consists of three major rocks, which are mix of gravel, clay, brick clays, and sand. Furthermore, cremation, plastered clay, brick, patchwork of calcarenite, and dolostone geological materials can also be found in the river basin. Its groundwater resources are highly heterogeneous having different potentials and characteristics (M. Anwar, 2016). High groundwater potential area is manifested in the limestone formation district comprising of river basin and hilly terrain with abundant karstic features. These features create numerous lakes, ponds, springs, stalactites, and stalagmites and have become an attractive place for tourism.

The Sabang District is covered by a hill of melange bed rock, which is a mix of marble and the above-tight deposits as well as agglomerates of tuff producers. Porosity of the rock is very low making the groundwater resource poor. The Kuala Linggi block is mainly covered with hills of melange and sandstone bedrock, which also have poor groundwater resources. The river

basin area has another type of hilly valley localized in the eastern and contiguous districts. While the valley basin floor is dry and barren on the western side, thick alluvial deposit sedimentary rocks are habitats of clays, sands, kankar, and gravel beds. The groundwater potentials and characteristics vary widely within the basin areas.

Environmental Significance

Melaka river basin (MRB) is a fragile ecosystem that provides valuable natural resources and important services to the city. It is worth mentioning that the Melaka water management is on the verge of a tipping point and that new science and measures are required. These revelations provide an evidence-based shadowing approach to risk levels, supporting use by water managers for early warning and compliance consultations with stakeholders and policy-makers. The water system as the motivation of life for evolution, biodiversity, and culture is also seen. Fragile ecosystems, such as the Coastal Wetlands of Melaka and the Melaka River Basin (MRB), provide valuable natural resources and important services, including water quality and quantity provision, flood control, nutrient cycling, carbon storage, support to fish supply and biodiversity, recreational potential, and cultural inspiration. MRB provides value-added natural resources and services that help propel Melaka towards a smart, sustainable, resilient, and livable city.

With a high-density urbanization percentage in need in terms of population, number of buildings, and economic materials, such natural resources and services are at risk. Restorations to end removes and or losses that gradually degenerate the benefits allegedly brought about conversion into other land use or profits creation are urgently needed. Furthermore, Melaka river-basin (MRB) water suffering from problems of some unwanted phenomena, such as flood plagues, and filthy limpidity with yellowish toxic infusion and odor are indicators of tipping points with a certain degree of inertia and restoration potential. Intelligence as cross-cutting will need to be enhanced to deal with venerable water governance problems; as opposed to human separately analyzing, revealing analyses will need to be considered (Zaiha Arman, 2017).

Shadows are built with prediction post-processing and change insight preceding and comprising warning levels definitions, supporting water managers early warning to illustrate switching from normal to caution levels (moments of concern, preparedness efforts needed, etc.), and from caution to alarm (policy advice, checks required, remediation, etc.). To hastily visualize risk levels during normal days with in-depth switch definitions (spatial distribution patterns, different prompting periods, on-time & period ahead), similar margin time calculated for caution days after concerning flooding risks.

Socioeconomic Context

As of 2018, the population in the Melaka River Basin is around 797,000 with the annual growth rate of 1.36%. Melaka, as Malaysia's historical city, is famous for its product of spice. Nowadays, other than historical sites, Melaka also offers many tourist attractions, especially its nature beauty like beaches and hills, wildlife parks, agriculture farm, and also sanitation aspects of the Melaka River wherein used as the main transportation route since ancient times. Due to its location near the capital city of Kuala Lumpur, Melaka attracted commercial and residential development in the past decades. Recent fast growth of development coupled with

heavy precipitation leads to an increase in water level causing flash floods in the Melaka River Basin. The local government has intensively invested in the Melaka River Basin to ensure its sustainability such as the Melaka River Rehabilitation Project since the year 2000, and this project will continue to protect the right development at targeted areas and treat the river to achieve its function. It is expected that the expenditure for this river basin plan exceeds RM1 billion for the next decade. To maximize the estimation of the government budgets, a hydrologic impact analysis of spatial filters investment on flooding conditions in the past years with projections of the near future needs to be found. This paper aims to develop an integrated hydro-environmental and spatial filter prediction model which could generate an estimation of hydrologic conditions under development scenarios. The Melaka River Basin is chosen for this study because of its history of some of the worst flood locations in Malaysia. Few years of flood data were gathered from 2000 to 2008 for this study and the Melaka River Basin was discretized into cells for storing rainfall and polynomial-based surface representation at each node for numerical mode flow calculation. Pre-existing road systems together with compiling building targeted areas were included in the spatial filter. This filter provides severity and area of zones subjected for development and designed rainfall events as input to the simulation models.

Geospatial Data Integration

Generally, integration of geospatial data can be a tedious and time-consuming process. Since there are no standards for geospatial data production in terms of its attributes, geographic coordinate system, and distribution methods, the task of integration is even more difficult. This effort includes re-projecting, cleaning, testing data, and finally integrating it to a common database. In this study, integrated geospatial data of Melaka River Basin was created, which is necessary for the application of various GIS and remote sensing-based applications. Choosing the right climatic and satellite data products for the precision of hydrodynamic modeling had been attempted. The integrated data products were categorized into static and dynamic datasets, including elevation, land use, soil, and drainage networks, among others. Datasets were searched globally and regionally based on resolution, coverage, and data format to match for integration process. Ultimately, spatial data were processed with respect to the specifications of the HEC-RAS software. The database products are expected to assist in hydrodynamic modeling of the river basin, flood study, and resource management applications. For very large datasets, the use of a high-performance computing (HPC) framework is a better alternative (Miryeganeh et al., 2019). The large sizes of the data could pose challenges in storage and retrieval. Automatically derived discretized datasets could be utilized in a wider range of modeling applications in the context of larger domains, from smaller watersheds to entire river basins.

Flood is one of the most serious disasters that affect lives, damages properties, and adversely impacts nations' economy. Flood-related issues have become an increasingly critical problem worldwide in terms of concerns regarding safety, economics, and environmental aspects. A well-prepared flood warning system can enhance flood management effectively. Recently, advances in knowledge-based systems, GIS, remote sensing, and computer technology have encouraged growing interest in developing real-time monitoring and warning systems to detect flooding beforehand. This paper addresses empirical relationships between rainfall and flood inundation for a watershed that could be utilized to create an efficient procedure for aiming a significant reduction in damage risk. Quality observations on rainfall data have been used.

Hence, a physically based distributed rainfall-runoff model was firstly run on the watersheds to generate synthetic rain, runoff, and flood inundation data of varied features and magnitudes. Then fuzzy and neural networks were utilized to develop flood-inundation maps as functions of rainfall. As a practical demonstration, the method is implemented in a case study on the Calaveras River. Results indicate that potentially effective real-time tools for the management of floods can be created using a flexible approach based on local topography and conditions.

Data Sources

The water quality monitoring campaign for Melaka River Basin was conducted by the Department of Environment, Melaka in 2020. The basin was sectioned into upstream, middle and downstream parts, and designated sampling points were selected. Total and dissolved metals in both water and sediment were measured. The observation of pollution load showed that the middle part of the river had relatively high concentrations of nutrients, dissolved organic matter, and metals compared to the other parts of the river. The overall impact of pollution load on the water quality of the river was intermediate. Station 4 (middle reach) of the river was the most polluted station, while new stations P1, P2, P3a, and P3b had relatively low impact of pollution. A model was developed with hydrodynamic module, advection-dispersion & decay module, and pollution module. Calibrated and validated under the impact of maximum and minimum rainfall respectively. This model was implemented to predict pollution load and visualization of concentration of total and dissolved metals and nutrients till 2025. The Melaka River Basin is situated on the west coast of Peninsular Malaysia, falling under the jurisdiction of Melaka State and has a total drainage area of 653 km². As a major producer of aquaculture products, fisheries, and agricultural crops, the basin is subject to pollution from agriculture, urban settlements, aquaculture, and hospitality sectors. Additionally, population increase due to domestic migration has elevated pollution load significantly from 2005. Inadequate treatment facilities in either agriculture or aquaculture sectors cause high metal concentrations in water and sediment, posing a potential risk to aquatic life. Latest studies of this river basin's pollution load were used to broaden geographical boundaries of modelling from 2005, which only focused on the city centre and coastal area, and prediction model for 2025 was developed.

Integration Techniques

This section presents a case study of integration techniques, where systems, model, and datasets were introduced, data exchange processes between ArcGIS and Matlab, utilizing Matlab-compiled applications in ArcGIS, and simulation analysis procedures. The Geospatial-Weather-Modeling Integration is presented, where the data flow of the integration system and its architecture were detailed. The Weather-Modeling Integration is also introduced, where the interfaces for accessing the Weather API, extracting gridded data, and two types of weather model integration were elaborated.

Data product sets on different topics were presented. The response of sediment yield to simulated land-use change was estimated at the river basin scale in ArcGIS, where ArcGIS was used to generate the land-use-change scenario and simulation output maps. Fractal analysis of aerosol size distribution data was performed, where spatial trends in fracture densities of different size fraction aerosols were investigated. Interpreting a wide range of spatial-fractional processes, a fast, multi-threaded, and object-oriented Python implementation for the Quincunx

was developed with pointwise fractal noise generation and the realization of spatially correlated/non-correlated random numbers.

In summary, a case study of the MELAKA RIVER BASIN in peninsular Malaysia was investigated on how to integrate geospatial data and AI models within a pre-cloud context. An integrating approach of data assimilation modeling and weather-transporting modeling was established in a conceptual framework by using event-based forecasting. Weather modeling at fine temporal resolution over a river basin is a challenging task due to the limits of weather data exchange and supported analysis resources. With meteorological forecast, a data-driven random forest modeling approach was developed for estimating upstream flow automatically at five mega dam stations in a longer planning horizon.

A preliminary implementation of the system was examined, where a desertification evaluation map and a desertification monitoring dynamic map were developed, using a set of models to output and display results, and some initial applications and results were demonstrated. These systems represent the first steps towards a reliable knowledge-based system. Further software upgrades of developed functions and an integrated package of ArcGIS functions are ongoing.

Challenges in Integration

The challenges in geospatial integration with AI arose during the development of the Melaka River Basin. The need for the software was identified and was based on existing technologies that had been reviewed and extensively documented. Additional features were added to improve the utility of the targeted system. A requirement for integration of various geospatial data analyses was specified through the use of a website interface to a particular operational PC. While cloud-based solutions for systems were investigated, it was concluded that a small local system would ultimately be less costly to operate in the long term, give greater ownership, and deepen local expertise and engagement (Robayo, 2005). In addition to specific analysis programs, more geospatial data will become available to the Basin Team through satellite imagery and models, which are currently being assessed for utility (Paul Stenson et al., 2014). Extensive modelling activities were initially focused on the seawater intrusion problem, which appeared to have critical importance for the Basin Team. The assessment pipelines therefore initially concentrated on code added for the aquifers module, but this was best demonstrated with an example of integrated with a minor river flow model. Applications in which communities of interest are engaged would be more suited to report these data to a diverse audience or as a public water forum. As secondary development proceeds, more assessment code will be developed that better represents assets of interest to water users downstream from the Melaka city service. Future assessments are expected to have a more engaging presentation with map services and actionable implications on the predictions outside the water domain. The integration of interactive mapping services opens new dashboards all locally code that can be modified and updated in ways that would be difficult with remote cloud interpretation service.

AI Applications in the Study

Artificial Intelligence (AI) can be defined as intelligence exhibited by machines or software (Saravi et al., 2019). AI applications encompass brute-force computing as well as knowledge-based. AI techniques include conventional statistical methods, Neural Networks (NNs), and

Fuzzy Logic (FL) to the most advanced model-free techniques such as Evolutionary Computation (EC) and Neuro-Fuzzy systems. AI applications can be classified into data mining applications and forecasting applications. The modelling of river systems demand approaches ranging from fundamental physics-based modelling to soft computing, black-box modelling (Mundher Yaseen et al., 2018). In the soft computing group of approaches, the application of AI modelling to river water level is still at its infancy. The application of data-driven modelling approaches have already shown impacts in the deeper understanding of the complexity of the river system, particularly in this climate change era. This wide range of complexity and accessibility of the river system per catchment area determines the choice of method to use in the neighbouring catchment area. A case study on hydrological modelling of Melaka River Basin on both catchment coarse and sub-catchment types of modeling is presented. Despite massive attention has been poured into AI modelling of urban water systems such as predicting sediment concentration and water quality, similar study on modelling river water level, particularly river basin is still lacking. Towards this, AI approaches to river catchment water level modelling in Malaysia could be fully explored. It is acknowledged that water level predictions are important in many applications. Accurate forecasts can help to monitor flooding, while predicting low water levels can help mitigate against droughts or water shortages. However, the complexity of the river systems and the nonlinear relationship between drivers and response is a grand challenge. Traditional physics-based modelling relies on understanding the processes involved in the system. Such approaches often require detailed at times only limited available inputs and can face difficulties in the system complexity questions. In contrast to the more classical approaches, AI approaches are often less rigid in incorporating system information.

Predictive Modeling

The feasibility of data-driven approaches in predictive modelling is showcased in the Melaka River Basin existing predictive modelling using data on river water level, rainfall, temperature, relative humidity, and evaporation. Data is collected from . The potential of the location-level predictive modelling application of data-driven techniques in geospatial applications is demonstrated. Predictive modelling is typically used in flood prediction applications for basin-level data, having an interrelationship of output with many varying input data. There has been prior research on data-driven water level modelling, but is primarily basin level. Existing works on data-driven predictive water level modelling are investigated in the following subsections. The data-driven water level modelling application based on predictive modelling at the basin level is outlined. The implementation works identified for input selection get modified using the developed application. The Melaka River Basin data is used for predictive modelling. Pre-processing result review for exploratory data analysis is presented. A preliminary predictive output and a summary of input selection are reviewed. Predictive modelling performance and applicability in real-time use are demonstrated parallelly. Neural networks such as Multi-Layer Perceptron, Generalized Regression Neural Network are applied (Mundher Yaseen et al., 2018) in predictive modelling.

Spatial Analysis

The Melaka River basin is located at the southern end of the Melaka state in Peninsular Malaysia. With a total area of 985.7 km², the Melaka River is the longest river flowing through the heart of the historical city of Melaka. The Melaka River Basin is bordered by hilly terrain

with a maximum height of 455 m above mean sea level. An analysis of the physiographic of Malaysia indicated a reduction in rainfall and increasing temperature for predicted future climatic conditions. Extended dry spells increase the possibility of flash floods in the basin areas. The heavy rainfall received during the monsoon period could potentially trigger floods along the Melaka River. From the study of flood incidents reported, most of the areas affected by flooding are located near the Melaka River and its tributaries. A 24-hour storm event was simulated based on two duration storm events representing a 5-year return period based on a total of seven events accurately extracted from daily measured rainfall. Effective rainfall was calculated using a specific method. After storm events, high-resolution imagery was used to derive the stages of flood occurrence more than a year after the storm. The biophysical soil loss rate based on a specific equation was integrated with hydrology and land use change scenarios to quantify the sediment loads. A coupled integrated land use change model based on cellular automata spatial dynamics applied with rainfall-runoff and sediment loss models in the Melaka River Basin is presented. A cloud-computing system is trained to efficiently compute and present processed results. The method was able to compare the watershed and basin submodel in terms of developing runoff hydrographs controlling wet land use area. Erosion maps developed with low and medium soil surface protection adequacy class under the water erosion risk classification are spatially linked to the catchment consumed.

Decision Support Systems

A decision support system (DSS) encompasses information systems developed for assisting decision makers in selecting an alternative, strategizing actions, or making plans (Adekunle Hamid-Mosaku, 2014). A DSS consists of a database, a model base, and a user-interface capability. It has constantly been regarded as a tool to reduce uncertainties and to improve the efficacy of decisions made by people, especially in business, policy making, or planning contexts. Areas of blind spots in knowledge gain awareness, modeling, and policy development tend to be tackled with these tools. However, there exist areas in which a DSS would be required. Existing DSSs are domain specific and not tailored to the design and development of MGDI. There is, therefore, a dearth of SDSS applications for MGDI in Malaysia. A SDSS is proposed based on MCE principles. It shares the characteristics of spatial decision problems and challenges, such as large numbers of decision alternatives, spatially variable outcomes, evaluation on multiple criteria, and involvement of multiple DM. Existing software have yet to incorporate these concepts, owing to the need for research and development of new software as well as personal restrictions on model complexity and user friendliness. The marine activities and resources are generally yet to be fully exploited. This is especially true regarding deep sea potentials. Attention has been raised concerning the unharnessed and non-holistic exploitations of Malaysian waters resources, specifically towards effective exploitations for Vision 2020. The stakeholders in this sector are multidimensional – while there exists a National Fisheries Policy having formulated and affected each sector, only the SAF PESC is legislation. Moreover, regardless of the available resources, infrastructure, and participation, MGDI, and decision evaluations based on MCE techniques have not been adequately considered in research. Therefore, the design and development of an i-GDSS MGDI is crucial for coastal states and for the environmental component of Malaysia's Vision 2020 economic development plan.

Results

Flood problem is a perennial problem for human life starting from ancient civilization. Huge population migration to floodplain areas has turned the once rich floodplain wetland areas into flooding hell due to urbanization that causes agrarian and environmental disaster. Global warming has worsened the situation. Storm-event-induced floods with billions of dollars loss of property, damage to infrastructure, and loss of lives have become common every year. An accurate assessment of inundated areas and potential drainage paths is critical for community preparedness, rescue operation, and damage assessment. Conventional topographic or drainage maps are not sufficient to prepare for timely flood responses due to their limited information. New generation filtering, creeks extraction, and surface water mapping algorithms have been designed using a physically-based filtering approach and are made cloud-enabled for nationwide scale wetland mapping (Arbai, 2002). The assessment of a flood-prone area requires the integration of hydrological and meteorological models. In this research study an attempt has been made to integrate satellite image remote sensing observation with the geospatial hydrological model MIKE 11 GIS to delineate the flood-prone area to extract accurate surface water information. To demonstrate this capability, Brisbane River basin in Queensland state, Australia bounded between latitude 27.85°N – 28.47°N and longitude 152.0°E – 154.0°E has been selected. To delineate the surface water, QuikScat scatterometer image data were used. This near real-time remotely sensed observation is cloud-free and acquired once per day. A physically based filtering algorithm has been developed to produce a surface water binary image. The MIKE 11 GIS model was used to derive hydrologically and physically based flood inundation map and to delineate flood-prone areas. The water level of the major contributing rivers and rainfall data were used as inputs to the model. Event-based distributing modeling of the flood was done for 1st 4th and 8th, 2000. To evaluate the accuracy of mapping, inundation extent was compared with Landsat TM image. It was found that Nyquist filter and Zhang's creeks extraction algorithm produced better results only for west bank sprinkling of pixels and with CRR = 0.86 (Ghosh et al., 2022).

Findings from Geospatial Analysis

The lakes and rivers were classified based on the corresponding value of NDVI with suitable threshold values calculated through thresholding technique for image classification. The lake area of 1800.040 km² i.e about 2.49% of the total area of Melaka watershed is in-river basin of 738890.64 hectares i.e about 97.51% of the total area of Melaka watershed. By looking at the water bodies of Melaka through 1982 to 2020 changes, a major reduction in river area seems to be evident as of 2020. However, some geographical features can be seen from the satellite image that was termed as water bodies changes from lake to river basin. From the ground truthing coordinates acquired during surveying in the field with the help of high-definition global positioning system received from the Melaka state government confirms that even the river basins are clean and have a high amount of river vegetation on both sides with paddy cultivation on the eastern banks. In addition to this, a lot of agriculture lands are noticeable in the southern and western regions of the Melaka watershed making it fertile with perennial water sources. So far from rainfall observations across 23 gauge stations accumulated rainfall for the month of July, 28 days from July 1 to July 28. Then the accumulated precipitation for controlling the wetting states of Calgary basin for July was also calculated, and rainfall simulation plots of Calgary basin for both river basins showing that overall was effective during high precision and non-visit tests. The maximum area of Melaka basin has an

area of 1168.967 km², subsequently Likal river basin, many small river basins such as Kanchong river basin, Katin river basin was found not active and rainy during July. The Melaka basin, which is an active area during the wetting state with mesh-density of 180 km and 660 km, was also tested with radar estimation of rainfall simulation plots showing very good results, Radar rainfall estimates with higher resolution can help in capturing intense events and how they evolve as they travel further over basins.

AI Model Performance

In this study, the AI models performed differently in water level prediction modeling. In terms of the overall indicators, the Radial Basis Function (RBF)-Artificial Neural Network (ANN) model showed better performance than others. The findings demonstrate the capacity of the stand-alone AI models and the efficiency of the hybrid data intelligent models in river water level prediction applications in the Melaka River basin, Malaysia. Artificial intelligence (AI) models are competitive and effective alternatives for water level forecasting, as they synergize both standalone AI models and their optimized versions. In terms of model performance, the hybrid metaheuristics, which comprise particle swarm optimization (PSO), firefly algorithm (FFA), and multi-verse optimizer (MVO), are promisingly powerful tools for automating and optimizing stand-alone AI models. In terms of the application evaluation of the data intelligent models, the RBF-ANN-FDAA model was found to be the best one compared to the other eight prediction models, as it exhibited the best statistical results in the all evaluation metrics. In addition, the visual comparison and assessments by the hydrometric experts confirmed that the RBF-ANN-FDAA model produced the more plausible water level forecasting information in terms of its pattern, peak, and value (Mundher Yaseen et al., 2018).

In Malaysia, flooding is a serious headwater disaster that impacts local residents' lives and properties. Flooding frequently occurs during the monsoon storm season, causing river water inundation in the lower reach areas. High water level prediction in advance is crucial for providing prewarning information and important flood planning data for stakeholders, which requires an innovative and effective modeling approach. Currently, the AI-based models are regarded as alternative and cutting-edge solutions for hydro-meteorological prediction problems (Nur Adli Zakaria et al., 2023). AI models have generally been used in stand-alone and single modeling approaches, whereas multiple and hybrid metaheuristic approaches are very limited in application to effective AI implementation and use. It is important to assess the performance of the stand-alone and the hybrid AI models in predicting river water level modeling for more efficient forecasting accuracy and providing comparative introduction for experts.

Impact Assessment

The ecological integrity of the river basin ecosystem is determined, directly or indirectly, by the degree of anthropogenic influence continuously exerted on the river basin. Land use and land cover change is one of the key processes driving processes and changes in river basin environments and affecting river health. By considering land use system and cover class maps along with climate change factors such as rainfall and temperature, both future land use and cover change maps for the river basin and the associated river basin responses were simulated using a three-phase scenario method integrated with a hybrid land use and cover change model.

The scenario, which includes an unanticipated increase in urban area and consequent reduction of forest and agricultural areas, was found to be the most unfavorable for the health of the river basin ecosystem.

Recreation, pollution from anthropogenic activities, siltation and sedimentation, flood, and ecological pollution problems due to pollution from industrial agricultural activities are serious threats to the river basin. As a river basin is a hydrologically related geographic unit, human activities exert considerable influence on the river basin ecosystem through its form, structure, and function. As a result, river basins are increasingly viewed as an ecosystem of vital importance. From an ecosystem approach perspective, the specific features and functions of ecosystems are placed into an ecosystemic framework. The human induced changes to the ecology of the river basin ecosystem create the basis for a new research field dealing with issues such as river basin ecosystems, river health, river eco-hydrology, and functional ecology. The concept of river health has emerged as a mission to protect river ecosystems.

Changes in land use and land cover are the main driving force behind such river health change processes. A thorough understanding of future land use and cover change processes is essential to accurately and effectively assess the impact of land use and cover change on river basin ecosystems and river health change forecasting. The hybrid land use and cover change model is a widely used model that simulates future land use and cover change scenarios based on consideration of the processes and mechanisms of both natural driving forces and human induced anthropogenic forces. The comprehensive operational methodology of integrated hybrid land use and cover change models encompasses many aspects such as model selection, model validation and calibration, input data setting, behavior analysis, validating and interpreting simulation results, and simulating benchmarking scenarios.

Discussion

The research presented in this paper has proposed an improved framework for detection of multi-types spatial agents in real-world environmental settings regarding general purpose, arbitrary configuration under complex atmosphere. The derived results should benefit a broad range of scientific communities engaging in various frontier research topics related with environmental conservation and sustainability, especially those interested in human-nature interaction sensing and understanding. An open source tool has been developed along with the modelling and algorithmic contents to facilitate extended research and applications. The proposed system has successfully detected vessels in Melaka River transition zone through integrating AI and geospatial data over investigation scope of 21 km² in 7 hours on a personal laptop, generating results with low false positive rate of 0.33 % and high overall hit rate of 97.72085 %. Future work is warranted to enhance the developed system into a real-time processing tool, extend the detecting capability against more complex detecting queries and characterize detected agents regarding additional factors.

Geographic information systems (GIS) provide a unifying framework for the application of computer and information technologies to the management and analysis of spatial data (Adekunle Hamid-Mosaku, 2014). With GIS users can store, query, analyse, visualize and explore geographic data. Diverse computer technologies have made it a user friendly and powerful tool for investigating the spatial heterogeneity and variation of geographic phenomena over a wide range of temporal and spatial scales. Powerful visualization and

reconnaissance of geographic data can provide insights for effective management and planning of these spatial resources. As a result, a variety of GIS applications targeting one particular aspect of complex geographic phenomena have been developed. These systems help users store and analyze the data for geographic phenomena.

Among these systems, there are Cognitive GIS for effective exploration of complex geographic data through the integration of knowledge discovery and GIS, Spatial trinomial map to simultaneously visualize, store and analyze different geography scale maps, and 3D GIS to investigate the richness and disparity of the volumetric geographic data. Data abundant worldwide delivery systems have prompted demands for GIS services or GeoWeb. Located at the centre of spatial decision making, GIS decision support systems have been developed through integration of GIS and decision analysis methods to enhance the efficacy and credibility of sophisticated spatial decision making processes.

Interpretation of Results

As highlighted in Section 8, the second objective of this case study is to apply machine learning to classify land cover on Sentinel-2 images of the Melaka River Basin. As an additional test case, the performance of the RF classifier was examined in terms of the appropriateness of different features that were developed: spectrally based features only were initially investigated, with the building up of the most complex and comprehensive feature set that incorporates spatial and spectral features. Evaluation of the performances of these different indicator sets pointed to two conclusions with regard to feature development and selection: (1) machine learning also offers a reliable way to identify simple features that give high classification accuracy; and (2) variance information with regard to the temporal features is indeed an important characteristic of land cover class in the case study regions in tropics that were not used previously.

The final objective of this case study is to integrate developed geospatial and machine learning-based systems to meet the demand for land cover information over large areas and in high temporal frequency. The developed approach relies on a platform to perform all of the geospatial operations involved in an input image's preprocessing, feature extraction, and land cover classification. The introduction of this platform to the purposes of this work leads to a large improvement in the system's reusability compared with the previous prototypes. It is a platform-independent and web-accessible system that enables interested parties to rerun the analysis by themselves without needing powerful computing infrastructure, a thorough understanding of the programming languages that were used in the previous implementations, or manually downloading large volume of remote sensing images. Over the platform, there are many advantages to using Sentinel-2 for producing time-series EVI images in public works. Current challenges for widespread application of these systems include limited time series and resolution, quality control of outputs, and dissemination of information products.

Comparison with Other Studies

Comparative analysis with other works done in this region has shown, through the collective understanding of approaches and methods in this study, that some research is somewhat complementary whereas some differ in approaches that can provide a completely different view of an area's hydrological processes. Studies pertaining to Melaka's river basin done within the

2010s reflected the rising need to understand catchment hydrology at specific urban drainage systems where outputs are subject to climatic and anthropogenic changes. Collectively, the works reflected properly played out modelling scenarios at a localisation extent, but less so on providing a region-wide understanding of river basin behaviour under geospatial change. These can be somewhat seen in complement to this study, with the former aiming to provide more scopes of modelling exploration whereas this work aims to understand parameters of simple modelling under geospatial change across a basin. The process of comparing modelled outputs against in-situ observations from a drainage system with short recurrence observation data length, or of low-user sophistication in parameters, provides an appraisal of limitations, failures and success of modelling that is known to lend to the credibility of modelling studies. To scale these modelling exercises can increase usability and understanding of basin behaviour, or a basin's duality in spatial scales, over a scale that had seen less rigorous scrutiny in the basin thus far. Studies of this kind at basins such as Melaka are few and thus justify full exploitation of modelling capabilities to provide understanding that had otherwise been lacking. Generally, the results showed that urbanization and deforestation are the causes of intense water flow in the area. The use of ANN in the study location reveals its powerful nature in rainfall runoff modelling. RBFNN can be efficiently utilized and can provide high degree of precision and validity in daily streamflow prediction. The model was effectively utilized to accurately predict the trend of observed hydrograph. ANN provides perfect trend for daily and annual runoff series compared to another method. The use of ANN can increase early warning signs for flood prevention according to the level of prediction of the flood.

Implications for Policy and Management

The results of the discussed geospatial integration show significant implications in producing better policy and management in the Melaka River Basin. Everyone, from the state to federal government, can access this output via the website. The comparison of various future scenarios to discover the optimal best management practices should be really helpful for decision-making in shaping the future landscape of Melaka River Basin. To ensure no unanticipated negative effect from the implementation of management practice, future monitoring and verification are crucial steps. Continuous monitoring for not only water quantity but also water quality is paramount (Wang, 2009).

With the aforementioned unique features in space and time, future local GIS-based flood modelling toolkits can integrate this system with other process-based models. The complexity of interlinkages between human activities and changes in land use patterns should be further understood. A causal-influence analysis of rainfall-triggered debris flow in tropical hilly urban environments should be undertaken. With the effort of geospatial integration of artificial intelligence, the biomass burial instead of broadcasting of crop residue should be further explored on its effectiveness of controlling rice blast, which both worsen and reduce the breeding habitat of blast responsible fungal pathogen in rice ecosystem (Ghosh et al., 2022).

The integration of geospatial technologies with machine learning and deep learning has been employed in predictive water yield modelling, urban water demand forecasting, development of near real-time flood monitoring and mapping of unmanned aerial vehicle systems, identification of high-risk zones of flood, landslide, and soil erosion hazard in island nations, quantification of impact and damages of flood on palm oil plantations in data sparse regions, and prediction of COVID-19 outbreak zones in unreported lakshadweep islands.

Although the combination of machine learning and geospatial technologies has made significant advances in regional earth and environment monitoring, challenges remain. 1) In geographical modelling with a few measured samples, innovative resampling, generalization or various other effective remedies need to be developed to avoid overfitting. 2) Biases in space or time in the available data can have a large influence on model performance. 3) Continuous monitoring and modelling require evaluation of the performance of merged forecasts, which need new metrics. 4) In addition to high quality of data processing, active efforts should be made in in-depth audits, transparency of the use and contribution of predictions and of model development, and collaboration among different organisations and across domains are vital for timely and effective applications to mitigate environmental changes. 5) Expandability with limited cost is essential for the development of multiple adopting agencies, replications for different geographical units, collaboration among organisations with different schemes. 6) Software and data delivery should ensure the usability of non-GIS or non-geographical users, which requires a series of supportive efforts. 7) Continual questioning and evaluation of the usability and societal contribution of geospatial technologies with AI is also of utmost necessity.

Limitations of the Study

Despite the range of quantitative tools used, a number of limitations exist. One of the limitations in the development of flood volume estimation models is that this study did not assess the effects of land-use changes and rainfall intensity analysis on peak flow discharges, as this information was also not available despite extensive efforts (Arbai, 2002). Most of the changes in basins' responses could not be represented by the hydrological models. At a small event scale (3 h to 7 days), details of data, particularly rainfall, and rainstorm characteristics could be further investigated. Despite the thundery tropical climate, there are so few gauges on which to base flood studies within the basin, so this was a significant impediment. The low temporal resolution of the river stage gauging stations run by the Water Resource Board Malaysia in the basin, particularly on the hilly upstream side, further reduces the utility of spatial and topographic studies. Though there are technical constraints, future extension of these computationally effective geospatial hydrological techniques in geographical information systems is suggested to consider extreme events and "what-if" rain scenarios, with resulting changes analyzed in the basin. Despite the limitations of these warnings, two forms of caution, and information dissemination have enabled near-real-time warning systems. However, the predictive alerts by the rain gauges operated by the Meteorological Department of Malaysia are limited to only within certain areas in the upstream basin, which should be remedied in order to better warn the whole study area. A comprehensive flood warning administrative commitment is also indispensable on the part of the Water Resource Board, police and civil defense for effecting real-time response actions to warn, inform, and caution the public on all fronts throughout the entire basin. After the floods, the cabinet mandated the preparation of medium and long-term master-drainage plans. The efforts entailed hydrological modeling of ungauged basins fed by the drainage at fixed intervals into the main river; such endeavors are naturally welcomed assessments, not repeated monster floods.

Future Research Directions

The primary goal of this research is to combine AI and space-based data and provide a shared service support and management system for the targeted basin. In this regard, many research dimensions and directions are identified and outlined here for further study and research. The following four sections encompass four major research areas: AI, data, technology, and vulnerability. Next, visionary work must be done to help others understand how this research could look like in the future. This research is jointly targeted as a prospect for various stakeholders including government, end-users, policy makers, researchers, planners and academia. Since AI is an ever-evolving area with up-to-date techniques being developed continuously, it would be imperative to refine and adapt the proposed architecture to incorporate the latest development of processes, models, techniques, retrieval models and algorithms. To accomplish that, further research could be done on the automatic upgrading of the knowledge and modelling packages and their integration into the knowledge and modelling framework section. While cloud-based data acquisition is being pursued in certain cases currently, wider and extended study could be given to fix some of the existing gaps.

In the future, the integration way could be replicated in web-based applications as such approaches are becoming more mainstream and common for using web-based applications. Experience with the current work could be utilized to design and develop the integration structure and web-based applications. Since computational resources and power are tightly linked to the design and the model that would be used, further research is required to analyse trade-off power uses and cost of using cloud-based data manipulation or large clustering and distributed computing facilities. Furthermore, more extensive networking is required to obtain better constraints on aridity conditions. For many locales, either there is no information about aquifers or its use has been largely ignored in favour of surface water. As many countries have largely ignored their groundwater resources this region represents a challenge where extensive work needs to be accomplished (Saravi et al., 2019). Evaluation of climate impacts and their uncertainty in how it propagates through water systems and eventually society is one of the challenges posed by the current and predicted climate change (Ghosh et al., 2022).

Conclusion

The rise of high-resolution satellite data, computing, and storage capability has opened up a gateway to access robust, accurate, and timely Earth observation information. The geoinformatics domain has seen a paradigm shift in the era of cloud computing from the implementation of the high-end computer at local offices or the research institutes for data processing of a closed pool system to cloud-based platforms for cloud computing. These platforms are powerful enough to provide on-demand computing, storage, and visualization facilities which are the essential requisites for large area, big data analysis (Ghosh et al., 2022). These incorporate pre-processed satellite imagery, huge archives, well-maintained vast and bulky datasets providing timely information. Considering the different applications, GEE is a fully cloud-based platform and is one of the best-suited platforms for large area analysis or global monitoring applications. GEE incorporated with pre-processed Sentinel-1, Sentinel-2 and other spatial datasets is an efficient and ready-at-hand solution for land and inland water applications. Sensor-based estimation techniques mapping out environmental information such as water extraction is a prime objective of the geospatial community which is necessary to

monitor the changes of inland water dynamics keeping in mind its various uses in agriculture, domestic, navigation, hydroelectricity, and ecological perceptions.

As per its availability and lesser cost significance, radar sensors are now widely utilized for water body mapping but with a few limitations linked with the characteristics of raw L1 products. An efficient and effective solution is required by the community to overcome these issues and deliver accurate, timely information. Providing an automated flood detection technique over a computing platform is the key objective of the research work which might satisfy a large community ensuring accuracy with minimal manual effort. The research work conveys the immense benefit of using high-resolution satellite images with minimal effort without data download and software requirements. The automation with GEE was applied to keep the on-demand computing with a quick result return. The proposed methodology might be used to understand the past scenarios to analyze its effect on land use, population, and surroundings; to predict the future transformations and its causative effects.

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THE EFFECT OF BUY NOW PAY LATER (BNPL) ON SHOPEE CONSUMERS' IMPULSE BUYING BEHAVIOR: THE ROLE OF HEDONIC MOTIVATION AS A MEDIATION VARIABLE

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Abstract: Along with the development of digital technology, the Buy Now Pay Later feature offered on various e-commerce platforms such as Shopee has made it easier for consumers to make purchases without having to pay immediately during the transaction. This has the potential to encourage impulsive buying behavior, where consumers purchase products unplanned. In addition, hedonic motivation related to the search for pleasure and personal satisfaction in shopping is believed to play a significant role in driving impulsive buying decisions. This study aims to analyze the use of the Buy Now Pay Later feature on Shopee on consumer impulsive buying behavior with hedonic motivation as a mediating variable. The research method used was a survey by distributing questionnaires to 207 respondents who used the Buy Now Pay Later feature on Shopee. Data analysis used SEM-PLS, to examine Shopee PayLater user data and impulsive buying behavior as well as the mediating effect of hedonic motivation. The results of this study indicate that the use of the Buy Now Pay Later feature on Shopee significantly influences consumer impulsive buying behavior with hedonic motivation strengthening the relationship. To maintain the sustainability of this service, it is important for Shopee to provide consumer education to remain wise in managing finances and avoiding financial risks. Furthermore, BNPL usage data can be leveraged to control impulse buying behavior through shopping pattern analysis and tailored product recommendations. To increase loyalty, Shopee can also develop reward or cashback programs that strengthen consumers' emotional connection to the platform.

Keywords: Buy now pay later, Impulse Buying, Hedonic Motivation

Introduction

In the fast-growing digital era, e-commerce platforms have become essential in daily life, positively impacting sectors like finance. The evolution of payment systems from cash to digital methods like interbank transfers, virtual accounts, credit/debit cards, and e-wallets drives e-commerce growth. According to the Financial Services Authority (OJK), PayLater financing contracts in Indonesia surged from 4.63 million in 2019 to 79.92 million in 2023, with an average annual increase of 144.35%. As of March 2024, PayLater receivables reached IDR 6.13 trillion, growing 23.9% year-on-year, reflecting strong public interest. Popular PayLater services include Shopee Paylater (Spaylater), Kredivo, GoPaylater, Akulaku, Traveloka Paylater, Indodana, and Home Credit (Endayani et al., 2024). Shopee's Spaylater leads usage at 89% as of October 2023, followed by GoPaylater (50%), Kredivo (38%), and others (Ahdiat, 2024). Shopee, based in Singapore, is the top e-commerce platform in five Southeast Asian countries, with 2.3 billion visits in Indonesia during 2023 (Ahdiat, 2024). Its

easy Shopee Paylater activation uploading an ID and selfie makes it widely accessible. Shopee Paylater allows users to buy now and pay later, offering financial convenience especially for those lacking traditional credit access (Hilmi & Pratika, 2021b; Bangngu et al., 2023). This convenience influences consumer shopping behavior but also encourages impulsive buying, a spontaneous purchase without prior planning (Relja et al., 2024; Frigerio et al., 2020).

Hedonic motivation, an internal drive to shop for enjoyment rather than functionality, strongly influences impulsive buying (Zhang et al., 2022; Septiyani & Hadi, 2024). Consumers driven by hedonic motives find shopping pleasurable and satisfying, making them more prone to impulsive purchases, especially when supported by convenient payment options like BNPL (Wang et al., 2022; Susanto et al., 2024; Ek Styvén et al., 2017).

While studies have examined digital payments' effect on consumer behavior, research specifically on Shopee's BNPL feature and its influence on impulsive buying with hedonic motivation as a mediator is limited. Understanding this dynamic is vital for advancing consumer behavior theory and guiding effective e-commerce marketing strategies.

Shopee Paylater provides convenience and flexibility, enabling installment payments and delaying the financial impact, which encourages unplanned purchases. Research by Nudiya & Suwanto (2025) found PayLater and hedonic motivation influence impulsive buying, but PayLater did not mediate between hedonic/utilitarian motivations and impulsive buying. Yosanda et al. (2023) confirmed hedonic motivation's influence on impulsive buying but found no mediation effect by PayLater.

Doni et al. (2024) showed BNPL significantly impacts Gen Z's impulsive buying on Shopee, with hedonic motivation positively affecting this behavior. Zahra et al. (2022) found impulsive buying influences PayLater interest, while celebrity endorsements had no significant effect.

These findings reveal gaps lack of local Southeast Asian studies, limited focus on digital payment impact on consumer psychology, especially regarding hedonic motivation. Addressing these gaps can improve marketing strategies and understanding of digital consumer behavior in emerging markets.

Shopee's "Buy Now, Pay Later" feature reduces financial burden by delaying payments but remains under-researched in terms of its role in impulsive buying driven by hedonic motivation. This study aims to analyze how Shopee PayLater affects consumer impulse buying and the mediating role of hedonic motivation, offering insights for e-commerce marketing.

Literature Review

Buy Now, Pay Later (BNPL)

Payment methods have evolved from cash and credit cards to digital wallets, contactless payments, and BNPL schemes. Fintech innovations simplify, speed up, and secure transactions while enhancing user satisfaction (Johnson, Rodwell, & Hendry, 2021). BNPL, offered by fintech companies as a payment option in online stores, allows consumers to receive products first and pay later—either in a single payment or interest-free installments (Guttman-Kenney et al., 2023). Unlike credit cards that require hard credit checks, BNPL generally requires only a soft credit check with fast approval, even for users with low credit scores (Hoo & Khee et al.,

2025). BNPL's easy registration and flexibility make it attractive compared to conventional credit (Relja et al., 2024).

Impulse Buying

Impulse buying is an unplanned purchase driven by a sudden urge to buy quickly, without careful consideration (Andriany & Arda, 2019). It is a pre-conscious decision not formed before entering the store (Wahyuni & Rachmawati, 2018). Consumers make purchases without determining product category or brand in advance (Lee & Chen, 2021).

Hedonic Motivation

Hedonic shopping motivation refers to shopping for pleasure and interest rather than practical benefits (Utami, 2018). According to Ozen and Engizek (2014), it includes seeking unique items, following trends, mood changes, and engaging with brands. Higher hedonic motivation increases impulsive buying since the behavior reflects lifestyle choices about time and money spent on shopping.

According to (Hilmi & Pratika, 2021a), cardless online credit systems make online shopping more appealing. The simple and fast process allows for faster payment transactions. Naturally, this ease and convenience leads to higher consumer purchase rates and can lead to impulse purchases. (Zahra, 2022) also noted that pay later features on online shopping apps or e-commerce platforms increase impulsive shopping behavior.

While BNPL offers convenience and comfort, it also raises concerns because it can trigger irrational financial decisions, particularly when impulsive impulses dominate the shopping process (Frigerio et al., 2020). The desire for immediate gratification often leads consumers to choose credit options like BNPL without considering the long-term impact. Research conducted by (Hilmi & Pratika, 2021b; Sari & Hermawati, 2020) shows that the paylater feature on e-commerce apps or platforms increases the rate of impulsive purchases.

The Influence of Hedonic Motivation on Buy Now Pay Later (BNPL) Usage

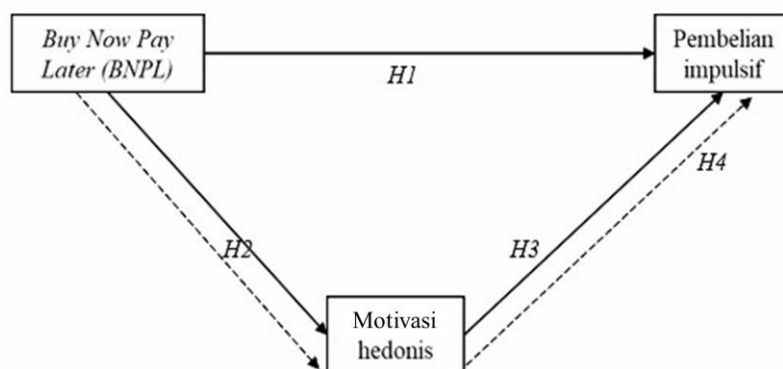
In the context of e-commerce, hedonic motivation is one of the main factors driving individuals to make impulsive purchases (Nurtanio et al., 2022). Consumers with a hedonic shopping lifestyle tend to be more susceptible to the temptation of promotions, ease of access, and features like BNPL that reduce immediate financial barriers (Wahyuni & Rachmawati, 2018). Hedonic behavior plays a crucial role in encouraging BNPL usage, particularly in the context of impulse buying and overconsumption (Susanto et al., 2024). BNPL provides convenience and flexibility, allowing consumers to fulfill their shopping desires without having to pay immediately, which can ultimately increase financial risk if not managed properly (Fihartini et al., 2024). BNPL functions not only as a means of payment but also as a means to fulfill the emotional and psychological needs of consumers with hedonic motivations (Riztika et al., 2025).

The Influence of Hedonic Motivation on Impulse Buying

Research by Aman et al. (2023) and Susanto et al. (2024) shows that hedonic shopping motivations including adventure, idea, value, and relaxation shopping positively influence impulse buying on Shopee.co.id. Adventure shopping fuels pleasure and enthusiasm, increasing impulsive purchases. Following trends (idea shopping) also raises impulsivity. Previous studies confirm hedonic motivation's positive effect on impulsive buying (Gawior et al., 2022). Ustanti (2018) highlighted that hedonic shopping lifestyles significantly shape middle-class shopping attitudes. Zheng et al. (2019) found hedonic motivation a key predictor of impulsive behavior in the digital era, where emotional satisfaction often outweighs rational thought.

Hedonic Motivation as a Mediator Between BNPL Use and Impulse Buying

BNPL creates convenience and financial accessibility, reducing psychological shopping barriers. This freedom boosts emotional drive and enjoyment, making hedonic motivation a mediating factor explaining how BNPL promotes impulsive buying. Mavilinda (2020) found hedonic motivation significantly influences product search and impulsive buying of fashion items on Instagram; higher hedonic motivation increases product search, which in turn raises impulse buying likelihood. Barokah et al. (2021) revealed that while lifestyle and hedonic motivation influence emotional shopping, only hedonic motivation and emotional shopping significantly affect impulsive buying. Emotional shopping did not mediate between lifestyle and hedonic motivation on impulse buying. Alghamdi & Alharthi (2024) showed hedonic motivation encourages BNPL use to enhance enjoyable, hassle-free shopping experiences, with Shopee PayLater motivating hedonic consumers toward impulsive purchases.



Hypothesis

Based on Figure 3 above, the following hypotheses are proposed:

- H1: The use of Buy Now Pay Later (BNPL) has a positive and significant effect on impulse buying.
- H2: The use of Buy Now Pay Later (BNPL) has a positive and significant effect on hedonic motivation.
- H3: Hedonic motivation has a positive and significant effect on impulse buying.
- H4: Hedonic motivation has a positive and significant effect in mediating the influence of Buy Now Pay Later (BNPL) use on impulse buying.

Research Methods

This research was conducted using a quantitative approach with a survey method to examine the relationship between Buy Now Pay Later (BNPL) and hedonic motivation, and impulsive buying. This study aims to understand the influence of Buy Now Pay Later (BNPL) usage among Shopee consumers on impulsive buying behavior, with hedonic motivation as a mediating variable.

The population of this study was users of the Buy Now Pay Later feature on the Shopee app in the Greater Jakarta (Jabodetabek) and West Java regions. The sample in this study was selected using a purposive sampling method. Purposive sampling, according to Schindler (2022), is the selection of a sample using specific criteria tailored to the research objectives. If the sample does not meet the criteria, it will be disqualified. The criteria were as follows:

- 1) Users of the Buy Now Pay Later feature on the Shopee app and have made Shopee Paylater transactions
- 2) Residing in the Greater Jakarta and Bandung areas
- 3) Aged 18–40 years

This study used a 5-point Likert scale with responses ranging from strongly disagree to strongly agree. The questionnaire, using a Google Form, was distributed online to respondents. Data was collected based on the scores of respondents' answers. Therefore, survey data conducted using a questionnaire constitutes primary data, meaning data recorded in advance and obtained directly from the original source for a specific purpose.

Statistical analysis is a method that utilizes statistical techniques to test hypotheses formulated in a study. In this study, the analysis process was conducted using SmartPLS software, using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) approach. SEM-PLS is a multivariate statistical analysis technique used to assess the relationship between latent variables, both those that can be measured directly and indirectly. This technique is highly suitable for exploratory research, using complex constructs, and does not require the assumption of normal data distribution or large sample sizes (Ghozali & Latan, 2012).

Hypothesis testing in this study was conducted through statistical analysis using t-tests and significance values. A hypothesis is considered significant if the t-value is > 1.96 and the p-value is < 0.05 . The hypotheses tested in this study are:

- H1: The use of Buy Now Pay Later (BNPL) has a positive and significant effect on impulse buying.
- H2: The use of Buy Now Pay Later (BNPL) has a positive and significant effect on hedonic motivation.
- H3: Hedonic motivation has a positive and significant effect on impulse buying.

The mediation hypothesis was tested by observing the indirect relationship between BNPL use and impulse buying behavior through hedonic motivation as a mediator variable. This test was conducted using a bootstrapping approach in SEM-PLS. A t-value above 1.96 or a significance value below 0.05 indicates a significant mediation effect. In this context, if hedonic motivation

significantly mediates the effect of BNPL on impulse buying, then hypothesis H4 can be accepted. The hypotheses tested are:

- H4: Hedonic motivation acts as a significant mediator in the influence of BNPL use on impulse buying.

Research Results and Discussion

The majority of respondents in this study were female, with 130 respondents, or 62.8% of the total. Meanwhile, 77 respondents were male, or 37.2%. This indicates that the majority of Shopee PayLater users in this study were female.

The most dominant age group of respondents was in the 24–29 age range, comprising 158 respondents, or 76.3% of the total. Furthermore, 24 respondents (11.6%) were aged 18–23, 20 (9.7%) were aged 30–35, and only 5 (2.4%) were aged 36–40.

The majority of respondents (118, or 57%) resided in the Greater Jakarta area, while the remaining 89 (43%) resided in Bandung.

All respondents (100%) in this study were active Shopee app users. This was a primary requirement for data collection, given that the research focused on consumer purchasing behavior using the Shopee PayLater feature.

All respondents had also made transactions using the Shopee PayLater feature. This number represents 100% of respondents, strengthening the validity of the data, as all participants had direct experience using this payment method.

The majority of respondents, 139 people (67.1%), used Shopee PayLater once a month. Meanwhile, 68 people (32.9%) stated they used this feature more than once a month. This data indicates a habit of routinely using the PayLater feature among respondents.

In this study, the analysis process was conducted using SmartPLS software, using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) approach. SEM-PLS is a multivariate statistical analysis technique used to assess the relationship between latent variables, both directly and indirectly measurable (Ghozali & Latan, 2012). PLS estimation is performed through three iterative stages: first, weight estimation to generate latent variable scores; second, estimation of the structural model (inner model) and measurement model (outer model); and third, estimation of the mean and location values (regression constants). The research model created is as follows:

Table 1: Convergent Validity

	BNPL	HM	IB
BNPL_01	0,875		
BNPL_02	0,870		
BNPL_03	0,804		
BNPL_04	0,888		
BNPL_05	0,817		
BNPL_06	0,782		

BNPL_07	0,795	
BNPL_08	0,832	
BNPL_09	0,808	
HM_20		0,874
HM_21		0,879
HM_22		0,746
HM_23		0,859
HM_24		0,856
HM_25		0,793
HM_26		0,784
HM_27		0,856
HM_28		0,827
HM_29		0,793
IB_10		0,903
IB_11		0,878
IB_12		0,799
IB_13		0,743
IB_14		0,878
IB_15		0,900
IB_16		0,842
IB_17		0,921
IB_18		0,893
IB_19		0,851

Source: Data Analysis Results (2025)

Based on the test results, all indicators in the Buy Now Pay Later (BNPL) variable have loading factor values above 0.70, with a value range between 0.782 and 0.888. This indicates that each indicator is able to represent the BNPL construct well. Likewise, the hedonic motivation (HM) variable, where all indicators show valid values, ranging from 0.746 to 0.879, so it can be concluded that the indicators in the HM construct also have strong convergent validity. Meanwhile, in the impulse buying (IB) variable, all indicators show very high loading factor values, ranging from 0.743 to 0.921. The highest value is found in indicator IB_17 at 0.921, while the lowest value is in IB_13 at 0.743—still in the valid category. Thus, all indicators in the three constructs (BNPL, HM, and IB) have met the requirements for convergent validity, as none of the loading values fall below the minimum threshold of 0.70.

Table 2: Discriminant Validity

Pengujian	AVE
BNPL	0,690
Hedonic Motivation	0,671
Impulse Buying	0,744

Source: Data Analysis Results (2025)

Based on the test results, the AVE values for each construct are as follows: BNPL at 0.690, hedonic motivation at 0.671, and impulse buying at 0.744. All three values exceed the minimum threshold of 0.50, indicating that each construct has adequate convergent validity and the ability to explain the variance of its indicators.

Table 3: Reliability Test

Pengujian	Cronbach's Alpha	Composite Reliability
BNPL	0,944	0,946
Hedonic Motivation	0,946	0,952
Impulse Buying	0,961	0,962

Source: Data Analysis Results (2025)

Based on the test results, the Cronbach's Alpha value for the Buy Now Pay Later (BNPL) construct was 0.944, for hedonic motivation it was 0.946, and for impulsive buying it was 0.961.

Composite Reliability (CR) was also used as an alternative measure to test internal reliability, which is considered more accurate in the context of Structural Equation Modeling (SEM) analysis because it takes into account indicator weights. Similar to Cronbach's Alpha, a Composite Reliability value above 0.70 indicates good construct reliability. The test results showed that the CR value for the BNPL construct was 0.946, for hedonic motivation it was 0.952, and for impulsive buying it was 0.962. Thus, all constructs met the requirements for composite reliability, meaning that the indicators within each variable have a stable and reliable contribution in explaining the construct.

Table 4: R-square test

Pengujian	R-square	R-square adjusted
hedonic motivation	0,821	0,819
impulse buying	0,909	0,907

Source: Data Analysis Results (2025)

Hypothesis

The hypothesis testing in this study was conducted using statistical analysis using t-test values and significance values. A hypothesis is considered significant if the t-test value is > 1.96 and the p-value is < 0.05 . The hypotheses tested in this study are:

- H1: The use of Buy Now Pay Later (BNPL) has a positive and significant effect on impulse buying.
- H2: The use of Buy Now Pay Later (BNPL) has a positive and significant effect on hedonic motivation.
- H3: Hedonic motivation has a positive and significant effect on impulse buying.

Table 5: Hypothesis Testing

Pengujian	Koefisien	t-statistics	p-value
The Effect of Buy Now Pay Later (BNPL) on Impulse Buying	0,454	6,734	0,000
The Effect of Buy Now Pay Later (BNPL) on Hedonic Motivation	0,906	45,224	0,000
The Effect of Hedonic Motivation on Impulse Buying	0,523	7,757	0,000

Source: Data Analysis Results (2025)

The results of this hypothesis test are as follows:

- The first hypothesis (H1) in this study examines whether the use of the Buy Now Pay Later (BNPL) feature has a positive and significant effect on consumer impulse buying behavior. To test this hypothesis, t-statistics and p-values were used, with the criteria that the hypothesis is considered significant if the calculated t-value is > 1.96 and the p-value is < 0.05 . Based on the test results, the t-statistic was 6.734 and the p-value was 0.000. These values meet the significance criteria, so hypothesis H1 is accepted. This positive effect indicates that the more frequently consumers use the BNPL feature, the higher their tendency to make impulse purchases. The magnitude of the effect can be seen from the regression coefficient of 0.454, meaning that BNPL use contributes 45.4% to changes in consumer impulse buying behavior.
- The second hypothesis (H2) examines the effect of BNPL use on consumer hedonic motivation. The analysis showed a t-statistic of 45.224 with a p-value of 0.000, indicating that the effect of BNPL on hedonic motivation is statistically significant. Therefore, hypothesis H2 is accepted. This positive effect indicates that the more frequently consumers use BNPL, the higher their hedonic motivation when shopping. A coefficient of 0.906 indicates that BNPL contributes 90.6% to influencing consumer hedonic motivation.
- The third hypothesis (H3) examined whether hedonic motivation has a positive and significant effect on impulse buying. The test results showed a t-statistic of 7.757 with a p-value of 0.000, which meets the criteria for significance. Thus, hypothesis H3 is accepted. This positive effect means that increasing consumer hedonic motivation will increase impulsive buying behavior. The coefficient of 0.523 indicates that hedonic motivation contributes 52.3% to impulsive buying behavior among Shopee consumers.

Table 6: Mediation Hypothesis Test

Pengujian	Koefisien	t-statistics	p-value
The effect of BNPL usage on impulsive purchases mediated by hedonic motivation	0,474	7,976	0,000

Source: Data Analysis Results (2025)

The test results show that the t-statistic for the effect of BNPL use on impulse buying, mediated by hedonic motivation, is 7.976, with a p-value of 0.000. This value clearly exceeds the specified criteria, thus concluding that the mediation effect is statistically significant. Therefore, hypothesis H4 is accepted. This means that hedonic motivation significantly mediates the relationship between BNPL use and impulsive buying behavior. This mediation effect is positive, indicating that BNPL use increases consumers' hedonic motivation, which in turn drives impulsive buying behavior. The mediation coefficient of 0.474 indicates that approximately 47.4% of BNPL's effect on impulse buying occurs through hedonic motivation as a mediator.

Conclusion and Suggestions

Conclusion

This study proves that

1. Buy now pay later (BNPL) use has a positive and significant effect on impulsive buying behavior among Shopee consumers.
2. BNPL use also significantly increases consumers' hedonic shopping motivation.
3. Hedonic motivation itself has been shown to play an important role and has a significant positive influence on impulsive buying behavior.
4. Hedonic motivation functions as a significant mediator in the relationship between BNPL use and impulsive buying. There is a direct effect of 0.454 and an indirect effect of 0.474, indicating full mediation, where BNPL use influences impulsive buying.

Practical Implications

1. Selecting Market Segmentation: Conducting more specific market segmentation to increase the effectiveness of marketing and sales strategies. One relevant approach is to target consumer segments with high hedonic motivation, namely consumers who tend to make purchases for pleasure, positive emotions, and enjoyable experiences. These segments include women, young people, and those with jobs that can finance purchases.
2. Companies must be able to encourage a more satisfying shopping experience, where consumers are required to pay in full immediately, which triggers emotional drives and hedonic motivation in shopping, thereby increasing consumer satisfaction
3. It is important for Shopee to provide clear education about BNPL usage so that consumers remain wise in managing their finances, avoid going over their limit, and maintain their personal financial health.
4. Shopee can utilize BNPL usage data to analyze impulse buying behavior and make product recommendations tailored to consumer characteristics, thus making impulse purchases more manageable and profitable.
5. Encourage consumers to continue using BNPL by offering special rewards or cashback that can strengthen emotional bonds and hedonic motivations in shopping.

Recommendations

1. Future researchers should expand the number of respondents so that research results are more representative and reflect consumer behavior more broadly.
2. Focus not only on a single e-commerce platform, but also include several similar brands or applications to obtain a more comprehensive picture of the influence of Buy Now Pay Later (BNPL) across the now-diverse digital ecosystem and applications.
3. Future researchers can consider including additional relevant variables, such as other psychological factors, demographic characteristics, or socioeconomic aspects, to deepen their understanding of impulse buying behavior and consumer hedonic motivations.

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A PEDAGOGICAL AND VOCATIONAL REHABILITATION PROJECT AT A HIGHER EDUCATION INSTITUTION

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Abstract: Vocational rehabilitation is designed to promote the qualification and inclusion in the labor market. Several countries have implemented state programs to support both people with disabilities and employers. The education system, including higher education, cannot remain on the sidelines of this reality, bearing in mind that employability is an aim of training, which is critical in Students with Specific Educational Needs (SSEN). This research analysed the implementation of a seven-month funded project to support SSEN (with hearing, visual and mental health limitations) at a Portuguese Higher Education Institution (HEI). Five students, still attending degrees or recently graduated, benefited from employability support sessions combined with psycho-pedagogical support, focused on interests and life projects, the development of personal and social skills, and connection with the community (employment entities). Therefore, the direct intervention (by a psychologist and a social educator) included, above all, career counselling, developing self-knowledge, searching for job offers and preparing for applications (e.g., CV preparation), culminating in the creation of a theoretical-practical employability support manual in accessible formats. Public and private entities were also contacted and made aware of the situation, professional rehabilitation services were publicized (e.g., digital flyer) and socio-professional opportunities were created. According to case follow-up and satisfaction questionnaires, the majority significantly valued the support of the project: they were very satisfied (n=4)/ satisfied (n=1) according to the objectives; and considered it indispensable (n=3)/ reported that was very important (n=2) that it continues. It should be noted that transition to working life/employability, as well as guaranteeing financial autonomy, has an impact on all life dimensions, promoting also social inclusion. Projects in this area, with joint responsibility of HEI and employers, are crucial, but more resources (human, technical and financial) must be guaranteed, and the continuity and scope of the initiatives must be ensured.

Keywords: Vocational Rehabilitation, Students with Specific Educational Needs (SSEN), Higher Education, Labor Inclusion

Introduction

Training for working life must go across different age groups, with particular emphasis on secondary and higher education, the stages preceding into the job market. For Students with Specific Educational Needs (SEN), there are additional demands, clearly expressed in their high unemployment rates. Vocational rehabilitation is designed to promote the qualification and inclusion in the labor market. Several countries have implemented state programs to support both people with disabilities and employers (Fundación ONCE & ILO Global Business and Disability Network, 2019; Institute for Employment and Vocational Training, 2025).

The inclusive employability began as a matter of charity and has become, in recent decades, a question of solidarity. However, it should be understood in the sense of using this population full potential and, more than that, it is still necessary to affirm it as a demand of citizenship – totally aligned with the 2030 Agenda for Sustainable Development (United Nations [UN], 2015). Today we are witnessing an evolution in social and employment policies aimed at the group of citizens with specific needs (disability), reflected in the expansion of employability opportunities, but it is not enough. International, and national (Portugal), legislative changes regarding professional inclusion and the people with disability rights, with incentives for hiring and adapting to the job – modalities, such as supported employment, inclusive employer branding, support products attribution and job quotas (Institute for Employment and Vocational Training, 2025) –, are fundamental to create the conditions for promoting good practices and make a difference.

Given the impact on the quality of life and social inclusion, employability is, already, a main concern of some Higher Education Institutions (HEI). The aim of this work is to explore the impact of employability support for SEN, as part of a funded project, developed at a HEI in central Portugal, between January and July 2023. The general objective was promoting the well-being, academic success, autonomy and development of skills that facilitate the academic and professional inclusion of SEN. As might be expected, given the specific characteristics around employability (mainly sought out by students in the final year of their degree) and the possible greater difficulties inherent in the process of adapting to higher education (first year students), most of the activities centred on the psycho-pedagogical area (74%) (e.g., define measures to support learning; help with academic works and study methods). The experiences reported here do, however, refer to employability cases (26%).

Literature Review

Transition to the Job Market in Students with Specific Educational Needs

Technical and Vocational Education and Training (TVET) links education and the work world, unlocking the potential of young people and adults for a better future. However, around 267 million young people are not in employment, education or training (United Nations Educational, Scientific and Cultural Organization [UNESCO, 2022]).

Equally worrying is the data pointing that about 16% of the world's population, about 1.3 billion people, currently experience significant disability (World Health Organization [WHO], 2024). In the EU in particular, approximately 100 million people have some disability, with devastating consequences. The European Commission (2024) indicates that only half of people with disabilities have a job (a scenario that differs from people without disabilities, given that

3 out of 4 people are employed); 28.4% of people with disabilities are at risk of poverty or social exclusion (vs. 17.8%); only 29.4% (vs. 43.8%) complete a higher education degree; and 52% feel discriminated in this scope.

In Portugal, remains a significant difference between the employment rates of people with disabilities (65%) – with additional barriers in women – and people without disabilities (79.7%), although this has decreased over the years. Similarly, unemployment among people with disabilities (14.7%) continues to be higher than that among people without disabilities (9.1%). Reference entities in the country have identified that there is also no significant increase in the hiring of this population (7% of placements of people registered as unemployed in 2024); and a low prevalence of workers with disabilities in the private sector (0.72% in companies with more than 10 employees) and in the public sector (3.2%), but with reports of gradual increases. Related to the risk of poverty or social exclusion the data shows consistently higher in the households of people with disabilities, worsening with the severity of the disability. There has been a decrease (in 2023) in complaints of discrimination on the disability or aggravated health risk, but this may indicate not an improvement instead a loss of confidence in the existing mechanisms (Observatory of Disability and Human Rights, 2024).

In this sense, the transition to the job market is a crucial stage in the construction of this group's life project, and training institutions must play an active role in supporting future professionals in this developmental task and in the career/rehabilitation counselling. In fact, there is a strategy in Portugal (National Strategy for the Inclusion of Persons with Disabilities 2021-2025), in accordance with Principles of the European Pillar of Social Rights, that advocates everyone should find answers to access qualification levels that facilitate social inclusion. It is not too much to emphasize that, with appropriate methodologies, inclusion also in higher education is possible, which has a positive impact on improving employability (Machado et al., 2020). So, the strategy seeks to ensure the rights of SSEN with regard to equal opportunities (including gender equality) and access to the labor market, promoting the individuality, self-determination, dignity and inclusion.

These issues have been, already, addressed over time in other important documents, like the Convention on the Rights of Persons with Disabilities (UN, 2006) – Article 27, which refers «the right of people with disabilities to work, on an equal basis with others [...] in a labor market and work environment that is open, inclusive and accessible to people with disabilities»; and the 2030 Agenda for Sustainable Development (UN, 2015), already mentioned, which particularly includes the goal 8 – decent work and economic growth. It should be noted that there are several studies (e.g., Rahim et al., 2024) proving the relationship between decent work and well-being, mediated by work engagement of people with disabilities.

Social Responsibility and Inclusion in the Job Market

Summarily, there is still a strong prevalence of workplace ableism/discrimination among young people and young adults with disabilities, which demands for research and effective solutions, to reduce barriers and improve facilitators, in attitudes, knowledge, awareness and accessibility, that is comprehensive and integrated policies (Atobatele & Okonkwo, 2024; Breaz, 2020; Lindsay et al., 2023; Morris et al., 2024; Nevala et al., 2019; Observatory of Disability and Human Rights, 2024; Ramos, 2022; UNESCO, 2022).

In fact, as part of a company's sustainability or social responsibility strategy, a comprehensive approach must be adopted with regard to people with disabilities (Fundación ONCE & ILO Global Business and Disability Network, 2019). The management of diversity and inclusion in the workplace is also a factor for organizations staying competitive (Singh, 2023).

This implies that both society and the workplace must be more responsible for inclusion, ensuring equal conditions and participation in the labor market, while fighting against discrimination. Thus, we will work towards promoting quality jobs and incomes that allow for a dignified and independent life. We mustn't forget that having a job provides personal value and a sense of usefulness, particularly for people with disabilities. Therefore, in addition to employers should be made aware of the skills and limitations of people with disabilities, the development of tailored training and adapting roles to the type of disability is essential, as well as promoting health in the workplace, including preventive measures and ergonomics. The use of technologies, including telecommuting, can also be a beneficial factor for inclusion (Ramos, 2022).

So, companies, with empathy, companionship, mutual help and adaptation, need to be well informed and understand that they should hire people on the basis of their abilities, the real need for their services (not out of charity or assistance) and the contribution to the organization. Add that stakeholders (including the State) have only an effective role if there is collaboration and partnership between everyone, in order to a more inclusive future (Gomes et al., 2022).

We analysed the implementation of a funded project for SSEN, in an HEI with other practices in this scope (e.g., an office for SSEN and another to support employability).

Methodology

An exploratory qualitative study was carried out with 5 final-year SSEN/recent graduates from a HEI in central Portugal, mostly female (only one male), with specific needs such as deafness (2 cases), visual impairment (1), and mental health problems (2).

Of the 5 cases, 2 were still studying for a bachelor's degree and 3 were already graduates (1 unemployed, 1 studying in a master's degree and 1 already covered by a supported employment measure, but with imminent end) - the predominant area of training was in social sciences, except for 1 engineering student, the only one attending another School, even belonging to the same institution.

The work carried out began with an assessment of the students' personal and social functioning profile, based on an interview and the use of standardized instruments (skills and professional vocation). Observation and follow-up records/reports were also used (based on regular support sessions), as well as feedback from students (also include a satisfaction questionnaire) and professors. Throughout the process, ethical requirements were guaranteed, including informed consent.

Results and Discussion

From the project implementation, between January and July 2023, the students' demand for the support provided stands out, in conjunction with existing services at the institution (office for SSEN and another to support employability) and referral by professors.

The work carried out fundamentally included individualized psycho-pedagogical support sessions (psychology and social education), focused on interests and life projects and on strengthening socio-personal skills, empowering active job search and access to the job market, with the students' accompanying, and contacts with community organizations were also covered.

The intervention developed resulted in: i) awareness of organizations/companies for the employment of people with disabilities, including information on legislation and services to support hiring (e.g., digital flyer; when necessary, was sent a report for the employer, with the consent of the person being supported); ii) career/rehabilitation counselling, developing self-knowledge and active job search skills (e.g., help with curriculum and cover letters; searching for employment opportunities; contacts with potential employers/networking; preparing for job interviews), monitoring all the process; iii) creation of a theoretical-practical employability support manual (physical and online available in the institutional repository - for audio reading -, as well as a braille version); iv) paid socio-professional experience; v) direct contact with company managers (for a visit and possible internship); and vi) contact with a City Hall to pursue a supported employment measure.

It is worth noting the success, despite the short duration of the project, in responding to all requests made by students, in conjunction with the existing services at the institution (SSEN office and another to support employability) and the referrals made by professors. Some cases followed had not yet finished their studies, so it was also well-succeed in a preventive scope.

The results are also positive in terms of students' perceptions. The instrument used evaluates parameters such as the ease of scheduling sessions, the availability of the professionals, the importance of the support in terms of the objectives and the relevance of its continuity, on a scale of 0 to 4 (where 0 corresponds to not at all satisfied and 4 to very satisfied), with the exception of the last topic, on a scale of 0 to 5 (where 0 corresponds to not at all important and 5 to indispensable).

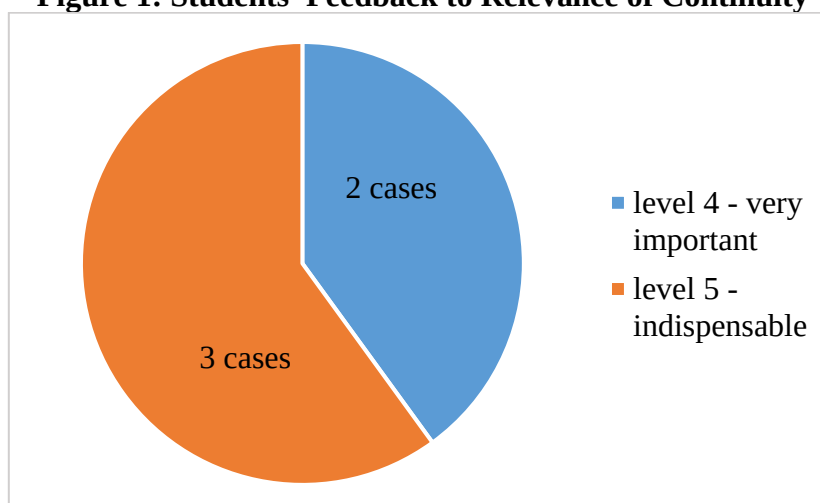
According to case follow-up and satisfaction questionnaires (Table), the majority students significantly valued the support of the project: they were very satisfied (n=4)/ satisfied (n=1) according to the objectives (also with socio-professional experience, when it applies); and considered it indispensable (n=3)/ reported that was very important (n=2) that it continues, which was not possible due the end of the project financial support. In an open space to comments/suggestions, these issues were also emphasized, as were the difficulties overcome, and it was even mentioned that other students should be able to benefit from this opportunity. They also suggested the presence of professionals from the different training areas concerned to share testimonies and network.

Table 1: Students' Satisfaction with the Support

Student	Ease of scheduling (0-4)	Availability of professionals (0-4)	Importance of the support (0-4)
A	4	4	4
B	4	4	4
C	4	4	4
D	4	4	3
E	3	3	4

Source: Table by the Authors

Figure 1: Students' Feedback to Relevance of Continuity



Source: Figure by the Authors

Therefore, the protocol articulation of this service in a HEI with community partners was fundamental, facilitating the promotion of socio-professional experiences that result in working conditions adapted to the needs of these graduates, ensuring their personal and professional fulfillment, fair earnings, and a dignified life, as outlined in the previously stated principles.

In consensus with the literature, a systematic review on the effectiveness of rehabilitation interventions for people with intellectual disabilities, focused on employment, transition to the labor market and functioning, facilitators indicated were secondary education with work experience and personal support services, supported employment (while sheltered work did not have this effect), job coaching, an adapted work environment, as well as family and business support. The barriers highlighted were discrimination in work experience, the use of classroom teaching and the lack of work experience during schooling (Nevala et al., 2019).

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About career counselling, another analysis highlighted its crucial role in overcoming the barriers faced by people with disabilities in the labor market, in the sense that personalised interventions improve skills, self-sufficiency and independence. Vocational guidance in these cases goes far beyond traditional career counselling and must be combined with the policies that guarantee the creation of accessible and inclusive environments (also harnessing the

potential of technology). This is a necessary transformation that allows people with disabilities to be celebrated for their unique contribution (Atobatele & Okonkwo, 2024).

In a study conducted with 30 people with disabilities (of various types), who participated in a 3-week professional counselling program, six months later, they were questioned about job satisfaction, relationships with colleagues and superiors, and about the quality of services provided (by a social worker). The results indicated that most of participants had a positive evaluation of the program and believe that, without it, they would remain unemployed (Breaz, 2020).

In this context, the relevance of creating proximity services to support the transition to the labor market is added, which do not replace public initiatives, but allow for a personalized, complementary, and tailored intervention to the needs of these students/young people/adults.

Conclusion

Employability issues are sensitive to the general community. In people with disabilities, not having a job becomes an added factor of social marginalization and economic exclusion, that urgently needs to be improved on the path to equity. It is essential to prepare these young people for the transition to the job market, which involves, in addition to academic training, the development of personal and social skills and awareness-raising and liaison with employers and society in general. Working conditions must be dignified and that depends on all of us.

The project under analysis demonstrated that, with relevant and integrated/collaborative measures, hopeful results for the future are possible. The aim of accompanying the SSEN in their transition to working life was achieved, with training strategies that facilitated structural and solid self-transformation. It should be emphasized that HEI, working collaboratively and in a network with employers, have an important role for a more informed, equitable and inclusive society.

These projects are essential, especially as a test for structural and lasting measures, otherwise they will create needs and expectations that will be quickly frustrated. More resources (human, technical and financial) must be guaranteed, and the continuity and scope of the initiatives must be ensured.

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STRATEGIC ALIGNMENT OF TVET POLICY AND WORK-BASED LEARNING TO FOSTER IR4.0 TALENT IN MALAYSIA: A CRITICAL REVIEW

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Abstract: *The Fourth Industrial Revolution (IR4.0) has altered global labour markets, necessitating education systems to cultivate future-ready individuals proficient in sophisticated technological and digital competencies. In Malaysia, the Technical and Vocational Education and Training (TVET) system, supported by policy frameworks like the Twelfth Malaysia Plan and Dasar TVET Negara 2030, has established Work-Based Learning (WBL) as a strategic approach to align education with industry requirements. This critical analysis assesses the degree to which Malaysia's TVET and WBL policies correspond with IR4.0 imperatives, incorporating comparative insights from international models, such as those of Germany, Singapore, South Korea, and Finland. The investigation reveals systemic deficiencies in institutional autonomy, fragmented governance, restricted industrial co-ownership, and inadequate performance monitoring. Notwithstanding robust policy aspirations, execution is hindered by insufficient financial allocation and superficial engagement between business and academia. The study finishes with policy recommendations highlighting modular curriculum, enhanced stakeholder participation, and data-driven program improvement to ensure effective talent development. The review enhances the discussion on TVET transformation by offering a multi-tiered methodology to assess policy coherence, operational preparedness, and global competitiveness within the context of IR4.0.*

Keywords: *TVET, Work-Based Learning, IR4.0, Talent Development, Industry Collaboration*

Introduction

The emergence of the Fourth Industrial Revolution (IR4.0) has significantly altered economies through the introduction of revolutionary technologies, including artificial intelligence (AI), cyber-physical systems, the Internet of Things (IoT), and advanced robots. These technological changes require a similarly profound adjustment in how nations equip their workforces, particularly through educational and skills development frameworks. The strategic convergence of education policy, worker training, and IR4.0 preparation has become essential to national competitiveness (World Economic Forum, 2020; Schwab, 2017).

Malaysia's answer to this dilemma is predominantly located within its Technical and Vocational Education and Training (TVET) framework, which is progressively regarded as a means for talent cultivation. The nation has implemented several policies, including the Twelfth Malaysia Plan and the National TVET Policy 2030, which prioritise Work-Based Learning (WBL), digitalisation, and industrial partnership (EPU, 2021; MOHE, 2022). Recent critiques suggest that these reforms frequently emphasise policy aspirations while neglecting institutional capacity, funding sustainability, and systemic coherence (Chettiar, 2017; Grech & Camilleri, 2020).

Unlike countries like Germany and Singapore, where TVET is integrated into national innovation plans and bolstered by robust industry collaborations, Malaysia has challenges due to fragmented governance and inconsistent execution (Paryono & Mashod, 2025). Consequently, whereas TVET and WBL are conceptually congruent with IR4.0 mandates, the implementation from policy to practice is inconsistent. This article conducts a critical analysis of Malaysia's alignment of TVET policy and WBL procedures in cultivating talent prepared for IR4.0, offering comparative insights from international models and pinpointing structural deficiencies that require rectification for successful implementation.

The Connection between Educational Policy, Industry 4.0, and Workforce Development

In the era of Industry 4.0, education policy must transcend mere knowledge transmission and actively cultivate workforce preparedness for intricate, technology-integrated workplaces. Countries at the forefront of innovation, such as Germany, Singapore, and Finland, exemplify that successful education systems are characterised by policies that serve as both enablers and integrators of skills, technology, and economic foresight (OECD, 2021; Paryono, 2022). These methods facilitate precise alignment among national priorities, industry requirements, and institutional norms, yielding uninterrupted talent streams into forward-looking sectors.

The educational policy framework in Malaysia has progressed through initiatives like the Malaysia Education Blueprint (Higher Education) and the Twelfth Malaysia Plan, which seek to enhance TVET, integrate IR4.0 competences, and emphasise employability via digitalisation and Work-Based Learning (EPU, 2021; MOHE, 2022). Nonetheless, critiques by Chettiar (2017) and Mazlan et al. (2025) highlight persistent deficiencies: mismatched curriculum frameworks, inadequate policy implementation at the institutional level, and absence of outcome-based accountability systems. These constraints impede the efficacy of TVET in accomplishing its strategic function.

Furthermore, a study by Banga & te Velde (2019) on developing countries underscores that education institutions frequently remain disconnected from industrial development due to antiquated pedagogies and fragmented policymaking. In Malaysia, the gap between policy formulation and institutional response persists as a significant issue, despite clearly defined blueprints (Grech & Camilleri, 2020; Singh, 2023). In contrast to Germany's model, which involves collaboration with chambers of commerce and industry associations in policy formulation, Malaysian TVET institutions frequently function under top-down mandates, possessing less autonomy in curriculum development.



To cultivate IR4.0-ready talent, education policy must serve as both a framework and a systemic lever that actively connects pedagogy, technological integration, stakeholder collaboration, and lifelong learning paths. In the absence of this coherence, reforms are likely to be performative instead of transformative.

Policy Analysis: Alignment of Malaysian TVET with IR4.0

Malaysia has exhibited a robust policy-level dedication to integrating its TVET ecosystem with the demands of IR4.0. Essential instruments comprise the Malaysia Education Blueprint 2015–2025 (Higher Education), which underscores graduate employability and lifelong learning; the Twelfth Malaysia Plan, which focusses on the cultivation of digital talent and technical upskilling; and particularly, the Dasar TVET Negara 2030, which delineates six strategic thrusts, including governance reform, industry engagement, inclusivity, and curriculum digitalisation (EPU, 2021; MOHE, 2022).

These frameworks prioritise Work-Based Learning (WBL), promoting models such as 2u2i and 3u1i as methods for industry engagement and practical education. This theoretically positions Malaysia in a superior stance compared to other emerging nations, as it expressly incorporates future skills into TVET planning. Nonetheless, numerous studies indicate that the execution of these rules is inconsistent and structurally problematic. Chettiar (2017) contends that although Malaysian policy documents are well crafted, they frequently lack a definite implementation plan, particularly at the institutional level.

Grech & Camilleri (2020) offer a valuable comparison in analysing the EU's TVET digitalisation policy, which requires nations to monitor skills development metrics and revise curricula every 3–5 years according to labour market projections. Conversely, Malaysian universities frequently lack access to real-time data and do not implement formal curriculum reform cycles that correspond with industry feedback (Salleh, 2020; Mazlan et al., 2025). Ramli & Zakariah (2024) assert that despite the strong advocacy for WBL in policy, numerous institutions have difficulties in its implementation owing to budget limitations, ambiguous industry roles, and insufficient monitoring metrics.

The governance of Malaysian TVET is critically fragmented, distributed among numerous ministries (such as MOHE, MOHR, and MARA), resulting in overlaps in funding, accreditation, and strategic direction. This fragmented approach undermines the efficacy of national initiatives, unlike the cohesive approaches in Singapore or Korea, where Technical and Vocational Education and Training (TVET) is centrally managed by a singular, authoritative entity (Lee et al., 2022; Paryono & Mashod, 2025).

Consequently, although Malaysia's policy framework demonstrates a desire to align TVET with IR4.0, deficiencies in governance, industry collaboration, and institutional responsiveness present significant obstacles to achieving these objectives. Effective transformation necessitates a transition from prescriptive governance to adaptive, data-informed, and locally empowered policy execution.



Global TVET Practices and Alignment with Industry Revolution 4.0

Worldwide, numerous established and emerging nations have successfully incorporated IR4.0 components into their TVET systems through the strategic integration of policy formulation, industry engagement, and institutional independence. These models provide significant insights for Malaysia, serving both as exemplary practices and as comparative benchmarks to evaluate systemic deficiencies.

Germany's Dual Training System, esteemed as a benchmark, integrates vocational schools and industry via organised apprenticeship agreements, collaboratively developed curricula, and dual evaluation processes (OECD, 2021). The efficacy of this program is rooted in its legal and financial responsibility framework, wherein enterprises are mandated to offer apprenticeships, and chambers of commerce oversee content and quality standards. This system guarantees that graduates are prepared for the industry and reduces skills mismatch, a chronic problem in Malaysia (Mustapha & Hussain, 2021; Mazlan et al., 2025).

Singapore's SkillsFuture initiative implements a lifelong learning framework that allocates credits to residents for the acquisition of micro-credentials, stackable diplomas, or upskilling in Industry 4.0 sectors. It underscores institutional adaptability and learner autonomy, supported by centralised oversight by SkillsFuture Singapore (S. F. S. G., 2021). Conversely, Malaysia's work-based learning (WBL) programs are predominantly confined to linear pathways and currently lack support for personalised or modular learning trajectories, hence restricting their responsiveness to rapidly evolving industry demands (Lee et al., 2022; Singh, 2023).

Finland and South Korea prioritise research and development in vocational institutes. Finnish vocational institutions collaborate with local businesses to develop innovation hubs and formulate curricula centred on challenges (UNESCO-UNEVOC, 2020). Meister High Schools in South Korea synchronise vocational education with national industrial plans, bolstered by direct finance and equipment-sharing arrangements with companies (Paryono, 2022).

Japan, despite its traditional corporate culture, emphasises the cultivation of soft skills and the long-term integration of employees. Vocational schools are associated with employment assurances and cultural competence curricula, promoting loyalty and versatile skill sets among graduates (Yamada & Tanaka, 2021). This underscores a deficiency in Malaysia's system, which frequently overlooks post-placement assistance or institutional follow-up subsequent to WBL programs.

Notwithstanding their diversity, these models converge on some fundamental enablers: centralised governance, enduring industry collaborations, modular learning, and ongoing curriculum renewal informed by labour market analytics. According to Harikirishanan (2024), numerous Malaysian WBL relationships are frequently symbolic, articulated through memorandums of understanding (MoUs) lacking substantial operational collaboration. Implementing lessons from these international experiences necessitates not just the replication of policies but also the establishment of supportive ecosystems legal, financial, and cultural to facilitate their execution.

The Function of Malaysian Polytechnics in Policy Implementation

Malaysian polytechnics function as the operational nucleus of the national TVET system, responsible for converting strategic policy objectives, such as those articulated in the Dasar TVET Negara 2030 and Transformasi Politeknik 2023-2030, into concrete workforce results. In the last ten years, these schools have broadened their academic scope from predominantly providing diploma programs to incorporating bachelor's degrees and Asasi TVET (Foundation) programs (JPPKK, 2023; MOHE, 2022). These improvements signify a comprehensive policy transformation aimed at enhancing the status of TVET and facilitating upward mobility for technically proficient students.

Nonetheless, although these programmatic expansions correspond with national objectives, numerous studies indicate discrepancies between aspirations and institutional capacity. Ali, Rahman, and Karsidi (2024) assert that numerous polytechnics encounter challenges in integrating IR4.0-related curriculum owing to restricted access to sophisticated technologies, inadequately trained academic personnel, and rigid program certification standards. This indicates that while the strategic direction is robust, institutional implementation is hindered by structural and operational obstacles.

The implementation of TVET-Tahfiz programs, which integrate Quranic instruction with engineering or digital technologies, underscores Malaysia's effort to reconcile cultural and technical ambitions. However, these hybrid models have challenges related to scalability, standardisation, and sustainability. Singh's (2023) critique of India's polytechnic reforms similarly highlights issues of inadequate stakeholder participation and resource fragmentation, despite the presence of progressive national frameworks.

In contrast to nations such as Singapore, where Institutes of Technical Education (ITE) enjoy considerable autonomy, substantial funding, and direct collaboration with industry, Malaysian polytechnics are subject to stringent regulatory and bureaucratic limitations (Paryono & Mashod, 2025). This constrains their capacity to swiftly reinvent curricula, collaboratively design programs with business, or create adaptable modular courses that can address immediate labour demands.

Moreover, industry partnerships, although often lauded in government reports, tend to be based on memoranda of understanding rather than being operationally robust, lacking frameworks for collaborative curriculum development, joint credentialing, or co-supervision of students during work-based learning placements (Harikirishanan, 2024; Ramli & Zakariah, 2024). These superficial interactions diminish the efficacy of WBL in cultivating graduates prepared for IR4.0.

In conclusion, although Malaysian polytechnics have structurally aligned with IR4.0 objectives via program reform and WBL integration, their institutional readiness and operational autonomy are still constrained. To effectively implement policies, polytechnics necessitate enhanced strategic autonomy, increased resource allocation, and ongoing industry partnership integrated into governance and curriculum development.



The Significance of Work-Based Learning (WBL) and Collaboration between Industry and Universities

WBL has become fundamental to Malaysia's initiative to develop graduates equipped for Industry 4.0, especially through frameworks such as 2u2i (two years at university, two years in industry) and 3u1i (three years at university, one year in industry). These frameworks integrate practical industrial experience into academic curricula, with the objective of cultivating both technical and interpersonal abilities vital for advanced, digitally facilitated work settings (Mohd Yusof et al., 2020; Hanafi et al., 2023).

The Malaysian Qualifications Agency (MQA) offers a systematic quality assurance framework through its Good Practices: Work-Based Learning (GGP:WBL) guideline. It requires that WBL programs incorporate dual supervision (academic and industrial), explicit learning outcomes, and workplace-validated evaluations (MQA, 2016). This theoretically establishes a strong connection between institutions and employers. Ramli and Zakariah (2024) contend that numerous work-based learning arrangements are ad hoc and inadequately managed, with institutions frequently facing challenges in obtaining consistent and relevant employment that correspond with curricular objectives.

Comparative analyses substantiate these apprehensions. In Finland, work-based learning (WBL) is included not only into technical education but also into innovation ecosystems, where vocational students engage in challenge-based projects collaboratively planned with businesses (UNESCO-UNEVOC, 2020). This differs from Malaysian WBL, which frequently confines itself to observational or regular technical activities, devoid of the imaginative problem-solving element required by IR4.0 enterprises.

A significant constraint in Malaysia is the inadequate readiness of industry mentors. Harikirishanan (2024) discovered that numerous mentors lack pedagogical experience, and some perceive student interns as unproductive labour rather than prospective collaborators. This indicates a structural deficiency. WBL remains predominantly institution-led rather than driven by partnerships, exhibiting insufficient co-ownership by industry in program design, assessment, and feedback mechanisms.

Moreover, although Malaysia has prioritised graduate employability as a critical success metric, evidence indicates that the correlation between work-based learning exposure and long-term employment is inconsistent. Anthony et al. (2022) observe that while WBL graduates demonstrate superior soft skills and adaptability, the lack of post-placement tracking results in institutions lacking evidence on long-term workforce integration or performance.

Germany's Berufsausbildung system monitors apprentice outcomes for up to five years after graduation, guiding curriculum revisions and industry collaboration plans (OECD, 2021). In the absence of feedback mechanisms, Malaysian TVET institutions function in a data-deficient environment, undermining their capacity to enhance WBL plans based on results.

In summary, although WBL is crucial to Malaysia's TVET plan, its execution is hindered by inconsistent quality, inadequate industry engagement, and insufficient performance evaluation. For WBL to effectively facilitate IR4.0 talent development, it must transition from a peripheral

role to integrated, co-owned collaborations between academia and industry, underpinned by real-time data, mentor training, and innovation-oriented placement design.

Conclusion and Policy Recommendations

This review critically assesses the alignment of Malaysia's TVET policies and WBL strategies with the overarching goal of developing talent for Industry 4.0. National frameworks like the Dasar TVET Negara 2030, Twelfth Malaysia Plan, and Transformasi Politeknik 2023-2030 outline specific goals for producing digitally competent, industry-ready graduates; however, the implementation landscape continues to exhibit significant structural and operational deficiencies. In comparison to globally benchmarked models from Germany, Singapore, Finland, and Korea, Malaysia's TVET system encounters issues related to fragmented governance, limited institutional autonomy, and inadequate industry engagement. While work-based learning (WBL) is regarded as an essential pedagogical approach, numerous programs remain confined to superficial industry placements that do not incorporate innovative tasks, real-time mentoring, or regular feedback mechanisms. The challenges are exacerbated by insufficient quality assurance mechanisms and a lack of capacity among educators and industry mentors to provide training relevant to IR4.0.

To achieve its IR4.0 talent development objectives, Malaysia must transition from mere blueprint rhetoric to a systems-based transformation in policy implementation. This involves enhancing the co-design of curricula with industry stakeholders, integrating real-world problem-solving into work-based learning tasks, and developing institutional capacity for modular, data-driven learning. Educators need to enhance their skills in emerging technologies, and industry stakeholders require more defined incentives and accountability frameworks to engage effectively in the education pipeline. It is essential to establish longitudinal tracking systems that monitor graduate performance and employer satisfaction to facilitate ongoing program refinement. In the absence of integrative efforts, Malaysia may sustain a skills development infrastructure that, while well-intentioned, lacks the necessary capabilities to enhance competitiveness in a global economy characterised by Industry 4.0. The future of Malaysian TVET depends on effective policy design, execution fidelity, stakeholder collaboration, and continuous adaptation to technological and economic changes.

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ENHANCING ADHESIVE PERFORMANCE THROUGH WASTE VALORIZATION: VISCOSITY AND MOISTURE ANALYSIS

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Abstract: The increasing demand for sustainable materials has prompted researchers to explore innovative methods of converting waste into functional products. This study investigates the physical performance of an eco-friendly adhesive synthesized from waste engine oil and polystyrene foam, focusing specifically on two critical parameters: moisture content and viscosity. These properties are essential indicators of an adhesive's stability, shelf life, and usability in real-world applications. The adhesive was formulated through a simple blending process, using shredded polyfoam gradually incorporated into heated waste engine oil without any added chemical solvents. Moisture content was evaluated by drying adhesive samples in an oven at 200°C and calculating the percentage of weight loss, while viscosity was measured using a rotational viscometer at room temperature. The results indicated that the adhesive exhibited low moisture content, ranging from 3% to 5%, which is beneficial for maintaining product stability and preventing microbial degradation during storage. Meanwhile, the viscosity values ranged from 400 to 500 centipoise (cP), reflecting a thick, stable adhesive with strong bonding potential and minimal dripping during application. These findings confirm that the synthesized adhesive demonstrates desirable physical characteristics for practical use in bonding wood, plastics, and other common substrates. The study supports the feasibility of using hydrocarbon-rich and polymeric waste streams as raw materials for adhesive production and provides a foundation for further research into optimizing mechanical strength, flexibility, and long-term durability. Overall, the results highlight the potential of waste-derived adhesives as cost-effective and environmentally responsible alternatives to conventional synthetic adhesives.

Keywords: Moisture content, Viscosity, Adhesive, Recycled polymer, Physical stability

Introduction

As industries move toward more sustainable production practices, the transformation of waste into functional materials has become a strategic focus in materials science and environmental engineering. Adhesives are one of the most widely used industrial products, essential in sectors ranging from construction to packaging, yet most commercial formulations rely heavily on petroleum-based chemicals. These traditional adhesives not only contribute to environmental degradation but also present disposal challenges and health risks due to volatile organic compounds (VOCs) and synthetic additives (Maulana et al., 2024; Siebert & Wilker, 2019).

Recent research has shifted toward the development of eco-friendly adhesives derived from renewable or waste materials, including natural polymers and post-consumer plastics

(Jarensungnen et al., 2023). However, much of the existing literature emphasizes the chemical synthesis process or bonding performance, while comparatively less attention is given to the physical behaviour of these adhesives under real-world conditions. Two critical parameters such as moisture content and viscosity play a fundamental role in determining the durability, application efficiency, and shelf life of any adhesive product (Moon et al., 2023; Tan et al., 2010).

Moisture content affects microbial stability and long-term adhesion, especially in humid or varying environmental conditions. High moisture levels can compromise bonding strength, promote degradation, and reduce the usability window (Bomba et al., 2014; Viana et al., 2017). Viscosity, on the other hand, determines how easily the adhesive can be applied and whether it will hold on vertical or irregular surfaces without sagging or dripping (Jimenez et al., 2021; Stribick & Schäfer, 2024). Understanding and optimizing these properties is crucial for making waste-based adhesives a viable replacement for conventional products.

Therefore, this study aims to evaluate the moisture content and viscosity of an adhesive synthesized from waste engine oil and polyfoam. The results will provide insight into the material's physical performance and its potential for use in various applications where consistent handling and stability are required.

Material and Methods

Materials

The raw materials used in this study were waste engine oil and extruded polystyrene foam (polyfoam). The waste engine oil was of the semi-synthetic type and sourced from motorcycle service operations at a local workshop in Pagoh, Johor, Malaysia. It was chosen for its hydrocarbon composition, which offers the potential to act as a binding agent in adhesive formulations. This waste product, commonly treated as hazardous, presents an opportunity for upcycling into valuable material with reduced environmental impact.

The second material, extruded polystyrene foam (XPS), was obtained from post-consumer packaging waste. Polystyrene was selected due to its thermoplastic nature and ability to dissolve in oil-based solvents under controlled heat. Before use, the polyfoam was manually shredded into small pieces using scissors to increase surface area and facilitate more efficient blending with the waste engine oil during adhesive formulation.

Adhesive Formulation

The adhesive was formulated using a physical blending method, avoiding chemical solvents or industrial additives. Initially, the waste engine oil was transferred into a beaker and gently heated using a tripod furnace. Heating the oil to a moderate temperature reduced its viscosity, making it more suitable for combining with solid polyfoam. The shredded polyfoam was then added incrementally to the warm oil.

The mixing process was carried out under a fume hood to manage any vapours released during heating and ensure safety during handling. Continuous stirring was applied to achieve a homogeneous mixture. The blending process lasted 10 -15 minutes, depending on the volume

and foam-to-oil ratio. After achieving a uniform consistency, the adhesive was cooled to room temperature and stored in sealed containers until further testing was conducted.

Moisture Content Analysis

To evaluate the adhesive's moisture resistance, the percentage of moisture content (%MC) was measured. Moisture content plays a crucial role in determining the shelf life and microbial resistance of adhesives, particularly when stored or used in humid environments. For this test, approximately 50 cm³ of the adhesive sample was poured into a heat-resistant dish and weighed using a digital balance. The sample was then dried in a drying oven at 200°C for one hour. Upon completion, the sample was weighed again to obtain the dry weight. The moisture content was calculated using the formula:

$$\text{Moisture Content} = \left(\frac{\text{Original weight} - \text{Dry weight}}{\text{Original weight}} \right) \times 100\% \quad \text{.....Equation 1}$$

This method provided an accurate measure of the adhesive's water content. The test was repeated for different sample ratios (4:1 and 5:3 polyfoam-to-oil mixtures), ensuring consistency and reproducibility in the data. The results were recorded for comparison and discussion.

Viscosity Measurement

Viscosity is a critical parameter that affects the workability, flow, and coverage of adhesives during application (Gharde et al., 2021). To assess this, a rotational viscometer was used to measure the resistance of the adhesive to flow under controlled shear. The samples were prepared in uniform volumes and tested at room temperature to simulate realistic handling conditions.

Each adhesive sample was placed into the viscometer chamber, and viscosity values were recorded in centipoise (cP). The test helped determine whether the adhesive was too thin (low viscosity) or too thick (high viscosity) for practical use. Values between 400–500 cP were considered optimal for maintaining strong adhesion while preventing dripping during vertical applications. This evaluation provided insights into the adhesive's ease of use, surface wetting behaviour, and potential bonding effectiveness.

Result and Discussion

Adhesive Formulation

Moisture content is a critical factor in determining the performance and stability of adhesive materials, particularly when derived from waste sources that may contain variable levels of residual water or hygroscopic components (Shivam Lad et al., 2022). In this study, the moisture content of two adhesive formulations was measured to evaluate their ability to retain or resist moisture under controlled drying conditions. Two different ratios of polyfoam to waste engine oil which 4:1 and 5:3 were selected to examine how composition affects water content retention, presented in Table 1.

Table 1: Moisture Content Test Data

Sample Ratio	Original Weight (g)	Dry Weight (g)	Moisture Content (%)
4:1	50.0	48.5	3.0
5:3	50.0	47.5	5.0

Each sample began with an original weight of 50 grams and was dried at 200°C for one hour to remove moisture. After drying, the 4:1 sample exhibited a dry weight of 48.5 grams, resulting in a moisture content of 3.0%, while the 5:3 sample had a dry weight of 47.5 grams, translating to a moisture content of 5.0%.

The lower moisture content in the 4:1 formulation indicates superior moisture resistance, which is favourable for long-term storage and durability. In adhesives, excessive moisture can lead to microbial growth, reduction in bond strength, and eventual degradation of the material (Mušič et al., 2024). A moisture content below 5% is generally acceptable for adhesives that will be used in both indoor and moderately humid environments. The relatively low 3.0% value suggests that the 4:1 adhesive has the potential for excellent stability, minimal shrinkage during curing, and reduced risk of mold or fungus development over time (Fu et al., 2022; Tran et al., 2024).

In contrast, the 5.0% moisture content found in the 5:3 formulation raises questions about water retention associated with higher polyfoam concentrations. Polystyrene foam is known to have a porous structure, which may trap small amounts of ambient moisture during storage or synthesis. Although 5.0% remains within a manageable threshold, the increased water presence could influence the adhesive's bonding performance, especially under fluctuating environmental conditions or when used with porous substrates like wood. Higher moisture levels may also delay curing time and increase the likelihood of adhesive creep or delamination over time (Bomba et al., 2014).

From a materials selection perspective, this finding supports the strategic use of optimized ratios that balance workability with performance. While higher polyfoam content might improve structural cohesion or reduce oil separation, it may compromise moisture stability. Therefore, the 4:1 formulation appears more favourable for applications where water resistance and long-term durability are essential, such as in carpentry, construction adhesives, or humid storage environments. These results contribute valuable insights into the role of formulation ratios in determining the physical reliability of eco-friendly adhesives derived from waste sources.

Viscosity Analysis

In this study, viscosity measurements were performed on two adhesive formulations, ratios 4:1 and 5:3 of polyfoam to waste engine oil using a rotational viscometer under standard room temperature conditions as presented in Figure 1. The 4:1 sample displayed a viscosity of 400 centipoise (cP), while the 5:3 sample reached a higher value of 500 cP.

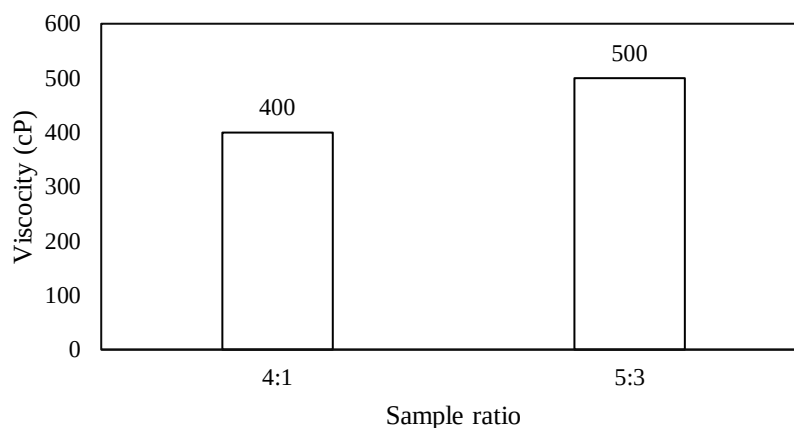


Figure 1: Viscosity Test Data

The increase in viscosity with higher polyfoam content is expected, as more solid polymer increases the internal resistance of the adhesive to flow. A viscosity of 400 cP in the 4:1 formulation indicates a moderately fluid adhesive suitable for general-purpose use. It allows for easy application using common tools such as brushes or rollers and offers good surface wetting characteristics. This level of viscosity is particularly favourable for flat surfaces or horizontal applications, where the adhesive must spread uniformly without pooling (Wang & Dong, 2009).

On the other hand, the 5:3 formulation, with its higher viscosity of 500 cP, represents a thicker and more robust adhesive. This characteristic is advantageous for vertical or uneven surfaces where sag resistance and gap filling are critical. A higher viscosity adhesive also tends to form stronger bonds on porous substrates, as it is less likely to seep into the material and lose adhesion at the surface (Guimarães Carvalho et al., 2020). However, it may also present challenges during application, requiring more force or specialized dispensing equipment, and can be less forgiving if adjustments are needed after application.

These results demonstrate a clear relationship between formulation ratio and rheological behaviour. The 5:3 ratio, while thicker and potentially stronger, may be more difficult to handle in delicate or detailed work. Meanwhile, the 4:1 formulation offers a smoother and more manageable application but may be less ideal in cases requiring structural filling. Selecting the appropriate viscosity for a given application depends on the material, orientation, and environmental context in which the adhesive will be used. Both formulations fall within an acceptable viscosity range for commercial adhesives, confirming that waste-derived formulations can be tailored to meet specific functional needs through simple compositional adjustments.

Conclusion

This study evaluated the physical performance characteristics of a waste-based adhesive synthesized from waste engine oil and polyfoam, with a specific focus on moisture content and viscosity, two critical parameters that influence the stability, usability, and application potential of adhesives. The investigation revealed that formulation ratios significantly affect both

properties, offering practical insights into how waste materials can be optimized for adhesive development.

Moisture content analysis showed that the adhesive formulations had low water retention levels, ranging from 3.0% to 5.0%, depending on the polyfoam-to-oil ratio. These values fall within acceptable limits for industrial adhesives, with the 4:1 formulation demonstrating superior resistance to moisture uptake. This suggests a longer shelf life, reduced microbial risk, and better performance in humid environments. In contrast, the slightly higher moisture level in the 5:3 sample indicates the need for cautious use in moisture-sensitive applications but still maintains functional integrity.

Viscosity testing highlighted a proportional increase in thickness with higher polyfoam content, from 400 cP to 500 cP. The 4:1 formulation provided a more fluid and manageable adhesive ideal for smooth and horizontal surfaces, while the thicker 5:3 formulation offered better sag resistance and gap-filling properties, suitable for vertical or porous substrates. Both viscosity values fall within optimal ranges for general adhesive applications, confirming the formulation's flexibility for different use cases.

Overall, the results validate the feasibility of using hydrocarbon-rich and polymeric waste streams to develop adhesives with customizable physical properties. These findings provide a foundation for further research into mechanical strength, adhesion quality, and environmental durability. By adjusting simple composition ratios, waste-derived adhesives can be tailored for specific performance demands, supporting sustainable material innovation in the adhesive industry.

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BUILDING CONDITION ASSESSMENT OF MALAYSIAN POLYTECHNICS USING BCARS: A DATA-DRIVEN MAINTENANCE STRATEGY

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Abstract: Building maintenance in higher education institutions is a critical aspect of ensuring safety, functionality, and long-term sustainability. However, the prioritization of maintenance budgets is often subjective and reactive. This study aims to assess the condition of polytechnic buildings in Malaysia using the Building Condition Assessment Rating System (BCARS) and to analyze the relationship between condition scores and budget allocation priorities. A cross-sectional building condition survey was conducted across six Malaysian polytechnics. The BCARS instrument was applied to assess defects in civil, mechanical, and electrical components. Descriptive analysis, Pearson correlation, and multiple regression were performed. Three polytechnics were classified as critical to very critical. Civil component defects contributed the most to overall BCARS scores ($\beta = .72, p < .01$). Correlation analysis showed a strong positive relationship between the number of defects and BCARS scores ($r = .85, p < .05$). Pareto analysis confirmed that approximately 80% of the total condition score was driven by four key components: walls, ceilings, doors, and roofs. The findings highlight the potential of BCARS as a data-driven decision support tool for prioritizing maintenance budgets. A focus on critical few components can significantly reduce deterioration risk and optimize limited resources. This study emphasizes that BCARS can help facility managers make maintenance budget decisions more systematically, transparently, and effectively, thereby supporting the sustainability of TVET education facilities in Malaysia.

Keywords: Building Maintenance, Polytechnics, Building Condition Assessment, Budget Allocation, BCARS

Introduction

Building maintenance is essential in ensuring safe, functional, and sustainable infrastructure in higher education. In Malaysia, polytechnic institutions play a vital role in technical and

vocational education. However, the prioritization of maintenance budgets remains a challenge as allocations are often based on ad-hoc or reactive decisions rather than systematic assessment.

Previous studies have shown that inadequate maintenance practices lead to accelerated deterioration and high costs Hauashdh et al., (2022). For instance, defects in structural and architectural components significantly influence user safety and long-term sustainability. Internationally, the adoption of data-driven systems such as BIM-based workflows Chen, (2019) and Building Performance Indicators (BPI) Leite et al., (2020) has improved decision-making. Nevertheless, in the Malaysian polytechnic context, systematic adoption of BCARS remains limited.

This study therefore addresses the gap by examining the effectiveness of BCARS in systematically evaluating building condition and linking condition scores with budget allocation priorities.

Research Objectives:

1. To identify factors that influence the effectiveness of systematic building condition assessment in Malaysian polytechnics.
2. To analyze the relationship between building condition assessment results (BCARS scores) and maintenance budget allocation priorities in Malaysian polytechnics.

Research questions (RQs):

RQ1: What factors influence the effectiveness of implementing BCARS-based building condition assessment in Malaysian polytechnics?

RQ2: Does BCARS score predict maintenance budget allocation priorities at the polytechnic level?

Research Gap

Previous studies have identified two key gaps in the context of higher education institutions: (i) consistent, data-driven building condition assessment practices are still limited, and (ii) the link between assessment scores (as “technical signals”) and transparent, prioritized budget allocation decisions is not yet well established. In Malaysia, the use of the BARS framework has been reported in the health/disability facilities sector, but evidence of widespread application in the education ecosystem particularly polytechnics is still lacking and fragmented. At the same time, local findings in public universities indicate that the number and severity of defects are largely driven by cross-life cycle factors (design, construction, operations, maintenance), with direct implications for cost, safety, and asset lifespan. Internationally, quantitative instruments such as the Building Performance Indicator (BPI) allow for objective ranking to prioritize interventions but the adaptation of equivalent methods for local technical education campuses remains underexplored. Furthermore, although BIM approaches have been proposed to close the gap in cost planning and maintenance scheduling, the practical mapping between condition assessment scores and prioritized budget allocations (data-to-budget) in the context of Malaysian educational institutions is still unclear. Finally, although the relationship between building condition/maintenance resources and user satisfaction has been demonstrated, the integration of the “service quality/satisfaction” dimension into the budget decision-making process based on assessment scores is rarely operationally explained in polytechnics. In summary, there is a gap in evidence on: (a) how BCARS scores in Malaysian polytechnics are systematically used to guide maintenance budget priorities, and (b) the factors

that influence the effectiveness of assessment and the transfer of scores into budget decisions that are transparent and responsive to users (students/staff).

Literature Review

Building Condition Assessment (BCA)

Building Condition Assessment (BCA) is to be performed at physical levels of buildings to help identify potential defects at an early stage that can have an impact on operations, safety and comfort of building users. Within higher education, the systematic application of BCA could affect facility maintenance efficiency, budget allocations and user satisfaction Leite et al. (2020). Dzulkifli et al. (2021) found that reactive maintenance practices are still widely applied in educational institutions in Malaysia. This type of maintenance caused repair actions to be done only after damage had happened, which increased the long-term costs. This is due to a lack of planning, technical inefficiency and resource limitations. In addition, Olanweraju et. al, (2022) found that a maintenance strategy based on current building conditions was less practised in public universities, and that a value-based performance maintenance system should be introduced. From a technical point of view, the COBRA Conference (2010) developed a CSP Matrix which can be used to assist building inspectors to perform visual inspections more consistently and systematically. The main components of BCA include visual inspection of building elements, defect scoring and condition rating. The most commonly used scoring method involves the combination of two factors, condition score (1–good to 5–very bad) and priority score (1–not critical to 5–very critical). The matrix score was calculated by multiplying the two scores and formed the basis for determining the priority of building repairs.

Maintenance Strategic and Budget Planning

Leite et al. (2020) customized the Building Performance Index (BPI) according to university applicability in Brazil to support more objective and targeted maintenance planning. It was also claimed that to lower the level of subjectivity, the use of quantitative performance indicators is recommended. This implies that the integration of BCA data with budget planning strategies is of an ever-increasing demand. Chen et al., (2019) proposed a data mining approach to extract post-delivery building defect patterns based on risk prediction methods. Although the study was based on high-rise residential buildings, this data mining approach can be utilized for the education sector to complement predictive maintenance. In addition, Hauashdh et al. (2022) found that inappropriate design, lack of regular maintenance, and the use of low-quality construction materials are the main causes of building defects. The authors also explained the need for structured periodic inspections and the integration of all parties in facility management. However, previous studies are not particular in showing how BCA results can be utilized to support the strategic allocation of maintenance budgets (Ramli et al., 2020; Yacob et al., 2016; Kenno et al., 2021). Although visual assessment methods are well propagated, the implementation of a holistic quantitative system is still limited in the Malaysian polytechnic setting. Therefore, a conceptual framework is developed by combining input factors such as defect records and age of buildings. The assessment process (protocol and scoring method), the assessment output (building condition rating), and integration of the output to maintenance budget planning in TVET educational institutions in Malaysia are still in the sub-optimal phase (Liu et.al, 2019).

Methodology

This study was carried out in three main phases: (i) Building selection, (ii) Fieldwork, and (iii) Data analysis.

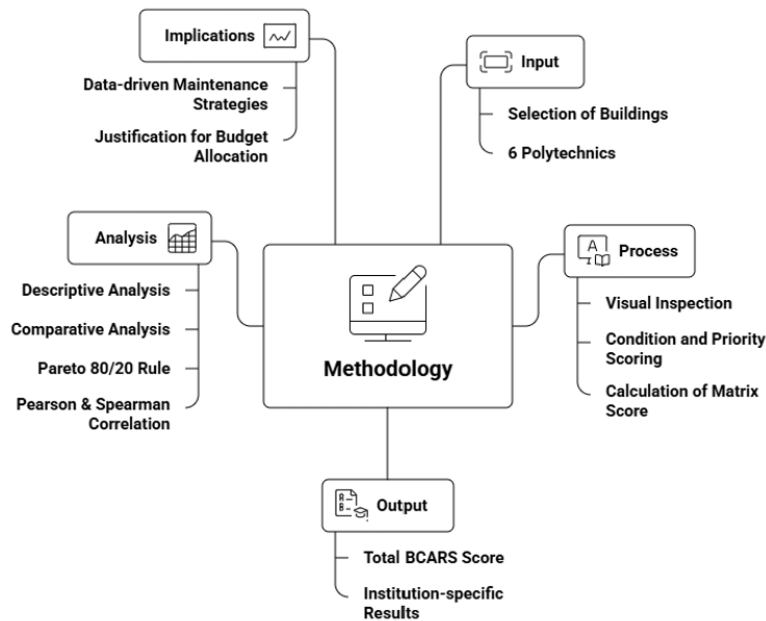


Figure 1: Methodology

Building Selection

Six polytechnics were selected as case studies, namely Polytechnic A,B,C,D,E and F. Selection was made based on the criteria of building age, gross floor area, and maintenance expenditure records over a four-year period. The engineering academic block was selected because it is a critical component that houses various teaching, learning and technical laboratory activities.

Fieldwork

Visual inspections were carried out using the Condition Survey Protocol 1 (CSP 1) protocol introduced by the Public Works Department (PWD, 2021). Each building defect was recorded in an inspection form organized according to component categories such as ceilings, walls, doors, windows, floors, roofs, water channels, structures, and finishes. For quantification purposes, each defect was given a condition score (1= good to 5= very bad) and a priority score (1= not critical to 5= very critical). The matrix score is calculated based on the equation 1;

$$\text{Matrix score} = \text{condition score} \times \text{priority score} \quad (1)$$

These scores are then summed to produce a **Total BCARS Score** for each institution.

Data Analysis

The data collected in this study were examined using a multi-layered analytical approach to ensure robust interpretation of building condition results. First, descriptive analysis was employed to highlight the distribution of defects and BCARS scores across the six polytechnics, providing a clear overview of performance patterns. Second, comparative analysis was carried out to evaluate differences in relative performance among institutions, enabling identification of those with more critical maintenance issues. Third, the Pareto principle (80/20 rule) was applied to determine the dominant building components that accounted for more than 70% of the total defect severity, thus prioritizing critical intervention areas. Finally, Pearson and Spearman correlation analyses were used to statistically establish the strength of association between the number of defects and overall BCARS scores, thereby validating the reliability of the assessment framework. This systematic combination of quantitative techniques reflects best practices in empirical research design (Creswell & Creswell, 2018; Saunders et al., 2019).

Results and Discussion

Sample Description:

A total of six institutions were assessed. Table 1 presents descriptive findings.

Table 1: Summary of BCARS Results

Institution	GFA (m ²)	Defects (Civil/Mech/Elec)	Total Defects	BCARS Score	Avg. Score
Polytechnic (A)	10,770	276 / 14 / 57	347	5,478	15.8
Polytechnic (B)	16,442	399 / 40 / 25	464	9,848	21.2
Polytechnic (C)	8,561	244 / 31 / 52	327	5,060	15.5
Polytechnic (D)	14,437	361 / 21 / 22	404	6,955	17.2
Polytechnic (E)	9,208	221 / 9 / 39	269	3,031	11.3
Polytechnic (F)	1,500	74 / 12 / 23	109	2,084	19.1

Source: (Author, 2025)

The findings Table 1 showed that Polytechnic B recorded the highest number of defects (464) with an average score of 21.2. On the other hand, Polytechnic E recorded the lowest number of defects (269) with an average score of 11.3. Overall, three institutions (Polytechnic A, D, F) were in the critical to very critical category, while two institutions (Polytechnic C, E) were categorized as moderate. Preliminary analysis also found a clear relationship between the number of defects and the overall BCARS score. Institutions with a higher number of defects tended to record a higher average score, indicating a more problematic physical condition of the building.

Correlation Analysis

Pearson correlation was conducted to test the relationship between the number of defects and the average BCARS score. The findings Table 2 showed a strong positive relationship ($r \approx 0.85$, $p < 0.05$), indicating that the higher the number of defects recorded, the higher the average

BCARS score, and consequently the worse the overall condition of the building. Correlation analysis demonstrated that the number of defects was significantly related to the average BCARS score, confirming that a higher defect load was closely related to the physical degradation of the building.

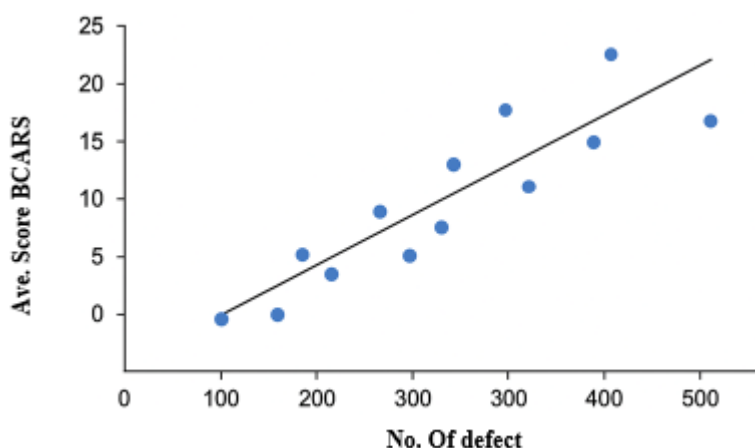


Figure 2: Correlation Between Number of Defects and Average BCARS Score

Source: (SPSS,2025)

Table 2: Correlation Analysis

	Skor Aver BCARS Total Defect Age GFA (m ²)			
Ave. Score BCARS	1	.85*	.21	.09
Total Defects	.85*	1	.34	.11
Building Age	.21	.34	1	.27
Gross Floor Area/GFA (m ²)	.09	.11	.27	1

*Correlation is significant at the 0.05 level (2-tailed).

Source: (SPSS,2025)

Regression Analysis

Linear regression was used to assess the extent to which technical factors (building age, GFA, total civil, mechanical, electrical defects) influenced the average BCARS score. The model results in Table 3 showed that:

Table 3: Linear Regression Analysis

Predictor	B	Std. Error	Beta	t	Sig.
(Constant)	5.120	3.210	0.0	1.59	.148
Total Defect (Civil)	0.042	0.011	.72	3.81	.004
Total Defect (Mechanical)	0.028	0.012	.38	2.33	.041
Total Defect (Electrical)	0.010	0.009	.19	1.12	.285
Building Age	0.013	0.018	.12	0.71	.498
GFA (m ²)	0.001	0.002	.09	0.55	.595

*Dependent Variable: Ave Score BCARS

Source: (SPSS,2025)

*The total civil defects were the largest contributor to the average score ($\beta = 0.72$, $p < 0.01$).
The total mechanical defects had a moderate but significant effect ($\beta = 0.38$, $p < 0.05$).*

Building age and GFA did not show a significant effect ($p > 0.05$), indicating that the condition of the building was determined more by the frequency of defects than by physical factors such as size or age. The linear regression results found that civil component defects (e.g. cracked walls, leaking ceilings, damaged doors) were the largest contributors to the increase in BCARS scores. This finding is consistent with the report by Hauashdh et al. (2022), which identified structural weaknesses and foundation defects as the dominant factors in the decline in the quality of Malaysian public university buildings. In contrast, the factors of building age and gross floor area (GFA) were not significant, indicating that the physical condition of the building was more influenced by the intensity of defects than the age or size of the building. This finding is in line with the study by Leite et al. (2020) which emphasized that quantitative building performance indicators are more relevant to measuring maintenance effectiveness than physical attributes alone.

Table 4: Regression Analysis

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate
1	.91	.83	.75	1.82

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	152.37	5	30.47	9.18	.017
Residual	30.12	9	3.35		
Total	182.49	14			

*Dependent Variable: Ave Score BCARS
Source: (SPSS,2025)

The results of the regression analysis Table 4 showed that the overall model was significant, $F(5,9) = 9.18$, $p < .05$, with an R^2 value of .83. This means that 83% of the variance in the average BCARS score could be explained by the independent factors tested. Among all the factors, the number of civil defects was the largest contributor to the increase in BCARS score with a coefficient value of $\beta = .72$ ($p < .01$). This factor clearly shows that damage to civil components such as ceilings, walls and doors has the greatest impact on the overall level of the building. Next, the number of mechanical defects was also found to be significant with $\beta = .38$ ($p < .05$), indicating a moderate influence on the BCARS score. On the other hand, other factors such as electrical defects, building age and gross floor area (GFA) did not show a significant effect ($p > .05$), thus indicating that these factors have little influence on the BCARS score in the tested model.

Pareto Analysis

Pareto analysis emphasized the value of prioritizing “critical few” components, aligning with international practices (Pampana et al., 2024). Targeted interventions on walls, ceilings, doors, and roofs could substantially improve building conditions within limited budgets. These findings also align with studies on user satisfaction (Ramli et al., 2020), where visible and frequently used components directly affect occupants’ perceptions of quality. Strengths include

cross-institution comparison using a standardized tool. Limitations involve focus on mechanical blocks only and absence of detailed budget integration. This study found that the majority of polytechnics are in critical condition, confirming that systematic assessment is urgently needed. Civil defects dominate condition scores, consistent with Hauashdh et al. (2022). Unlike age or size, the intensity of defects better predicts deterioration, supporting findings by (Leite et al. 2020).

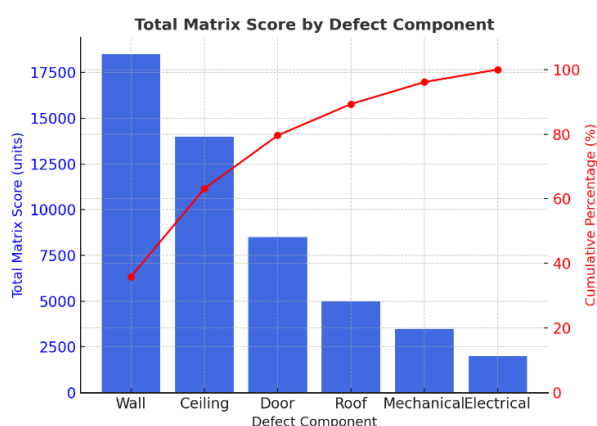


Figure 3: Distribution of Total Matrix Scores
Source: (Author,2025)

The Pareto graph above Figure 3 shows the distribution of total matrix scores according to defect components in the six polytechnics studied. It can be observed that the wall, ceiling and door components contributed the highest total matrix scores, each exceeding 8,000 units. Cumulatively, these three components contributed more than 70% of the total defect score, thus emphasizing their importance as dominant factors in determining maintenance priorities. Other components such as roof, mechanical and electrical showed much lower matrix scores, which were between 2,000 and 5,000 units only. Although the number is small, these components still need attention to avoid recurring damage in the long term.

Overall, this pattern supports the Pareto principle (80/20 Rule) which states that a small number of factors (20%) contribute to a large number of effects (80%). Therefore, maintenance strategies need to focus on walls, ceilings and doors first to ensure effective use of the budget and the safety of building users.

Prioritization Analysis

By combining BCARS scores and maintenance budget priorities, an institutional priority table can be produced:

Table 5: Prioritization Analysis

Ranking	Inst.	Avg. Score	Condition	Priority Recommendation
1	Polytechnic B	21.2	Very Critical	Need urgent maintenance & highest budget
2	Polytechnic F	19.1	Critical	Needs immediate intervention, high budget
3	Polytechnic D	17.2	Critical	Needs immediate intervention, high budget
4	Polytechnic A	15.8	Critical	Requires intensive scheduled maintenance
5	Polytechnic C	15.5	Moderate	Preventive maintenance should be increased
6	Polytechnic E	11.3	Moderate	Adequate routine maintenance, moderate budget

Source: (Author,2025)

The rankings in Table 5 shows a clear stratification of building conditions across the six polytechnics. Polytechnic B recorded the highest average BCARS score, requiring urgent remedial work and the highest budget priority. Polytechnics F and D are still in the critical range, requiring immediate intervention focusing on the dominant civil components to curb deterioration. Polytechnic A is borderline critical; intensive scheduled maintenance should be implemented to avoid escalation. Polytechnics C and E are categorized as moderate; focus shifts to routine prevention and defect suppression. Overall, the gradient of scores supports risk-based allocation, directing resources to the most degraded assets first in the near term. The competence of technical staff plays a crucial role in the effectiveness of building inspections and maintenance implementation. Therefore, it is important to strengthen the technical training of maintenance staff in visual inspection methods, reporting using BCARS, and understanding of risk priorities. To this end, it is recommended that TVET institutions develop Standard Operating Procedures (SOPs) for building condition inspections. This SOP should; (i) Set inspection frequencies (at least twice a year). (ii) Provide standard inspection forms based on CSP 1, (iii) List assessment and scoring criteria for each building element, (iv) Determine digital reporting protocols so that defect data can be entered into a central monitoring system for reporting and further analysis. In addition, institutions can conduct regular internal technical audits to assess the effectiveness of the implementation of this SOP and reduce the risk of recurring defects.

Conclusion

This study demonstrates that the use of BCARS as a framework for assessing building condition in Malaysian polytechnics can provide a more objective and systematic picture of the level of defects and maintenance needs. The main findings show that civil defects are the dominant factor that most influences the building condition score, followed by mechanical defects, while the factors of building age and gross floor area (GFA) are found to be less significant. Correlation and regression analyses confirm the strong relationship between the number of defects and BCARS score, thus emphasizing the need for data-based assessment in making maintenance decisions. In addition, through Pareto analysis, the study emphasizes that critical components such as walls, ceilings, and doors contribute more than 70% of the damage, making them the main priority areas for intervention. Budget prioritization is also

hierarchically arranged based on each polytechnic's BCARS score, where institutions with "critical" and "very critical" categories should receive immediate and higher allocations.

Overall, this article not only fills the research gap regarding the integration of condition assessment with budget planning, but also offers a practical data-based approach to improve the effectiveness of maintenance strategies. This has important implications for the sustainability of TVET facilities in Malaysia, especially in ensuring a safe, conducive, and cost-effective learning environment.

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FROM LOCAL TASTE TO GLOBAL MARKET: DIGITALIZATION AND ECONOMIC EMPOWERMENT OF THE ‘CRISP!! ENYE-ENYE’ MICROENTERPRISE IN LEBAK, BANTEN

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Abstract: *The International PKM Collaboration Program (KPI) is implemented by UPN Veteran Jakarta in collaboration with Thaksin University and micro-business partner Crisp!! Enye-Enye in Mekaragung Village, Lebak, Banten. The aim is to enhance production capacity, human resources, marketing, and business management through digitalization and appropriate technology, while maintaining local wisdom based on cassava processing. Over an eight-month period (March–November 2025), the program began with a survey to identify key challenges, including manual production processes without standard operating procedures (SOPs), ineffective organizational structures, suboptimal packaging design and digital promotion, and the absence of business legalization. Four main aspects became the focus of training and mentoring. Production: development and implementation of SOPs, food safety training, and use of simple machinery. Human Resources: organizational structure restructuring, job description development, and team coordination enhancement. Marketing: redesigning logos and packaging, creating social media business accounts, product photography techniques, and digital promotion strategies. Management: understanding business legalities (NIB, business license, PIRT, halal certification) and assistance with administrative procedures. Technological support includes automatic slicers, sealers, digital scales, and stainless steel drying racks to enhance efficiency and quality. Pre-test and post-test evaluations showed improvements in understanding of Production (76%), Human Resources (68%), Marketing (68%), and Management (64%). This program supports the achievement of SDGs, such as poverty reduction, decent work, economic growth, innovation, reducing inequality, responsible consumption and production, and global partnerships. As a result, Crisp!! Enye-Enye now has more consistent product quality, attractive packaging, a strong brand identity, broader market access including export opportunities in Southeast Asia,*

improved management and financial systems, as well as enhanced human resource capacity and community participation, particularly among homemakers.

Keywords: *International Service Collaboration; ‘Crisp!! Enye-Enye’; Digitalization of MSMEs; Economic Improvement.*

Introduction

Micro, Small, and Medium Enterprises (MSMEs) are an important pillar of the global economy, especially in developing countries, due to their contribution to Gross Domestic Product (GDP), job creation, and strengthening local economic resilience (Budiman, 2024; Nurandi, 2024; Piliang, 2024). In addition to their economic role, MSMEs also serve as guardians of cultural diversity through the preservation of local products and traditional knowledge. In the era of globalization, advancements in information technology and social media have opened new opportunities for MSMEs to expand their markets, strengthen their branding, and enhance operational efficiency through digitalization. (Sholihin, 2024; Suryana & Garvera, 2024; Syikin et al., 2020; Utami et al., 2024; Zefriyenni et al., 2022).

Lebak Regency, Banten Province, has significant economic potential through food products based on local commodities, one of which is cassava. Traditional processed products such as Enye-Enye have become the culinary identity of the region and have broad market potential, both domestically and internationally. However, most businesses still face limitations in terms of production, human resource management, marketing strategies, and business legality. These limitations hinder the competitiveness of SMEs in an increasingly competitive market. (Manggalani, 2024; Syarif, 2024; Ubik, 2024).

The micro business “Crisp!! Enye-Enye” in Mekaragung Village, Lebak, Banten, represents both the problems and opportunities. Although this product has penetrated foreign markets such as Malaysia and the United Arab Emirates through informal channels, its production process remains traditional without standardized Standard Operating Procedures (SOPs), the packaging design is outdated, the organizational structure is suboptimal, and the business's legal status is incomplete. This situation requires strategic intervention through a collaborative approach that combines community empowerment, appropriate technology, and digital marketing strategies.

The International Community Service Collaboration Program (KPI) between the Jakarta Veteran National Development University, Thaksin University, and micro-business partners is designed to address these issues. The program focuses on enhancing production capacity through the implementation of standard operating procedures (SOPs) and simple technologies, organizational restructuring and job descriptions, updating packaging design and brand identity, optimizing digital marketing, and managing business legalities. This approach is expected to not only improve product quality and competitiveness but also expand market access to the regional ASEAN level.

Through structured and measurable interventions, this activity contributes to the achievement of several Sustainable Development Goals (SDGs), particularly poverty reduction (SDG 1), inclusive economic growth (SDG 8), innovation based on local wisdom (SDG 9), reducing

inequalities (SDG 10), sustainable consumption and production (SDG 12), and global partnerships for development (SDG 17).

This article discusses the background of the program, its conceptual basis, and the results of its implementation in the field, along with the changes observed in production, human resources, marketing, and management. The paper also identifies the challenges faced and proposes strategies to strengthen the group's business capacity for future sustainability.

Literature Review

Micro, Small, and Medium Enterprises (MSMEs) make a significant contribution to the global economy, particularly in developing countries. MSMEs not only play a role in job creation and increasing Gross Domestic Product (GDP), but also drive local economic resilience (Tambunan, 2019; OECD, 2022). In Indonesia, MSMEs account for over 60% of the national GDP and employ approximately 97% of the workforce (Ministry of Cooperatives and MSMEs, 2023). More than just economic entities, SMEs also function as preservers of cultural diversity and local wisdom, enriching the nation's identity (Dhewanto et al., 2020). However, despite their great potential, many SMEs in rural areas still face serious challenges, such as limited access to technology, capital, and markets.

Digital transformation is one of the key strategies that can enhance the competitiveness of MSMEs. The use of social media and e-commerce platforms enables businesses to conduct broader, more effective, and cost-efficient marketing (Chaffey & Ellis-Chadwick, 2019). Digital marketing serves not only as a promotional tool but also as a direct interaction medium with consumers to understand market needs and preferences (Kotler et al., 2021). Research by Astuti and Sembiring (2024) indicates that the implementation of electronic customer relationship management (e-CRM) can significantly improve the marketing performance of SMEs. However, the success of digitalization heavily depends on the human resource capacity to manage these digital platforms. (Dwivedi et al., 2021).

In addition to technological aspects, local wisdom is an important resource that can serve as the basis for product innovation. Local wisdom encompasses cultural values and traditional practices passed down across generations, which can be combined with modern innovations to create unique and value-added products (Rahmawati & Wulandari, 2021). Integrating local elements into business strategies can strengthen brand identity while building emotional connections with consumers (Prastowo, 2020). For example, the Enye-Enye cassava-based product from Lebak, Banten, demonstrates how local potential can be transformed into a commodity capable of competing in the international market.

In managing MSMEs, efficient production management is key to maintaining consistency in product quality and quantity. The implementation of Standard Operating Procedures (SOPs) has been proven to reduce production variation and improve food safety (Hubbard, 2019). Additionally, structured human resource management with clear task allocation contributes to work effectiveness and team coordination (Dessler, 2020). Business legalities such as the Business Identification Number (NIB), halal certification, and distribution permits are also strategic factors that open up broader market access opportunities and partnerships with external parties. (Kementerian Perdagangan RI, 2022).

Furthermore, international collaboration in empowering MSMEs provides strategic advantages in the form of knowledge transfer, technology adoption, and market network expansion (Knight & Liesch, 2016). Vrontis et al. (2020) emphasize that cross-border partnerships can help MSMEs penetrate global markets more effectively. In the context of community service, synergy between universities, local governments, local businesses, and international partners can serve as a catalyst for the development of SMEs based on local wisdom that are ready to compete in the ASEAN region.

Methodology

This community service program uses a participatory approach that emphasizes the active involvement of partners from the planning stage to the evaluation stage. The activities are carried out under the International Community Service Collaboration (KPI) scheme between the University of National Veterans' Development Jakarta (UPNVJ), Thaksin University, and the micro-enterprise partner Crisp!! Enye-Enye in Mekaragung Village, Lebak District, Banten. The program implementation spans eight months, from March to November 2025.

The methodology of the activity consists of four main stages, namely:

1. **Survey and Situation Analysis.** The initial stage includes field visits, in-depth interviews with business owners, observation of production processes, and identification of core issues covering aspects of production, human resources, marketing, and management. Data is collected through direct observation and photographic documentation, and verified through focus group discussions with partner members and village officials.
2. **Training Sessions.** Training is designed to provide technical and managerial knowledge to partners. Training materials include:
 - a. The Production Aspect develops and implements Standard Operating Procedures (SOPs), food safety principles, and the use of appropriate technology.
 - b. The HR aspect involves organizational restructuring, formulation of job descriptions, and effective division of tasks.
 - c. The Marketing Department redesigns the logo and packaging, develops a digital marketing strategy, and creates business accounts on social media.
 - d. The Management aspect handles business legality (NIB, halal certification, PIRT) and financial recording.
 - e. Training is conducted interactively using a combination of lectures, discussions, case studies, and simulations.
3. **Mentoring Sessions.** After the training, the team provides mentoring to ensure implementation of the material. At this stage, production SOPs are tested, the new organizational structure is implemented, new packaging designs are prepared, digital business accounts are activated, and legal documents are processed. Mentoring also involves marketing trials in local markets and professional product photography for digital promotion.
4. **Transfer of Appropriate Technology** Evaluation and Monitoring. Evaluation is conducted using pre-test and post-test methods to measure improvements in partners' knowledge and skills in each aspect. Success indicators include improved understanding scores, completeness of legal documents, availability of SOPs, packaging design improvements, and business social media account activity.

Monitoring is conducted periodically through field visits and online communication to ensure the sustainability of the program after the intervention.

All activities are carried out based on the principles of capacity building and technology transfer, whereby partners not only receive instant solutions but are also equipped with the skills and resources that enable them to develop their businesses independently. The program is also synergized with the Sustainable Development Goals (SDGs), particularly points 1, 8, 9, 10, 12, and 17, to ensure a broader and more sustainable impact.

Results and Discussion

The description and discussion of the findings obtained from the field will be presented in this section. Solutions to the problems that have been presented will be answered based on the methods and stages that have been presented, as explained below:

a. Surveys and Licensing

The initial visit by the International PKM Collaboration Team (KPI) to Cigundi Village was welcomed by the Village Head, Mr. Madyasin, who invited the team to inspect the production site of Neng Duwita's Crisp!! Enye-Enye SME. From this meeting, issues related to business management, digital marketing strategies, packaging quality, production SOP improvements, and organizational structure strengthening were identified. On May 16, 2025, the team submitted a Request for Implementation of the PKM and conducted a socialization of the activity plan. On May 20, 2025, a technical meeting was held with the Village Head and partners to discuss participants, schedules, responsible parties, and the agenda, accompanied by field observations.

b. Training

1. Training on Production Aspects

Before the intervention, the production process for Crisp!! Enye-Enye was mostly done manually without any documented Standard Operating Procedures (SOPs), so product quality was often inconsistent. Through training and mentoring, the partner successfully developed SOPs covering every stage of production, from raw material processing to packaging. The use of appropriate technology, such as automatic slicing machines, sealers, digital scales, and stainless-steel drying racks, improved production efficiency and reduced the risk of contamination. Pre-test and post-test results showed a 76% increase in the partner's understanding of production aspects, indicating effective knowledge transfer. These findings align with Hubbard (2019), who emphasizes the importance of SOPs in maintaining consistency and food safety in small-scale industries.

2. Training on Human Resource Aspects

Initial problems in the HR aspect included an suboptimal organizational structure and unclear job descriptions. The program intervention resulted in organizational restructuring with specific roles and responsibilities, accompanied by written job descriptions for each position. These changes improved coordination among team members and reduced task overlap. The evaluation showed a 68% increase in partners' understanding of HR management. These results support Dessler's (2020) theory that clear role distribution has a positive impact on organizational productivity and performance.

3. Training on Marketing Aspects

Before the program, partners' digital marketing activities were limited and used the business owners' personal accounts. Through branding and digital marketing training, partners successfully created new logos, modern packaging designs, and official business accounts on Instagram, Facebook, and WhatsApp Business. Simple product photography techniques were taught to produce more attractive promotional content. Following the intervention, social media engagement increased, and marketing reach expanded beyond the local area. An improvement in understanding of marketing aspects was recorded at 68%, demonstrating the effectiveness of the implemented digital marketing strategy. (Kotler et al., 2021).

4. Training on Management Aspects

Before the intervention, Crisp!! Enye-Enye did not have formal legal status such as a Business Identification Number (NIB) and product certification. The program provided intensive assistance in obtaining an NIB, PIRT, and halal certification, as well as training in financial recording based on updated production cost prices. The partners' understanding of management aspects increased by 64%. This step opens up opportunities for access to broader markets, including modern retail networks and export potential, as emphasized by the Indonesian Ministry of Trade (2022) regarding the importance of legal status for formal market penetration.

c. Assistance

Assistance in Production and Human Resources

The International PKM Collaboration Team (KPI) provided assistance with production and human resources (HR) aspects at the Crisp!! Enye-Enye Micro Business, one day after the training. The aim was to ensure that the training material could be directly applied in the field and to help partners compile daily operational documents.

Production assistance, led by Mr. Jenji Gunaedi, SE., MM, began with a review of the production process at the partner's site, from raw material preparation to product storage. The team identified potential risks such as process inconsistencies and potential contamination, then developed Standard Operating Procedures (SOPs) containing work steps, technical parameters, and product quality standards.

Human resource assistance, led by Dr. Desmintari, SE., MM, focused on improving the previously informal division of tasks. The team helped to develop an organizational structure, establish written job descriptions for each position, and conduct work coordination simulations to improve the effectiveness of communication flows.

The result of this assistance is the compilation of production SOP documents and a complete organizational structure with job descriptions, which will serve as the foundation for improving product quality, work efficiency, and future business development.

Assistance in Marketing Aspects

The Community Service Team at UPN Veteran Jakarta, together with **Dr. Miguna Astuti**, assisted the micro business Crisp!! Enye-Enye in the direct implementation of marketing strategies. The assistance began with **brainstorming a new logo concept**, including the selection of colors, fonts, and icons that reflect the character of the product. The resource

person provided technical input related to design harmony and target markets. The result was a fresh, dynamic, and memorable logo, which was then applied to a **new packaging design** featuring stronger materials, clear information layout, and modern graphic touches. The next session focused on **digital marketing**, including the creation of official accounts on Instagram, Facebook, and WhatsApp Business, the use of the new logo as a visual identity, and the development of a concise and informative business description. Participants were trained in basic product photography techniques, uploading the first promotional content, and initial interaction strategies with potential customers..

This assistance resulted in a new visual identity and active digital marketing channels, which are expected to increase competitiveness and expand Crisp!! Enye-Enye's market reach.

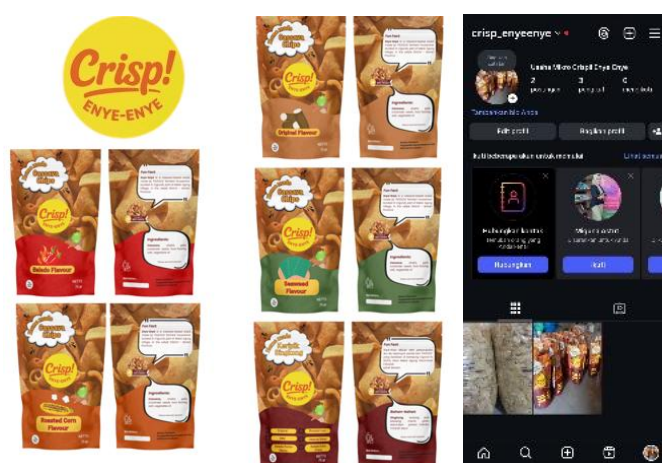


Figure 1: Marketing Assistance (New Logo, New Packaging Design, and Creation of Digital Accounts)

Source: (Processed data 2025)

Assistance in Management Aspects

The KPI team assisted Crisp!! Enye-Enye owner Neng Duwita in preparing the legal documents for her business, which is also located at her residence. The assistance focused on checking the completeness of documents such as ID cards, tax identification numbers, domicile letters, business photos, business activity descriptions, and KBLI determinations. All data was checked for consistency and compliance with requirements to avoid rejection during registration.

Once the documents are complete, participants are invited to the local UMKM office to submit their documents and receive procedural guidance. However, registration for the NIB and PIRT through the free grant program cannot be done because the 2025 quota has been filled since May, leaving new opportunities in mid-2026 due to a reduction in the quota from 50 to 20 SMEs. Nevertheless, the results of the mentoring ensure that Crisp!! Enye-Enye is administratively ready to begin the legalization process once the program reopens.



Figure 2. Assistance (Visiting the Lebak Regency MSME Office represented by the Head of the KPI Team – Dr. Miguna Astuti.,S.Si.,MM.,MOS.,CPM.,CIRR)

Source: (Processed data 2025)

d. Transfer of Appropriate Technology

The KPI Team from UPN Veteran Jakarta, led by Dr. Miguna Astuti, handed over Appropriate Technology (TTG) to the Crisp!! Enye-Enye micro business owned by Neng Duwita. The equipment provided included an automatic sealer, digital scale, automatic slicing machine, and stainless-steel drying rack, in accordance with the budget and production needs. The aim is to improve efficiency, maintain product quality consistency, and reduce contamination risks. Participants received explanations on the functions and usage of each tool and had the opportunity to try them out directly. As a result, preparation time for raw materials and packaging was significantly reduced, packaging weight became more uniform, and product cleanliness was better maintained. The event concluded with the signing of the handover minutes. With this equipment, Crisp!! Enye-Enye now has more modern, hygienic, and efficient production facilities to strengthen its competitiveness in the market.

e. Evaluation and Monitoring

Training and mentoring for micro businesses “Crisp Enye-Enye” was conducted with the aim of improving knowledge, skills, and business management, covering four main aspects, namely production, human resources (HR), marketing, and management. This initiative was organized in collaboration with partners following thorough coordination and preparation, with a schedule tailored to participants' availability and the operational conditions of their businesses. Attendance rates were consistently high, with participants demonstrating enthusiasm through active engagement in discussions, practical exercises, and question-and-answer sessions.

The success of the program was measured through pre-tests, post-tests, direct observation, and analysis of participants' work results. The evaluation results showed significant improvement, with participants demonstrating the ability to apply standard operating procedures, maintain consistent product quality, and systematically record processes in the production aspect. In the human resources aspect, participants began to understand task distribution and roles, resulting in a more organized and effective workflow. The marketing aspect has made progress with the ability to manage business social media, design more attractive packaging, and develop simple digital promotion strategies. Meanwhile, in the management aspect, participants gained a comprehensive understanding of procedures and licensing requirements, with some even beginning the process of obtaining business

legalization. This success was supported by participants' high commitment to learning, active support from service partners, and the alignment of materials with field needs.

At the end of the program, pre- and post-training assessments showed a significant improvement in participants' understanding of standard operating procedures, business social media management, effective task distribution, and knowledge of business licensing procedures. Although participants' enthusiasm and participation were high during the program, maintaining the implementation of these practices requires ongoing support, particularly in terms of consistency in digital marketing, documentation of production processes, and the completeness of business legal documents. Here is an explanation:

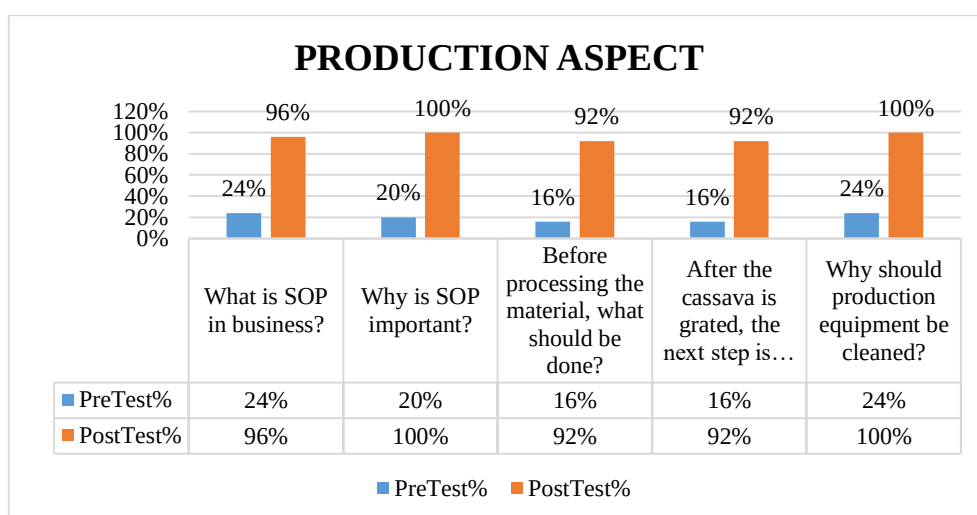


Figure 3: Pre-test and Post-test Results for Production Aspects

Source: (Processed data 2025)

Based on the results of the pre-test and post-test on the aspects of Production and SOP, there was a significant increase in participants' understanding from an average of 20% to 96%, or an increase of 76%. Before the training, participants' understanding of the definition, urgency, and technical steps of SOP was still low, but after the training, almost all participants were able to answer all questions correctly, with some indicators even reaching 100%. The combination of theory, discussion, and hands-on practice proved effective in transferring core knowledge, enabling participants not only to understand the concepts but also to master the correct work procedures to maintain consistent product quality and hygiene. These results form a strong foundation for the sustainable implementation of SOPs in the daily operations of the “Crisp Enye-Enye” business.

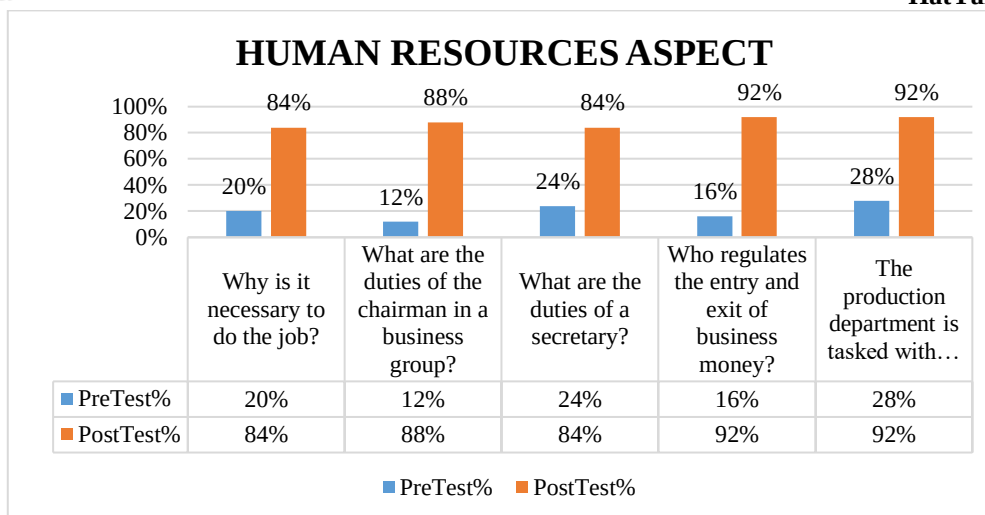


Figure 4: Pre-test and Post-test Results for Human Resource Aspects (Organizational Structure)

Source: (Processed data 2025)

Based on the results of the pre-test and post-test on human resources and organizational structure, there was an increase in participants' understanding from an average of 20% to 88%, or an increase of 68%. Before the training, participants' knowledge of task distribution, the roles of each position, and the functions of the production department was still low, but after the training, all indicators showed a significant increase, with the highest achievement of 92% in understanding the roles of financial managers and the production department. The training method, which combined conceptual explanations, task allocation simulations, and case studies, proved effective in raising awareness of the importance of a clear organizational structure. This understanding is expected to enhance teamwork effectiveness, production efficiency, and the sustainability of the “Crisp Enye-Enye” business.

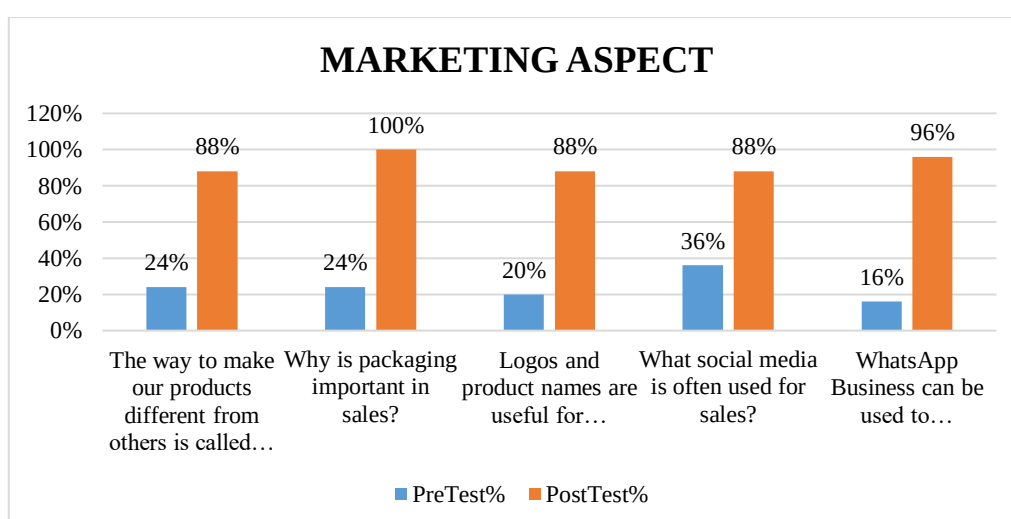


Figure 5: Pre-test and Post-test Results for Marketing Aspects

Source: (Processed data 2025)

Based on the results of the pre-test and post-test on the Marketing aspect, participants' understanding increased from 24% to 92%, or an increase of 68%. Before the training, knowledge related to product differentiation, packaging functions, logos, and the use of digital media was still low, including the use of WhatsApp Business, which was only 16%. After the training, all indicators saw a significant increase, with understanding of the importance of packaging reaching 100% and the use of WhatsApp Business at 96%. Visual learning methods, case studies, and content creation simulations proved effective in equipping participants with digital marketing skills. These results reinforce the importance of updating branding elements and online promotion strategies to expand the market, increase sales, and build the brand image of **“Crisp Enye-Enye”**.

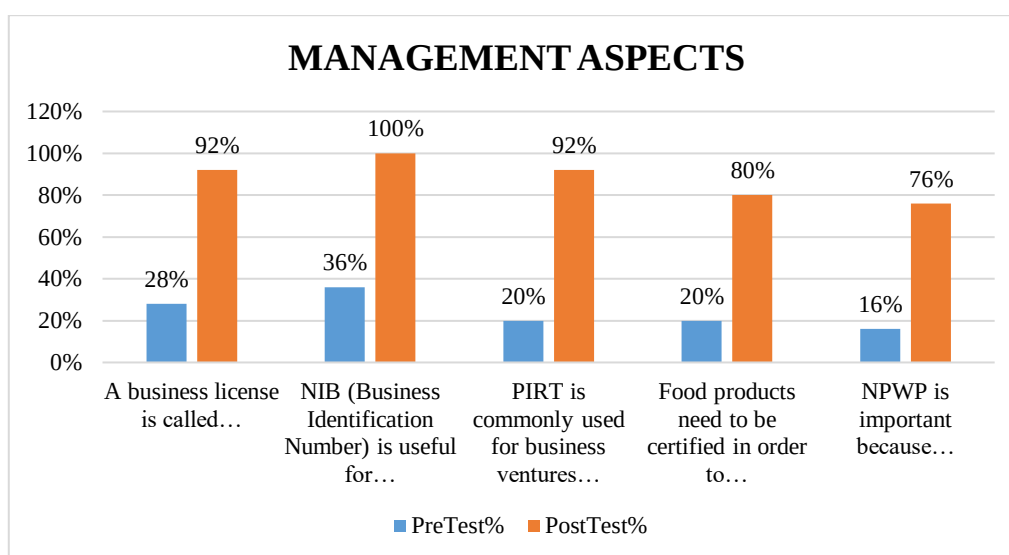


Figure 6: Pre-test and Post-test Results for Management Aspects

Source: (Processed data 2025)

Based on the results of the pre-test and post-test on the Management (Business Legality) aspect, participants' understanding increased from 24% to 88%, or an increase of 64%. Before the training, knowledge related to the types and functions of business legality documents, such as NPWP, PIRT, halal certificates, business licenses, and NIB, was still low. After the training, all indicators showed significant improvement, with understanding of the NIB reaching 100% and business permits and PIRT reaching 92%. The training method, which combined regulatory explanations, case studies, and form-filling simulations, proved effective, enabling participants not only to understand the concepts but also to apply them in practice. These results indicate an increased awareness of the importance of business legality for expanding markets, enhancing credibility, and supporting the sustainability of **“Crisp Enye-Enye”**.

Table 1: Summary Related to the Evaluation of Several Partner Knowledge and Partner Skills Activities

Description	Target	Before PKM	After PKM	Improvement
Knowledge Enhancement				
Production Aspects - SOPs in production and business processes	60%	20%	96%	76%
Human Resources Aspects - Organizational Structure and Job Descriptions	60%	20%	88%	68%
Marketing Aspects - Product differentiation (logo, packaging, etc.) and digital marketing and various digital platforms	60%	24%	92%	68%
Management Aspects - the importance of business legality and how to prepare documents for business legality	60%	24%	88%	64%
Average Increase in Knowledge	60%	22%	91%	69%
Skill Improvement				
Production Aspects - developing SOPs and compiling Production SOPs	60%	16%	100%	84%
Human Resources Aspects - developing organizational structure and job descriptions, and establishing the organization and job descriptions	60%	12%	96%	84%
Marketing Aspects - Product differentiation activities (logo design, packaging, etc.) and creation of digital accounts for marketing purposes.	60%	24%	100%	76%
Management Aspects - preparing documents for business legality purposes	60%	20%	84%	64%
Average Improvement in Skills	60%	18%	95%	77%

Source: (Processed data 2025)

Based on the evaluation of activities, there has been a significant increase in partners' knowledge in various aspects. In terms of production, understanding of SOP development in production and business processes increased from 20% to 96%, or a 76% increase. In the human resources aspect, understanding of organizational structure and job descriptions increased from 20% to 88%, a rise of 68%. In the marketing aspect, knowledge related to product differentiation, such as logos, packaging, and digital marketing across various

platforms, increased from 24% to 92%, a rise of 68%. Meanwhile, in the management aspect, understanding of the importance of business legality and the preparation of legal documents increased from 24% to 88%, or an increase of 64%. Overall, partners' knowledge increased from an average of 22% to 91%, or an increase of 69%.

In addition, the evaluation of partners' skills also showed positive results. In terms of production, the ability to develop and complete production SOPs increased from 16% to 100%, or an increase of 84%. In terms of human resources, the ability to develop organizational structures and job descriptions increased from 12% to 96%, or an increase of 84%. In the marketing aspect, the skill of differentiating products and creating digital marketing accounts increased from 24% to 100%, or an increase of 76%. In the management aspect, the skill of developing business legal documents increased from 20% to 84%, or an increase of 64%. Overall, partner skills increased from an average of 18% to 95%, or an increase of 77%.

Furthermore, in addition to improvements in skills and knowledge, there has also been an increase in income. The Crisp!! Enye-Enye micro-enterprise in Mekaragung Village initially produced goods traditionally and sold them in semi-finished form. Through the PKM program, the partner received training, mentoring, packaging innovation, appropriate technology support, as well as strengthening in digital marketing and business legality. As a result, knowledge increased by an average of 69% and skills by 70%. Weekly income from 180 kg of cassava rose from Rp7,385,000 to Rp22,155,000 (200%), exceeding the 100% increase target.

Table 2: Increase in Income

Before PKM (1 Week Production) activities	PKM Activity Targets	Increase in Revenue
a. Raw Material: 180 kg Cassava	a. Raw Material: 180 kg Cassava	a. Raw Material: 180 kg Cassava
b. Processed into Dried Enye-Enye: 80 kg	b. Processed into Dried Enye-Enye: 80 kg	b. Processed into Dried Enye-Enye: 80kg
c. Fried into Enye-Enye: 96 kg or 96,000g	c. Fried into Enye-Enye: 96 kg or 96,000 g	c. Fried into Enye-Enye: 96 kg or 96,000g
d. Seasoned into: 114 kg	d. Seasoned into: 114 kg	d. Seasoned into: 114 kg
e. Number of Packages: 1,477 packs / 65g	e. Number of Packages: 1,477 packs / 65 g	e. Number of Packages: 1,477 packs / 65g
f. Old Packaging Price: IDR 350,-	f. Packaged into new packaging (Standing Pouch)	f. New Packaging Price: Rp. 2,500,-
g. Price Per Package: IDR 5,000		g. Price Per Package: Rp. 15,000
Revenue (1477 x Rp. 5.000) = Rp. 7.385.000	Revenue Target (Increase by 100%) = Rp. 14,770,000	Revenue with New Packaging (1,477 x Rp. 15,000) = Rp. 22,155,000
Revenue Increased by 200%		

Source: (Processed data 2025)

Conclusion

The International Community Service Collaboration Program (KPI) implemented between the Jakarta Veteran National Development University, Thaksin University, and micro-business partner Crisp!! Enye-Enye has had a significant impact on increasing production capacity, strengthening human resource management, optimizing digital marketing, and fulfilling business legality. Through the implementation of Standard Operating Procedures (SOPs), the use of appropriate technology, organizational restructuring, packaging design updates, and the creation of digital business accounts, the partner was able to improve operational efficiency, expand market reach, and strengthen brand identity.

The evaluation results show an increase in partners' knowledge in the areas of production (76%), human resources (68%), marketing (68%), and management (64%). This improvement not only impacts product quality and business competitiveness but also opens up broader market opportunities, including the potential for expansion into the ASEAN region. This program also makes a tangible contribution to achieving several Sustainable Development Goals (SDGs), particularly in reducing poverty, promoting inclusive economic growth, fostering innovation based on local wisdom, reducing inequality, and strengthening global partnerships.

Overall, digitalization-based interventions integrated with the preservation of local wisdom have proven to be an effective strategy in empowering MSMEs. This mentoring model has the potential to be replicated in other regions with similar characteristics to encourage sustainable, market-oriented community-based business development.

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ANALYSIS OF DOMESTIC SOLID WASTE DISTRIBUTION IN TELUK LIKAS, KOTA KINABALU, SABAH

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Abstract: *The increase in solid waste generation led to the negative impacts on the environmental ecosystem, particularly in aquatic areas. Therefore, this study was conducted to examines the distribution and characteristics of domestic solid waste contributing to leakage into the coastal waters of Teluk Likas, Kota Kinabalu. Field surveys were conducted at 13 identified locations along the coast to record waste type, relative quantity, and sources of solid waste and surrounding human activities. The findings revealed that plastic waste constituted the highest category of solid waste, ranging from 1 to 15 kilograms at each hotspot location. The analysis also found that the primary source of solid waste in the study area originated from household waste. These findings are expected to serve as a reference for local authorities in formulating more effective and sustainable solid waste management strategies.*

Keywords: *domestic solid waste, GIS, distribution, Teluk Likas, plastic*

Introduction

The environment represents an invaluable natural asset entrusted to humanity to be protected, managed, and sustained. Nevertheless, the accelerated pace of development in the 21st century has significantly transformed natural landscapes worldwide. In the pursuit of economic gain, ecosystem balance is often overlooked, as development projects frequently alter or replace natural physical characteristics. Such trade-offs are difficult to avoid, given that development commonly entails the conversion or loss of natural areas as an opportunity cost. Consequently, the progressive reduction of natural environments in favor of development has contributed to escalating levels of environmental degradation, now considered to be a matter of serious concern.

In Malaysia, the latest population estimate is about 34.1 million people, with an annual growth rate of 2.0 percent (Department of Statistics Malaysia, 2024). This growth has caused many natural areas, especially forests, to be cleared for industry, administration, and housing. As a result, the natural environment has been degraded, and at the same time, the amount of solid waste produced by the population has increased.

Solid waste management is a common problem, especially in cities. Therefore, the production of solid waste, particularly household waste, should be reduced so that the government does not have to spend too much on its management. Waste management covers all stages, from collection and storage to transportation and disposal. Even though the total cost of managing solid waste is very high, the fees charged to the public are much lower than the real cost. Because of this, local authorities face difficulties in improving services for the community. The main challenges include lack of funds, high operating costs, shortage of vehicles, limited manpower, and insufficient equipment (Hasnah et al., 2012).

Therefore, this study was conducted to examine the distribution and characteristics of domestic solid waste contributing to leakage into the coastal waters of Teluk Likas, Kota Kinabalu.

Literature Review

Solid Waste

Solid waste management has become one of the major problems faced by society. The rapid increase in solid waste generation due to population growth is a key factor contributing to the reduction of landfill lifespan. At present, Malaysia relies heavily on landfills to manage nearly 95 percent of the solid waste produced. This issue has become more critical with recent statistics showing that only 165 out of 296 landfill sites in the country remain operational (Utusan Online, 2017). In 2013, Malaysia recorded the disposal of nearly 33,000 metric tonnes of waste per day, which cost RM1.2 billion in waste collection operations. On average, each individual generates 0.8 kg of waste per day, while in major cities such as Kuala Lumpur, the average waste generated per person reaches 1.25 kg per day (Mymetro, 2016).

By 2017, the amount of solid waste produced in Malaysia had increased to 37,000 metric tonnes per day, equivalent to 13.5 million tonnes annually (Utusan Online, 2017). These statistics indicate that the problem of waste generation and solid waste management in the country is not decreasing but rather growing alongside the nation's economic development. The increasing volume of solid waste calls for new approaches in technology and management systems to effectively address this issue.

Therefore, the management of domestic and industrial waste is crucial to protecting the environment and ensuring sustainability as well as the quality of life for society. Solid waste management in urban areas is also regarded as a global issue. Reducing domestic waste generation should be prioritized to lessen the financial burden on the government. The cost of solid waste management, which includes collection, storage, transportation, and disposal, is extremely high. Although high management costs should encourage the development of more efficient waste management systems, the fees imposed on the public are much lower than the actual cost. This situation makes it difficult for local authorities to improve service quality due to limitations in funding, workforce, vehicles, and equipment (Hasnah et al., 2012). In addition, the shortage of suitable landfill sites further contributes to the challenges of waste management in Malaysia (Hasnah et al., 2012).

Methodology

Study Area

This study will be conducted in the Likas Bay area (figure 1) which is located 5 km from the Kota Kinabalu City Centre. Likas Bay is a focus among tourists and residents as a location for leisure activities, swimming, fishing and fishing activities by fishermen. There is a recent study by Abd Rahman et al (2024) which proves that the Likas Bay area has been exposed to solid waste pollution, especially microplastics. Because this area has aesthetic value to the local community as a location to find peace and recreation, it is important to ensure that the Likas Bay ecosystem is maintained. Therefore, this study is conducted in this area to ensure that the ecosystem of the marine waters of Likas Bay will be safer and more secure from solid waste pollution



Figure 1: Study area

Source: (Google earth, 2025)

Methodology

Field observations were conducted at 13 locations that had been identified as waste accumulation points. The All-in-One Offline Maps application was utilized as the primary data acquisition tool, as it enables the simultaneous recording of geographic coordinates and the classification of domestic waste observed on-site. One of the key advantages of this application is its ability to function without an internet connection, thereby ensuring efficiency and reliability during fieldwork. In addition to geospatial data collection, the application facilitates the documentation of samples through photographs and audio-visual recordings, providing visual references directly linked to the recorded coordinates.

During the survey, data on domestic solid waste were collected with a focus on three aspects: the source of the waste, the type of waste, and the estimated weight or size. The first parameter recorded was the **type of waste**, categorized into plastics, paper, textiles, metals, glass, rubber, and other miscellaneous items. The second parameter was the **weight or size of waste**, which

was estimated based on practical indicators: load trolley (large accumulation), full plastic bag (medium accumulation), and small portion (minor accumulation). These categories offered a consistent framework for comparing the relative volume of waste across sites. This combined approach allowed for both qualitative and semi-quantitative assessments of domestic solid waste in Teluk Likas

Results & Discussions

The results of this study provide clear evidence that solid waste leakage into the waters of Teluk Likas is a multifaceted problem, influenced by both human behavior and limitations in waste management infrastructure. A total of 13 contributing locations were identified, with domestic and household activities emerging as the dominant sources. The particularly high percentages recorded for “domestic” (96.77%) and “household” (193.94%) waste underscore the critical role of residential areas in exacerbating marine litter. This finding is consistent with previous studies that highlight the significance of household waste as a major contributor to marine pollution in coastal communities (Jambeck et al., 2015; Chen et al., 2021).

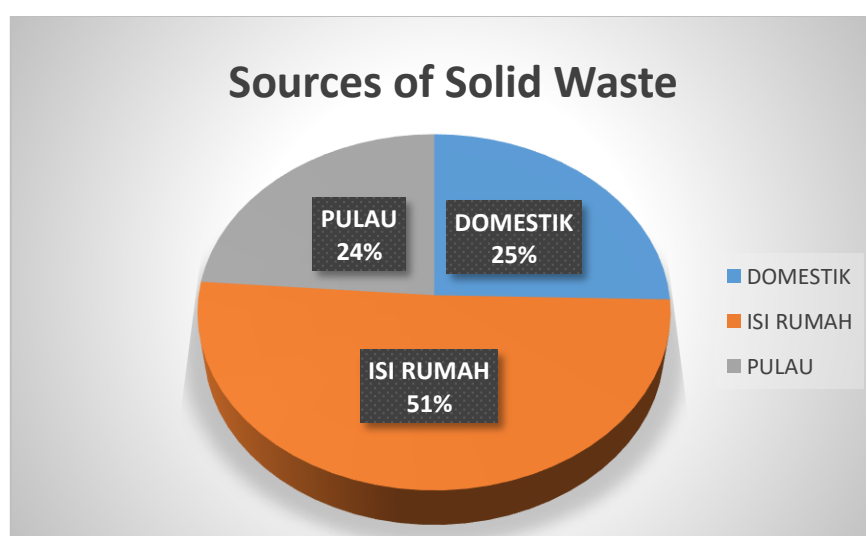


Figure 2: Sources of Solid Waste

In addition, waste contributions from island communities (90.67%) reveal a further dimension of the challenge. Limited accessibility and inadequate formal collection services in island settlements may intensify waste leakage into nearby waters. Similar issues have been reported in small island developing states (SIDS), where the logistical difficulties of waste transport and processing hinder effective management (Kershaw & Rochman, 2015; Maharana et al., 2022). This highlights the need for more targeted interventions in geographically isolated areas, where waste management challenges are amplified.

The classification of waste into categories such as “burdened trolleys” (0.34%), “full plastic bags” (1.21%), and “small quantities” (100.80%) illustrates the varying scales of waste input. While larger waste items clearly pose visible threats, the overwhelming proportion attributed to small, incremental littering suggests that persistent, low-level disposal practices are collectively more detrimental in the long term. This pattern reinforces the importance of

addressing not only large-scale illegal dumping but also daily behaviors that contribute to the cumulative waste burden (Willis et al., 2017).

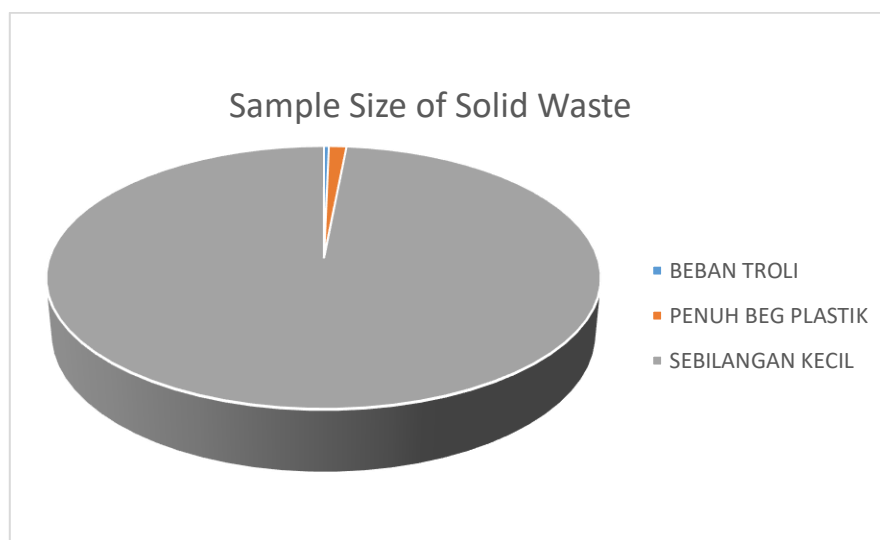


Figure 3: Sources of Solid Waste

Despite ongoing government efforts to curb the discharge of solid waste into marine environments, the persistence of the problem indicates that infrastructural initiatives alone are insufficient. Community cooperation, awareness, and behavioral change are essential complements to policy and enforcement measures. Without the active participation of local populations, government-led initiatives risk being ineffective or unsustainable (UNEP, 2016; Tudor et al., 2019).

Overall, the findings underscore the urgent need for an integrated solid waste management approach that combines structural improvements with community engagement. Policies must address both large and small-scale sources of leakage, while also considering the unique challenges faced by island and coastal settlements. Such strategies are crucial not only for reducing the visible solid waste burden in Teluk Likas but also for safeguarding the ecological integrity and long-term sustainability of coastal and marine ecosystems.

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ENTREPRENEURIAL LEADERSHIP AND DYNAMIC CAPABILITIES FOR KNOWLEDGE-DRIVEN INNOVATION IN ACADEMIC LIBRARIES

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Abstract: *This paper maps and conceptually analyses the integration of Entrepreneurial Leadership (EL), Dynamic Capabilities (DC), and the Knowledge-Based View (KBV) as drivers of innovation and strategic renewal in academic libraries, with a focus on Malaysian higher education. It synthesizes earlier seminal works and incorporates insights from a bibliometric mapping of 80 Scopus-indexed publications (2020–2024). VOSviewer was applied to visualize co-authorship networks, thematic clusters, and citation linkages, while thematic coding identified theoretical, contextual, and competency gaps. The analysis reveals a persistent fragmentation: EL, DC, and KBV are each conceptually mature but remain insufficiently integrated within a unified framework. The bibliometric mapping indicates leadership-oriented terms establishing isolated clusters with limited overlap with capability- and knowledge-based themes. Malaysian studies emphasize operational and technical aspects, while leadership is rarely positioned as a strategic driver of institutional transformation. The study positions EL as the strategic driver that mobilizes vision and resources, DC as the operational enabler that translates intent into adaptive action, and KBV as the knowledge-based outcome. This triadic configuration, contextualized to Malaysian academic libraries, addresses the global integration gap and offers a transferable framework for innovation in knowledge-intensive public sector organizations. Practically, the proposed framework guides library leaders and policymakers in designing leadership development initiatives, capability-building strategies, and knowledge management practices that align with local governance while supporting national higher education and innovation agendas.*

Keywords: *Entrepreneurial Leadership, Dynamic Capabilities, Knowledge-Based View, Academic Libraries, Bibliometric Analysis, Malaysia*

Introduction

Academic libraries are undergoing rapid transformation driven by technological change, evolving scholarly communication patterns, and rising expectations to contribute strategically to institutional and societal goals. Millions of people aged 55 and above remain offline, with age emerging as the strongest predictor of digital exclusion, followed by income and education (Dezuanni et al., 2024). This digital divide highlights the urgency for libraries to shift from custodial roles to active engagement with digital scholarship, research data management, open

science, and cross-sector collaboration. These shifts are most evident in knowledge-based economies, where higher education institutions (HEIs) are evaluated on their capacity to mobilize knowledge into innovation and socio-economic outcomes.

In Malaysia, this transformation is guided by frameworks such as the Malaysian Education Blueprint (Higher Education) 2015–2025, Malaysia MADANI, and Industry 4.0 (IR4.0), which emphasize innovation, internationalization, and the development of a knowledge-driven society. Academic libraries are expected to align with these agendas by strengthening research ecosystems, enabling entrepreneurial activity, and advancing the Sustainable Development Goals (SDGs). Meeting these expectations requires leadership that can reposition services, foster organizational agility, and sustain relevance in competitive higher education environments (Zainal et al., 2023; Rahim et al., 2022).

Three theoretical perspectives—Entrepreneurial Leadership (EL), Dynamic Capabilities (DC), and the Knowledge-Based View (KBV)—offer a mutually reinforcing framework for navigating this complexity. EL emphasizes opportunity recognition, calculated risk-taking, and resource mobilization, equipping library leaders to anticipate emerging needs and initiate innovation (Renko et al., 2015; Carpenter, 2012). DC operationalizes this intent by enabling organizations to sense trends, seize opportunities, and reconfigure processes to sustain competitiveness (Teece, 2018; Jadhav et al., 2023). KBV underpins both by positioning knowledge as the central strategic asset, emphasizing its creation, organization, dissemination, and application as the basis for innovation (Kasemsap, 2016; Hussain & Li, 2022). Together, KBV provides the intellectual capital, EL directs its strategic mobilization, and DC ensures adaptive renewal, forming a robust lens for examining leadership and innovation in academic libraries.

Although the complementarity of EL, DC, and KBV is recognized in broader organizational research, their integration in academic libraries remains limited. International studies often examine these constructs in isolation—for example, leadership styles without capability mechanisms, capability frameworks without leadership drivers, or knowledge management practices without strategic alignment—thereby constraining understanding of how they interact to shape innovation outcomes. Leadership models informing libraries are also predominantly derived from Western HEIs, where governance and resource contexts differ substantially from Malaysian public universities. Applying these models directly risks overlooking constraints shaped by national policy priorities, public service culture, and centralized governance. Frameworks such as the Dynamic Capabilities of Academic Libraries (DCAL) (Zainal et al., 2023) and ENTRELEAD (Aslam, 2020) provide useful starting points but remain empirically untested in Malaysian contexts, particularly in combination.

Since 2019, pressures on Malaysian academic libraries have intensified with digital disruption, fiscal constraints, and rising performance benchmarks. Libraries have introduced digital platforms, community engagement initiatives, and research support services, yet barriers such as outdated infrastructure, skills gaps, and limited strategic support continue to hinder sustained innovation. Existing Malaysian studies largely emphasize technical and operational aspects (automation, system upgrades) rather than leadership as a strategic. Leadership research often confines analysis to transformational or transactional styles, overlooking how leadership interacts with knowledge assets and organizational agility (Ashiq et al., 2018). Empirical work on EL in Malaysian libraries remains sparse, and little is known about how leaders build the

capacity to sense, seize, and transform in alignment with institutional and national agendas (Sa'ari & Goulding, 2024).

Methodologically, much of the existing literature relies on narrow surveys or descriptive approaches, limiting insights into the complexity of leadership–capability–innovation dynamics. As a result, the lived experiences, strategies, and decision-making processes of library leaders remain underrepresented (Zainal et al., 2023). Theoretically, a model integrating EL, DC, and KBV in Malaysian academic libraries has yet to be empirically validated. Most existing studies address these constructs separately, leaving the interaction between leadership, capabilities, and knowledge assets under-theorized (Zainal et al., 2023; Sa'ari & Goulding, 2024; Jadhav et al., 2023; Koloniari et al., 2018; Sahibzada et al., 2020; Ashiq et al., 2019).

This study addresses the gap by systematically examining how EL and DC, underpinned by KBV, can be mobilized to transform academic libraries within Malaysia's policy, cultural, and operational realities. The objectives are threefold: (1) to map the empirical and conceptual literature on EL, DC, and KBV in academic library contexts globally and in Malaysia through bibliometric analysis; (2) to identify theoretical, contextual, and competency-building gaps that limit integrated understanding of EL–DC–KBV dynamics in knowledge-intensive service environments; and (3) to develop a policy-relevant integrated framework that positions EL as the strategic driver, DC as the operational enabler, and KBV as the knowledge-based outcome tailored to Malaysian academic libraries.

This paper proceeds with a literature review outlining the theoretical foundations and empirical studies on EL, DC, and KBV. It then explains the research methodology, presents bibliometric findings and thematic results, and discusses implications for theory, policy, and practice before concluding with key takeaways, limitations, and directions for future research.

Literature Review

EL is defined as a proactive, opportunity-driven, and innovation-oriented approach adopted by academic library leaders to navigate institutional complexity and drive meaningful change. It involves developing new organizational structures, creating innovative services, and fostering partnerships that enhance the library's strategic role within the university ecosystem (Carpenter, 2012; Pothier, 2019). EL emphasizes the capacity to recognize opportunities, take calculated risks, and mobilize resources for innovation (Renko et al., 2015; Gupta, MacMillan, & Surie, 2004). This orientation positions leaders as visionary change agents who support priorities such as student entrepreneurship, research commercialization, and interdisciplinary collaboration. In Malaysia, EL is crucial for repositioning libraries as institutional partners that enable innovation and contribute to university transformation agendas (Sa'ari & Goulding, 2024).

EL provides a foundation for linking leadership with the KBV. Entrepreneurial leaders create conditions where knowledge is recognized, organized, and mobilized as a strategic asset. By fostering collaboration and experimentation, they transform knowledge into institutional resources that drive innovation and relevance, embedding KBV into organizational practices and outcomes.

KBV frames knowledge as the primary asset for achieving sustained competitive advantage, emphasizing processes of creation, organization, dissemination, and utilization (Kasemsap, 2016; Koloniari, Vraimaki, & Fassoulis, 2019). In higher education institutions (HEIs), these processes underpin adaptability and innovation, with KBV-driven environments fostering collaborative cultures, continuous learning, and ICT-enabled knowledge flows (Koloniari et al., 2018; Gunjal, 2023; Jiang, Liu, & Liu, 2024; Jain, 2015). Globally, KBV has been operationalized through integrated knowledge management (KM) frameworks, such as GC@BU, which align learning commons, coordination mechanisms, and resource management with institutional objectives (de Bem et al., 2016; Xiao, 2020). Empirical research shows that leadership strengthens KBV-based KM practices, improving cooperation, innovation, and entrepreneurial success (Jain, 2015; Hussain & Li, 2022). In academic libraries, staff competencies, ICT readiness, and shared vision predict knowledge performance (Shoid & Kassim, 2014), yet tacit knowledge networks remain underutilized, and KM strategies are rarely integrated with entrepreneurship agendas.

DC further extend this perspective, representing the organization's ability to sense opportunities, seize them through strategic action, and reconfigure resources for sustained competitiveness (Teece, 2018; Jadhav & Shenoy, 2022). In HEIs and libraries, DC supports agility, service relevance, and adaptation to disruption (Baba & Abrizah, 2018). Empirical studies demonstrate DC's mediating role between leadership and performance: Nguyen, Han, and Pham (2024) show this in ICT-SMEs, while Farzaneh et al. (2023) confirm that knowledge-based DC enhance innovation outcomes. Similar findings emerge in knowledge-intensive organizations, where DC connects leadership vision with innovation processes to sustain advantage (Wong, 2021). From an innovation perspective, DC enables both exploratory and exploitative innovation, integrating knowledge resources in line with KBV principles (Hernández-Linares et al., 2024).

The interaction of EL, KBV, and DC remains underexplored in Malaysian academic libraries. While global research highlights their complementarity, most studies examine them in isolation, and empirical integration is scarce. Although KBV-linked practices improve service quality and adaptability (Koloniari et al., 2018; Gunjal, 2023) and leadership has been shown to influence knowledge sharing and innovation (Ashiq et al., 2019; Davis & Macauley, 2011), the causal pathways to measurable innovation outcomes remain unclear. This gap limits theoretical refinement and the development of leadership strategies tailored to knowledge-intensive educational settings (Wong & Chan, 2018; Aslam, 2020).

To consolidate these insights, empirical studies can be grouped into two tiers: Tier 1 ("Core Empirical") includes those that directly test relationships among EL, DC, and KBV using data-driven methods; Tier 2 ("Supporting") encompasses works providing indirect evidence, theoretical grounding, or contextual insights. Together, this body of work establishes EL as the strategic driver, DC as the capability mechanism, and KBV as the outcome, offering a coherent framework for examining innovation in Malaysian academic libraries.

Table 1: Core Empirical Evidence on EL, DC, and KBV in Academic Libraries and Higher Education (2011–2025)

Construct/Theory-Based	Author(s) & Year	Context	Key Dimensions	Key Findings
KBV	Sahibzada et al. (2020)	Chinese HEIs	Knowledge creation; utilization	KBV processes mediate the leadership–performance link, positioning KBV as a dependent variable connecting EL and DC.
	Koloniari et al. (2018)	Academic libraries	Knowledge creation; organization; dissemination	KBV fosters a collaborative culture that supports innovation.
	Hussain & Li (2022)	Higher education	Knowledge management processes	Leadership strengthens KBV-based practices, enhancing entrepreneurial success.
	Shoid & Kassim (2014)	Malaysian academic libraries	Staff competencies; ICT readiness; shared vision	Competencies, ICT readiness, and vision predict KBV performance in libraries.
EL	Sa’ari & Goulding (2024)	Malaysia & UK libraries	Strategic thinking; systems thinking; opportunity recognition	Entrepreneurial competencies are critical for repositioning libraries strategically.
	Carpenter (2012)	US libraries	Visionary orientation; proactive behavior	EL drives structural change, partnerships, and innovation capacity.
	Renko et al. (2015)	Multi-sector incl. HE	Vision; innovation; risk-taking	Developed and validated 8-item EL scale, providing a reliable measure for EL.
DC	Jadhav et al. (2023)	Academic libraries	Sensing; seizing; transforming	DCAL model links dynamic capabilities to service quality in libraries.
	Baba & Abrizah (2018)	Malaysian academic libraries	Sensing; transforming	DC enhances service relevance and strategic positioning.
	Nguyen, Han, & Pham (2024)	ICT-SMEs	Leadership–performance mediation	DC mediates the leadership–performance relationship.
	Farzaneh et al. (2023)	Multi-sector	Knowledge-based DC	DC significantly improves innovation performance, reinforcing the KBV–DC link.

Table 1 consolidates Tier 1 core empirical studies that directly operationalize Entrepreneurial Leadership (EL), Dynamic Capabilities (DC), and the Knowledge-Based View (KBV) within higher education and library contexts. These studies provide the strongest empirical foundation for the integrated framework. Complementing these are Tier 2 supporting works, which offer broader theoretical and contextual insights. For example, Ashiq et al. (2019) and Davis & Macauley (2011) highlight how visionary and relationship-based leadership traits foster knowledge sharing and collaboration. Global studies further illustrate EL's role in driving makerspaces, digital transformation, and innovation ecosystems (Stover et al., 2019; Kim, 2020; Kim, 2021), while DC has been linked to resilience and adaptive renewal across knowledge-intensive organizations (Aslam, 2020; Wong & Chan, 2018). These supporting studies enrich understanding of the institutional, cultural, and policy conditions under which EL–DC–KBV dynamics can be applied, particularly in Malaysian higher education.

Research Gaps and Rationale

The preceding synthesis in Table 1 has established how Entrepreneurial Leadership (EL), Dynamic Capabilities (DC), and the Knowledge-Based View (KBV) have been operationalized across various organizational settings, including small and medium-sized enterprises (SMEs), information and communication technology (ICT) ventures, higher education institutions (HEIs), and academic libraries. Collectively, these studies reinforce a consistent pattern in which EL functions as an independent variable, DC operates as a mediating capability mechanism, and KBV outcomes are positioned as dependent variables. However, despite the breadth of empirical evidence, several areas of theoretical and contextual fragmentation remain, shaping the contribution of the present study.

First, the absence of integrated models is evident. Existing research frequently treats EL, DC, and KBV in isolation, with limited attempts to examine their interplay within a unified conceptual framework (Sa'ari & Goulding, 2024; Jadhav et al., 2023). This lack of integration constrains the ability to explain how leadership behaviours translate into knowledge-based advantages through capability renewal processes. Second, context-specific limitations persist in the literature. Much of the empirical foundation derives from Western HEIs, where governance structures, policy frameworks, and resource environments differ significantly from those in Malaysia and the broader Southeast Asian region (Sa'ari et al., 2018; Shehata & Eldakar, 2023). Consequently, regionally relevant insights into how EL–DC–KBV dynamics unfold in public university libraries remain scarce.

Third, competency-building challenges are underexplored. Keyword co-occurrence analysis revealed the absence of terms such as 'competency' or 'skills development', reinforcing this thematic gap. While strategic thinking dimensions such as intent focus, systems thinking, and intelligent opportunity recognition have been linked to innovation outcomes in libraries (Zainal et al., 2023; Sa'ari & Goulding, 2024), empirical work on how these competencies are cultivated and sustained in Malaysian academic libraries is limited (Ashiq et al., 2019). Without such evidence, it is difficult to design leadership development interventions that effectively embed entrepreneurial behaviours into institutional practice. Finally, uncertain performance pathways hinder theoretical refinement. Although DC has been repeatedly associated with improved service relevance, innovation, and organizational agility (Baba & Abrizah, 2018; Wong & Chan, 2018), the mediating role of EL and the moderating influence of KBV in these

relationships remain insufficiently tested, particularly in knowledge-intensive service environments such as academic libraries (Hernández-Linares et al., 2024; Tariq et al., 2024).

By addressing these interlinked gaps, the present study proposes an integrated EL–DC–KBV framework that positions leadership-driven knowledge mobilization as a pathway to sustainable innovation, strategic collaboration, and competitive positioning in Malaysian academic libraries. To achieve this, the study employs a bibliometric approach to systematically map the empirical and conceptual landscape of EL, DC, and KBV, as well as related constructs, within academic library contexts. Given the fragmented and context-specific nature of existing studies, bibliometric analysis facilitates the consolidation of global and Malaysian evidence, the identification of thematic clusters, and the recognition of influential authors, institutions, and sources. This mapping provides the empirical foundation for conceptualizing an integrated EL–DC–KBV framework tailored to Malaysian academic libraries.

Based on the synthesis of prior studies, this paper proposes an integrated EL–DC–KBV framework tailored for academic libraries (Figure 1). In this configuration, EL functions as the strategic driver that mobilizes vision, resources, and opportunity recognition; DC serve as the operational mechanism that translates leadership intent into adaptive sensing, seizing, and transforming actions; and KBV anchors the process by positioning knowledge creation, organization, and utilization as the ultimate outcome of innovation. This triadic pathway reflects the interdependence of leadership intent, capability renewal, and knowledge mobilization, while situating Malaysian academic libraries within broader policy and governance contexts.

From this framework, several guiding propositions can be articulated for future empirical testing:

- P1: EL positively influences the development of DC by shaping opportunity recognition, strategic orientation, and resource mobilization.
- P2: DC mediate the relationship between EL and KBV outcomes, enabling leadership intent to translate into sustained innovation and service adaptability.
- P3: KBV outcomes strengthen innovation by embedding knowledge creation, organization, and utilization into adaptive practices aligned with institutional and national agendas.

In this framework, EL is conceptualized as the independent variable, DC as the mediating mechanism, and KBV as the dependent variable. Together, this triadic pathway explains how leadership intent is translated into adaptive action and knowledge-driven innovation within Malaysian academic libraries. While KBV represents the theoretical outcome, its practical manifestations include Innovation & Strategic Outcomes, such as service relevance, strategic positioning, and SDG alignment.

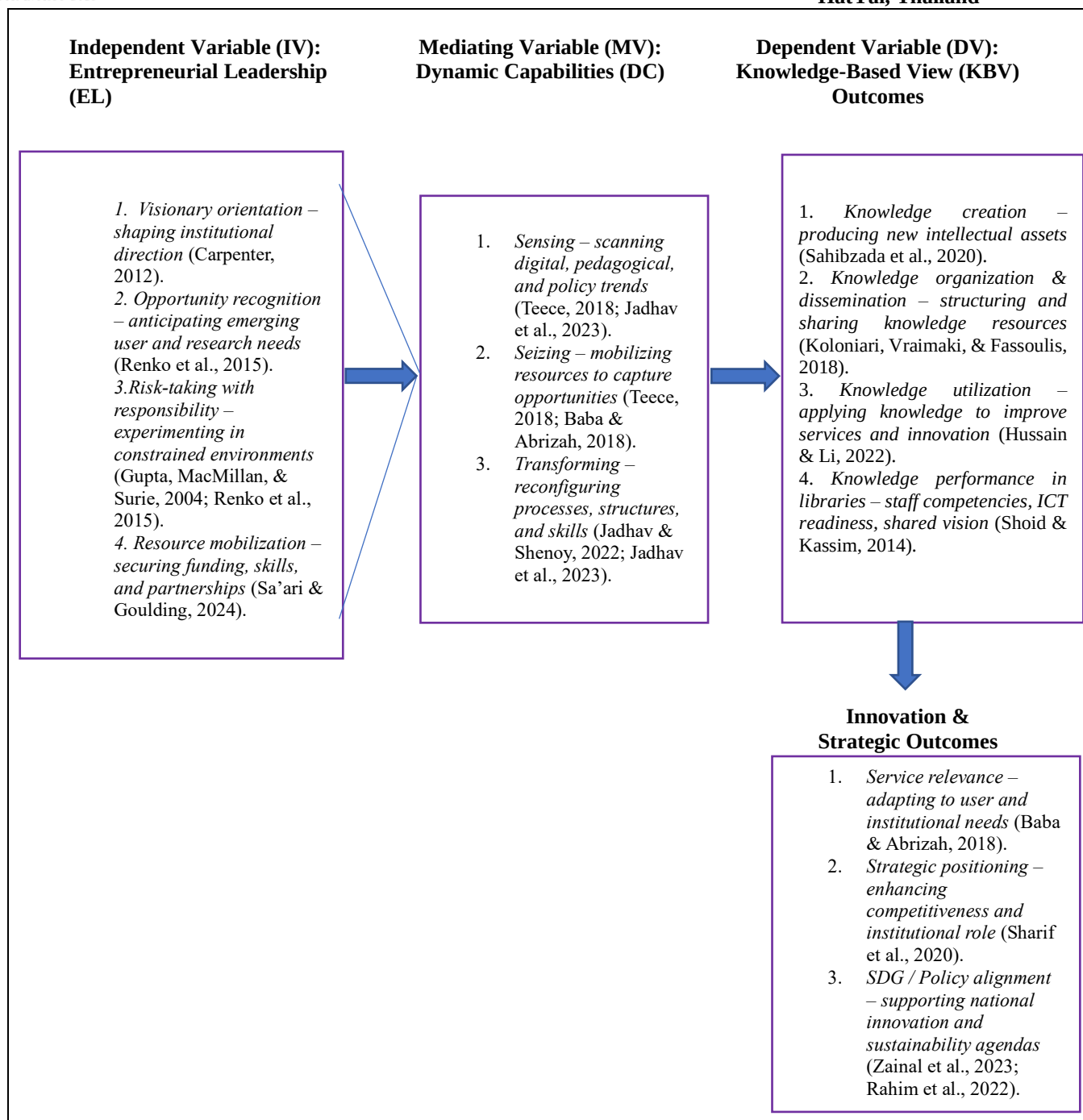


Figure 1: Integrated EL–DC–KBV Framework and Innovation Outcomes for Academic Libraries

Methodology

Research Design

This study combines bibliometric mapping with a conceptual synthesis of seminal and recent literature to propose an integrated EL–DC–KBV framework for Malaysian academic libraries over the period 2020–2024. Bibliometric analysis was selected because prior reviews showed that research on EL–DC–KBV in academic library contexts is fragmented, with limited

integration across theoretical perspectives and geographies. Unlike traditional systematic reviews or meta-analyses, bibliometric methods provide both descriptive and network-level insights, capturing publication trends, influential contributors, thematic clusters, and collaboration networks in ways that manual review alone cannot achieve (Ellegaard & Wallin, 2015). This approach is particularly suitable for EL–DC–KBV research, which spans leadership studies, knowledge management, and information science.

The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and replicability in data collection and screening (Page et al., 2021). VOSviewer software (van Eck & Waltman, 2010) was used to construct and visualize bibliometric networks such as co-authorship, keyword co-occurrence, and citation linkages, which form the empirical basis for developing the integrated EL–DC–KBV framework.

Data Source and Search Strategy

The dataset was retrieved from Scopus on 12 August 2025. Scopus was chosen as it is the largest abstract and citation database of peer-reviewed literature, with broad coverage and reliable metadata, making it the most common source for bibliometric mapping (Harzing & Alakangas, 2016; Herrera-Franco et al., 2020). Its interoperability with VOSviewer supports accurate extraction of bibliographic data.

The search strategy focused on EL in library and information management contexts, which served as the entry point for examining links with DC and KBV. While the bibliometric search string centred on entrepreneurial leadership, constructs of dynamic capabilities and the knowledge-based view were systematically identified during the screening and coding process. This approach ensured coverage of integrative studies while capturing bibliometric density in the most developed strand of research (EL). To maximize coverage, the Boolean query applied truncated terms:

```
TITLE-ABS-KEY (entrepreneurial* AND librar*)  
AND PUBYEAR > 2019 AND PUBYEAR < 2025  
AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE,  
"re"))  
AND (LIMIT-TO (LANGUAGE, "English"))
```

The inclusion of “entrepreneurial*” captured references to entrepreneurial leadership and related constructs (e.g., entrepreneurial orientation, entrepreneurial skills), while “librar*” retrieved studies on libraries, librarianship, and related settings. Constructs such as DC and KBV were incorporated at the screening and coding stage to avoid excluding relevant publications that may not explicitly reference these terms in titles, abstracts, or keywords.

The initial search yielded 250 records. After PRISMA-based screening of titles, abstracts, and keywords, records were included if they addressed entrepreneurial leadership in a library or information management context, were empirical or conceptual studies published in peer-reviewed outlets, and were written in English. Records were excluded if they were non-academic (e.g., reports, editorials, theses) or did not directly address entrepreneurial leadership

in library contexts. Following this process, 80 records were retained, forming the empirical dataset for mapping publication trends, thematic structures, and collaboration networks.

Data Analysis

Trend by Year Analysis

The annual publication trend for entrepreneurial leadership and library-related research between 2020 and 2024 reveals distinct fluctuations. Output peaked in 2020 with 20 documents, followed by a gradual decline through 2021 (19 documents), 2022 (12 documents), and reaching its lowest point in 2023 (9 documents). This contraction may reflect shifting research priorities during the pandemic and its immediate aftermath, as well as delays in project execution and publication pipelines.

In 2024, output rebounded sharply to match the 2020 peak of 20 publications. This resurgence likely aligns with post-pandemic strategic initiatives, renewed funding streams, and heightened institutional emphasis on innovation, digital transformation, and leadership capacity-building in libraries. The trajectory underscores both the resilience of the research community and the evolving relevance of EL as a lens for addressing contemporary challenges in the library and information sector.

Table 1: Annual Publication Output on Entrepreneurial Leadership and Libraries (2020–2024)

Year	Document Count
2020	20
2021	19
2022	12
2023	9
2024	20

Co-authorship Analysis (Authors)

The co-authorship analysis identified a tightly connected cluster of ten authors actively collaborating in the niche field of entrepreneurial leadership within library contexts. As shown in Table 2, each author contributed to one publication, indicating an equal citation count of seven, with an average publication year of 2020. The equal citation and document counts, coupled with identical total link strengths, suggest that these authors co-authored the same high-impact publication, which has been cited multiple times in the field.

The network visualization in Figure 3 further illustrates the strength of these collaborative ties. All ten authors are directly linked, forming a single, cohesive cluster, indicative of an intensive collaborative effort rather than isolated partnerships. Such concentrated co-authorship structures are common in niche or emerging research areas, where a small group of researchers works closely to establish foundational literature. In bibliometric terms, this cluster represents a potential “core team” shaping the early discourse on entrepreneurial leadership in library and information science.

Table 3: Citation Impact of Authors in Entrepreneurial Leadership and Library Research (2020–2024)

Author	Documents	Citations	Total Link Strength	Avg. Pub. Year
Agi K.	1	7	1	2020
Amadei B.	1	7	1	2020
Hughes J.	1	7	1	2020
Jordan R.	1	7	1	2020
Koechner D.	1	7	1	2020
Nelson M.	1	7	1	2020
Olson M.	1	7	1	2020
Quihuis M.	1	7	1	2020
Rose M.	1	7	1	2020
Tangorra J.	1	7	1	2020

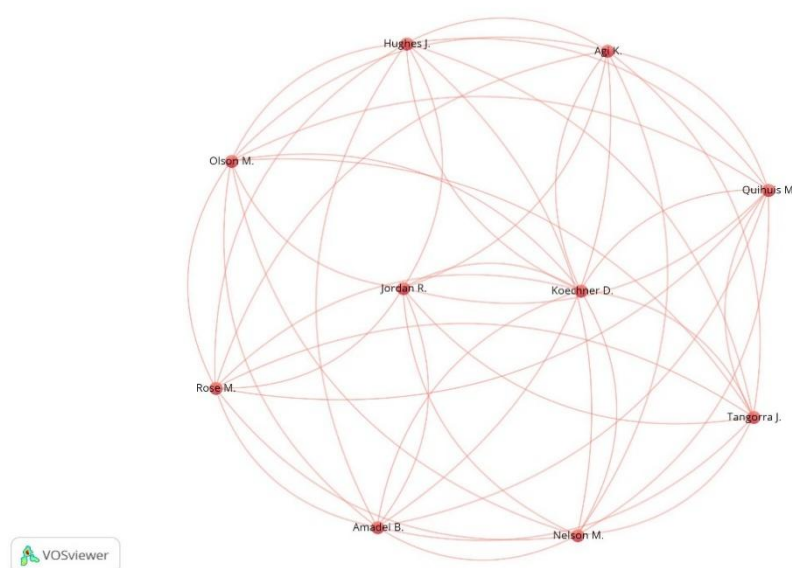


Figure 1: Author Citation Network Visualization in Entrepreneurial Leadership and Libraries Research (2020–2024)

Co-authorship (Institutions)

The institutional co-authorship network is dominated by U.S.-based organizations, indicating a highly localized collaboration network in entrepreneurial leadership and library-related research. The University of New Mexico emerges as a central node, linked to all other institutions in the cluster, reflecting its role as a primary hub for collaborative output.

Private-sector entities such as Sensorcomm Technologies, Inc., and non-profit organizations like the Alliance for Peacebuilding appear in close association with research-focused institutions, including Drexel University and the University of Colorado, Boulder. This blend of academic, corporate, and non-profit actors suggests an interdisciplinary approach, although the absence of international linkages may limit the diversity of theoretical perspectives applied,

including underrepresented frameworks such as DC and the KBV, as observed in earlier analyses.

Table 2: Co-Authorship (Institutions) in Entrepreneurial Leadership and Libraries Research (2020–2024)

Institution	Country	Collaborating Institutions	Notable Links
University of New Mexico	USA	All are listed in this cluster	Strong central node
Alliance for Peacebuilding, Washington	USA	Multiple	
Peace Innovation Lab, Stanford	USA	Multiple	
University of Colorado, Boulder	USA	Multiple	
Drexel University	USA	Multiple	
Ginet	USA	Multiple	
Sensorcomm Technologies, Inc.	USA	Multiple	

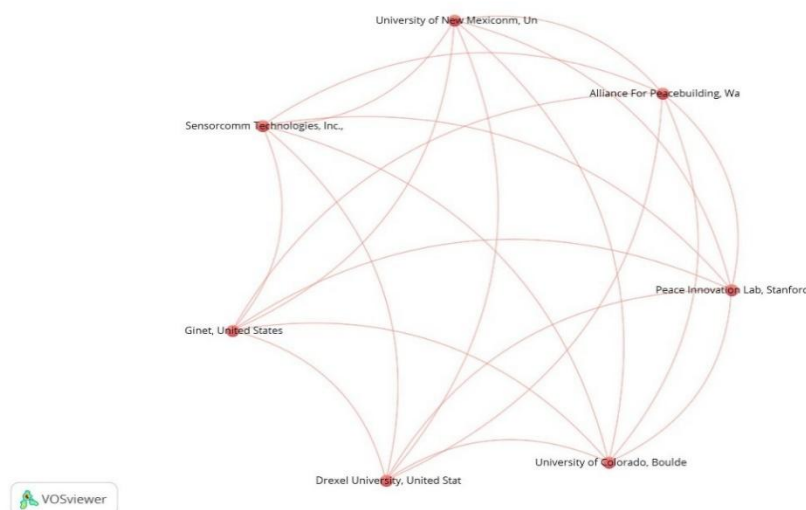


Figure 2: Co-Authorship Network Visualization (Institutions) (2020–2024)

Source Citation Analysis

The source citation analysis indicates that Systems is the most highly cited source within the dataset, achieving 42 citations from a single document published in 2024. This is followed by the Journal of Academic Librarianship, which, despite publishing five documents, amassed a total of 56 citations, averaging 18.67 citations per publication. The Journal of Business and Finance Librarianship also demonstrates notable influence with 18 citations from two publications, reflecting its cross-domain relevance to both entrepreneurship and library sciences.

Although specialized library journals such as Heliyon, Portal, and Public Services Quarterly produce a comparatively small volume of publications, their sustained visibility underscores

the capacity of niche scholarly outlets to shape discourse and advance targeted areas of library and information science research. The network visualization indicates relatively sparse inter-source linkages, suggesting that this niche is concentrated within a limited set of journals with minimal citation exchange across the broader publication landscape.

From a bibliometric perspective, this pattern highlights the reliance on a concentrated set of scholarly platforms for disseminating the entrepreneurial leadership studies in library contexts. This concentration could limit theoretical diversity, as seen in the earlier keyword analysis, where frameworks such as DC and KBV were absent from the dominant discourse. Broadening the range of publication venues may help integrate such underrepresented theoretical perspectives into the mainstream conversation.

Table 3: Top Cited Sources in Entrepreneurial Leadership and Library Research (2020–2024)

Source	Documents	Citations	Avg. Citations	Avg. Pub. Year
Systems	1	42	42.00	2024
Journal of Academic Librarianship	5	56	18.67	2022.33
Journal of Business and Finance Librarianship	2	18	3.60	2021.80
Heliyon	1	5	5.00	2023
Portal	1	4	4.00	2024
Public Services Quarterly	1	4	4.00	2020



Figure 3: Citation Network Visualization of Sources (2020–2024)

Most Cited Analysis

Table 6 presents the most cited articles on entrepreneurial leadership and library research (2020–2024). The citation analysis reveals that the most frequently cited work is by Gupta and

Rubalcaba (2022), with 33 citations, highlighting the strategic role of university libraries as open innovation partners in fostering global entrepreneurship (Journal of Academic Librarianship). This is followed by their later collaboration with Gupta and Pereira (2024), which examines the adoption of social networking sites by entrepreneurial librarians to globalize startup operations, accruing 23 citations (Library Hi Tech). Other highly cited contributions include Otiike et al. (2022), who applied business entrepreneurial theories to academic library innovation strategies (20 citations), and Fink et al. (2020), who explored the governance of digital infrastructure through the deployment of software libraries (21 citations). Notably, the thematic scope spans from entrepreneurial strategies in library contexts to organizational empowerment, service innovation, and public library transformation. Works by Palmer (2022) and Barbakoff (2021) underscore the future-readiness and community resilience roles of public libraries, whereas Tajpour et al. (2020) and Moradi and Noori (2020) focus on entrepreneurial approaches within universities and SME collaborations. Collectively, these studies demonstrate an evolving research front where libraries are positioned not only as knowledge repositories but as proactive actors in entrepreneurship, innovation ecosystems, and socio-economic development.

Table 6: Most Cited Sources in Entrepreneurial Leadership and Libraries Research (2020–2024)

Cited by	Authors	Title	Source Info
33	Gupta V., Rubalcaba L.	University libraries as open innovation partners: Harnessing hidden potential to foster global entrepreneurship	Journal of Academic Librarianship (2022), Vol. 48, No. 2
23	Gupta V., Rubalcaba L., Gupta C., Pereira L.	Social networking sites adoption among entrepreneurial librarians for globalizing startup business operations	Library Hi Tech (2024), Vol. 42, No. 3
20	Otiike F., Barát Á.H., Kiszl P.	Innovation strategies in academic libraries using business entrepreneurial theories: Analysis of competing values framework and disruptive innovation theory	Journal of Academic Librarianship (2022), Vol. 48, No. 4
21	Fink L., Shao J., Lichtenstein Y., Haefliger S.	The ownership of digital infrastructure: Exploring the deployment of software libraries in a digital innovation cluster	Journal of Information Technology (2020), Vol. 35, No. 3
16	Palmer M.	Study of Future Public Library Trends & Best Practices	Public Library Quarterly (2022), Vol. 41, No. 1
16	Tajpour M., Kawamorita H., Demiryurek K.	Towards the third generation of universities with an entrepreneurial approach	International Journal of Technoentrepreneurship (2020), Vol. 4, No. 2
15	Moghaddas S.Z., Tajafari M., Nowkarizi M.	Organizational empowerment: A vital step toward intrapreneurship	Journal of Librarianship and Information Science (2020), Vol. 52, No. 2
13	Gupta V., Gupta C.	Transforming entrepreneurial research: Leveraging library research services and technology innovations for rapid information discovery	Online Information Review (2024), Vol. 48, No. 3



11	Qian X., Shi H., Ge C., Fan H., Zhao X., Liu Y.	Application research on service innovation and entrepreneurship education in university libraries and archives	International Journal of Computational Science and Engineering (2020), Vol. 22, No. 1
9	Barbakoff A.	Building a Future-Ready Workforce: The Role of Public Libraries in Creating Equitable, Resilient, and Entrepreneurial Communities	Public Library Quarterly (2021), Vol. 40, No. 2
9	Moradi Y., Noori S.	Entrepreneurial cooperation model between university and SMEs: A case study in Iran	Sustainability (Switzerland) (2020), Vol. 12, No. 21

Keyword Co-occurrence Analysis

The keyword co-occurrence analysis reveals that entrepreneurship is the dominant thematic anchor in the dataset, occurring 15 times with the highest total link strength (20). This suggests that entrepreneurial concepts are widely integrated into library-focused research between 2020 and 2024. Supporting themes include innovation and service innovation, indicating that EL is frequently discussed with innovative practices in library services. Academic libraries, university libraries, and digital libraries form another prominent thematic cluster, linking the entrepreneurial discourse to institutional contexts. Keywords such as decision-making and entrepreneurial skills further highlight the focus on leadership competencies and strategic capabilities within these institutions.

Table 7: Top Keywords (≥ 2 Occurrences) in Entrepreneurial Leadership and Libraries Research (2020–2024)

Keyword	Occurrences	Total Link Strength	Avg. Pub. Year	Avg. Citations
Entrepreneurship	15	20	2021.55	2.75
Innovation	5	6	2022.50	6.33
Academic Libraries	3	3	2022.33	10.00
Digital Libraries	5	6	2021.17	38.17
Service Innovation	2	2	2022.00	12.00
Library Services	2	2	2021.50	3.50
University Libraries	3	3	2020.33	10.00
Entrepreneurial Skills	5	5	2021.00	0.40
Decision Making	2	2	2024.00	7.00
Library	2	2	2024.00	8.50

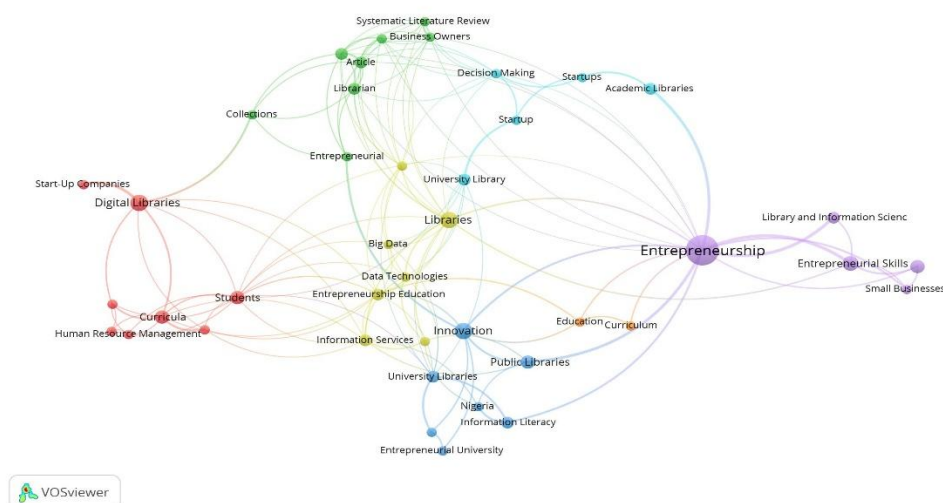


Figure 6: Keyword Co-Occurrence Network Visualization (Minimum 2 Occurrences) (2020–2024)

Thematic Evolution Analysis/Keyword Overlay Visualization

The thematic evolution analysis reveals a clear shift in research priorities within the EL and library connection between 2020 and 2024.

Early-stage themes (2020–2021) were characterized by foundational and structural concepts such as Start-Up Companies, Corporate Entrepreneurship, Strategy, and University Libraries. These keywords suggest an initial emphasis on establishing theoretical underpinnings, organizational contexts, and strategic orientations. Themes such as Digital Libraries and Entrepreneurial Skills also indicate an early alignment with capability-building and technology adoption.

Mid-stage themes (2022) reveal a transition toward operational and service-oriented innovation. Keywords like Service Innovation, Information Services, and Academic Libraries signal a growing interest in practical applications and institutional transformation. The emergence of Big Data and Innovation as co-occurring terms points to a stronger integration of technological enablers into the entrepreneurial leadership discourse.

Emerging themes (2023–2024) show a pivot toward decision-making, stakeholder engagement, and evidence synthesis. Keywords such as Decision Making, Business Owners, and Systematic Literature Review suggest an increasing sophistication in research design and a stronger connection to applied leadership contexts. The inclusion of libraries and Startups in this stage highlights ongoing entrepreneurial experimentation within the library ecosystem.

Notably, despite the evolution of practical and strategic themes, core theoretical constructs such as DC and KBV remain absent from the dominant thematic progression, reinforcing the conceptual gap identified in earlier analyses. This absence presents a significant opportunity for future research to integrate these frameworks more deliberately and systematically into the evolving discourse.

Results and Discussion

This section integrates insights from the conceptual synthesis and bibliometric mapping to present a consolidated interpretation of how EL, DC, and KBV have been positioned in academic library research. The integration is both temporal and analytical: while the bibliometric analysis concentrated on publications from 2020–2024 to capture the most recent thematic developments and collaborative patterns, the conceptual synthesis deliberately incorporated earlier seminal works (e.g., Carpenter, 2012; Renko et al., 2015; Koloniari et al., 2018) to establish the theoretical lineage of these constructs. This combined lens ensures that the discussion reflects both the enduring conceptual foundations and the evolving application of EL, DC, and KBV in contemporary research.

First, the integrative reading of both datasets confirms that EL, DC, and KBV are each conceptually robust and are rarely brought together within a single, empirically grounded framework. The content synthesis highlighted the tendency for studies to treat these constructs in isolation—for instance, leadership styles examined without associated capability mechanisms (Sa'ari & Goulding, 2024) or DC frameworks applied without leadership drivers (Jadhav et al., 2023). This fragmentation is reinforced by the bibliometric mapping, where leadership-oriented terms form distinct clusters that seldom intersect with capability-related or knowledge-based clusters. Theoretically, this indicates that the mediating role of DC in translating EL into KBV outcomes, which is central to capability-based views of strategic renewal, has not been systematically tested in the academic library domain.

Second, the Malaysian contribution, although increasingly visible in recent years, remains thematically constrained by contextual realities. Bibliometric patterns indicate that local research often centres on digital transformation, service enhancement, and technical innovation (Baba & Abrizah, 2018) but seldom frames leadership as the strategic driver of institutional transformation. This thematic positioning reflects governance centralization, public service norms, and resource limitations, which can restrict the application of entrepreneurial and risk-taking leadership behaviours (Shaifuddin et al., 2021). The absence of locally grounded integrative models suggests that direct transplantation of Western frameworks is unlikely to achieve sustained innovation without contextual adaptation.

KBV is widely recognized in the literature as a strategic outcome variable, anchored in knowledge creation, organization, and utilization (Koloniari et al., 2018; Hussain & Li, 2022); however, the bibliometric mapping shows it is weakly connected to EL and DC in the research network. This limited co-occurrence reveals that studies rarely examine these constructs together, making it difficult to model performance pathways linking leadership intent, capability enactment, and knowledge-based outcomes (Nguyen et al., 2024). As a result, KBV's explanatory power in contexts where knowledge mobilization is intended to drive strategic advantage remains underdeveloped, highlighting the critical integration gap that the proposed framework seeks to address.

From a bibliometric perspective, the network structure provides empirical visibility into these conceptual gaps. Co-occurrence analysis reveals that leadership clusters are thematically self-contained, while capability and knowledge-based clusters operate in parallel rather than in convergence. In theoretical terms, this reflects a disjointed discourse in which EL, DC, and KBV are treated as adjacent rather than interdependent constructs. Country-level trends further

indicate that while Malaysia ranks among the top contributing nations, its research focus emphasized operational and technical dimensions over integrative, leadership-driven capability building. These bibliometric signals corroborate the thematic fragmentation observed in the content synthesis and underscore the missed opportunity for cross-pollination between global theory and local application.

Such a triangulation aligns with Malaysia's higher education innovation agenda and the Sustainable Development Goals (Zainal et al., 2023; Rahim et al., 2022), and provides a transferable model for knowledge-intensive public sector organizations. The findings of this study, therefore, lay the groundwork for future research to operationalize and empirically validate this integration, bridging the historical conceptual foundations with contemporary thematic trajectories in a manner that advances both theory and practice.

Conclusion

This study set out to map the literature on EL, DC, and KBV in academic libraries, identify theoretical and contextual gaps, and propose an integrated EL–DC–KBV framework tailored to Malaysian academic libraries. By combining a targeted bibliometric analysis (2020–2024) with a broader conceptual synthesis of seminal works, the study revealed that while leadership, capability, and knowledge perspectives are each conceptually mature, they remain insufficiently integrated into a coherent explanatory model. The analysis advances understanding by positioning EL as the strategic driver, DC as the operational enabler, and KBV as the knowledge-based outcome. This triadic pathway unifies fragmented perspectives and demonstrates how leadership intent is translated into knowledge mobilization through capability renewal. The proposed framework delivers a policy-relevant blueprint for academic libraries to embed leadership-driven, knowledge-based strategies within their transformation agendas. Practically, this alignment strengthens institutional agility, innovation, and service relevance while supporting Malaysia's higher education reforms and the Sustainable Development Goals. At the same time, the bibliometric mapping relied on targeted search terms that may have excluded adjacent constructs such as digital leadership or absorptive capacity. This limitation narrows interpretive scope and highlights the need for broader theoretical integration in subsequent studies. Future research should adopt mixed-method and longitudinal designs to capture both structural patterns and lived leadership experiences, while comparative investigations across institutions and cultures can test the robustness of the proposed framework. Additional inquiry into governance and policy contexts will also be necessary to understand how EL, DC, and KBV interact under different institutional logics. Conclusively, the findings offer both a theoretical pathway and a practical roadmap for repositioning Malaysian academic libraries as knowledge-driven innovation partners within the knowledge economy.

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RESEARCH ON INTERACTIVE FUNCTION OPTIMIZATION OF ONLINE COURSE INTERFACE DESIGN

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Abstract: *With the development of digital education, the interactivity of online course interfaces has become a key factor affecting teaching quality. Currently, some online course systems suffer from problems such as a lack of interactive methods, cumbersome operations, and a disconnect between interactive content and course content. These issues hinder learners' interactive experience and, consequently, teaching efficiency. This study explores the current status of interactive features in some online course interface designs. By analyzing the current state of interactive features, this study proposes optimization principles such as learner-centeredness, interactive diversity and targeting, enhanced simplicity and operability, and improved feedback mechanisms. Specific strategies are also provided for integrating interactive modules, designing gamification mechanisms, optimizing operational paths, and creating learning communities and collaborative spaces. This study aims to provide a reference for improving the quality of online course platforms and promoting the digital transformation of education.*

Keywords: *Online Course; Interface Design; Interactive Features; Optimization Strategies*

Introduction

With the acceleration of educational informatization and the widespread adoption of lifelong learning, online courses have become an essential component of today's education system. Online courses have fundamentally changed the current uneven distribution of high-quality course resources and, to a certain extent, improved the quality of teaching (Yan, 2018). The development of distance education courses must also focus on scientific and reasonable teaching design and high-quality teaching interaction (Wang, 2015). The online course interface is not only a window for information transmission, but also an important platform for teacher-student interaction, student-student interaction, and emotional communication. The primary delivery medium in integrated e-learning is the computer interface, not only because it effectively supports rich environments for collaborative student work, but also due to its multimedia features that enable the presentation of educational content in virtually any imaginable form (Tabbers, Kester, Hummel, & Nadolski, 2004). However, some current online course platforms still have numerous shortcomings in interface design, such as a lack of diverse interactive methods, complex operation paths, and lagging feedback mechanisms, which seriously hinder the fluency and immersion of learning. Therefore, it is necessary to systematically analyze the current status of interactive features in online course interfaces from a user experience perspective and explore feasible optimization paths to improve overall teaching effectiveness.



Analysis of the Current Status of Interactive Functionality: Interactive Methods Lack Diversity

Colleges and universities need to strengthen student-teacher interaction to stimulate learning motivation; improve environmental support to strengthen learning motivation; improve online course design to reduce learning pressure (Zhao, 2018). But some current online education platforms still face challenges in the design and implementation of interactive features, hindering learner engagement and teaching effectiveness. For example, there's a lack of diversity in interactive formats. Some platforms remain limited to traditional, basic functions like text discussions, commenting, assignment submissions, and video tutorials, lacking diverse interactive methods such as voice, collaborative whiteboards, real-time Q&A, and virtual role-playing. While communication between teachers and students, and between students themselves, has broken the constraints of time and space, it's difficult to convey genuine emotions through text, images, or videos alone, and the smooth flow and feedback of emotions that characterize face-to-face instruction cannot be achieved (Pan, 2021). For example, when teachers point out problems with students' line application in hand-drawing courses, relying solely on verbal descriptions in video tutorials often makes it difficult to convey the message clearly and intuitively, leading to deviations or ambiguities in students' understanding of the specific issues. However, the introduction of collaborative whiteboard tools allows teachers to directly annotate and demonstrate in real time on student-submitted artwork, effectively enhancing the visualization and pertinence of teaching feedback, improving interactive teaching efficiency and deepening learners' understanding.

The Operation is Cumbersome and the Path is Unclear

Cooperative learning is a commonly used instructional form in modern educational technology, which enables learners to better and more promptly identify their own problems through interaction with others (Bai & Zhao, 2022). But the interactive functions of many platforms are scattered across different modules or hidden in multi-level menus. When raising a question or participating in a discussion, learners often need to go through multiple page jumps, identity verification, and function selections. The entire process is time-consuming and labor-intensive. For example, when some students use some online teaching platforms, they need to go through five steps: "Course Homepage → Activity Center → Discussion Area → Subtopic → Post" to complete an interaction, which may take more than 3 minutes on average. This not only reduces the usability of the system, but also increases the user's cognitive load and operating costs. For learners with weaker adaptability to technology or older age, this complexity is more likely to cause frustration and resistance to use, ultimately affecting their participation and learning enthusiasm.

Interactive Content is Disconnected from Course Content

Discussion forums on some platforms lack effective topic guidance and content management mechanisms, leading to discussions straying from the core course content and becoming filled with casual chatter, emotional outbursts, or irrelevant topics. For example, in an "Introduction to Art" course, numerous discussion forum posts centered around questions like "Is the exam difficult?" and "How will the teacher grade it?" rather than focusing on substantive content such as "Renaissance aesthetic characteristics" or "The formal language of traditional Chinese art." This disconnect not only wastes learning resources, but also undermines the academic



value and pedagogical function of interaction, gradually reducing the platform to a "social forum" rather than a "learning space," ultimately leading to a decline in learners' trust in and reliance on interactive features.

Feedback Mechanisms Lag Behind

Feedback is one of the important measures to achieve "learning and evaluation integration" and is also an indispensable means to ensure the quality of online learning (Cai, Guo, & Lou, 2020). But some platforms lack effective closed-loop feedback loops. Teachers, burdened by heavy teaching workloads, struggle to respond promptly, and the system lacks automatic reminders or AI-assisted response mechanisms. This results in students' questions going unanswered for extended periods, and discussion threads remaining largely unattended. In teaching sites that partially utilize online course resources for instruction, adult higher education still faces issues such as scarce and underutilized course resources, lack of interaction between teachers and students, and inadequate learning support services (Tang & Guan, 2020). If learners are in a state of being "ignored" for a long time, they are likely to feel helpless, which reduces their enthusiasm for participation and forms a vicious cycle.

Design Principles for Optimizing Interactive Features:

Learner-centeredness

This means that interactive features should fully consider learners' cognitive patterns, operational habits, interests, preferences, and individual differences. In online education, it is necessary to analyze the learning needs of learners and understand their preferences for the content and form of online courses. Only online courses designed based on such rules can arouse learners' interest and promote their learning (Zhao & Liu, 2010). Effective learning activities must be grounded in students' actual learning conditions; in other words, teaching should be determined by learning (Hu, 2024). Learners of different age groups, professional backgrounds, and learning goals have varying needs for interaction. For example, young students may prefer the immediacy and liveliness of bullet-screen Q&A or voice interaction, while working adult learners may prioritize efficient, accurate knowledge-based Q&A and task-oriented communication. Therefore, platforms should offer customizable interactive interface options, such as allowing users to choose between "simple mode" and "enhanced interaction mode," set personalized notification preferences, and even recommend appropriate interaction methods based on learning styles. Only by considering user needs can we enhance their willingness to participate and user satisfaction.

Diversify and Target Interactions

Interactions should not be a cookie-cutter collection of features, but rather be aligned with the course content and teaching objectives. Some online courses blindly pursue the aesthetic appeal of the interface, indiscriminately piling up large amounts of text, images, animations, and other information on the page, thus neglecting learners' visual experience (Zhang & Xu, 2010). For theoretically intensive foundational courses, interactive methods such as quizzes, concept analysis discussions, and peer review can be designed to strengthen understanding and retention of key concepts. For practical or project-based courses, advanced interactive methods such as collaborative whiteboards, achievement display walls, group discussion forums, and virtual simulations should be introduced to support students' knowledge transfer and

competency development through "learning by doing." For example, design courses could incorporate a shared canvas feature to facilitate real-time collaborative drawing and teacher feedback; language courses could also incorporate AI-powered pronunciation feedback to enhance language application skills. Only by precisely matching the specifics of the course can interactions truly serve teaching objectives and improve user learning efficiency.

Enhance Simplicity and Operability

Being in the era of information explosion, the greatest difficulty users face is no longer the lack of resources, but rather locating resources in the fastest and most accurate way (Guan & Li, 2014). An effective interactive system should have a clear and organized visual layout, with intuitive and easy-to-find functional access points to avoid user confusion caused by complex hierarchies or ambiguous naming. The interaction between the teaching platform, learners, and teachers should be as simple and clear as possible (Jiang, 2006). For example, it is recommended that core interactive actions such as asking questions, participating in discussions, or submitting feedback be completed within no more than three clicks or steps. By simplifying the operation process, the user's operational burden can be effectively reduced. At the same time, the use of visual means such as icons, color design, and dynamic prompts can enhance function recognition and reduce learning costs, especially helping learners with weaker technical adaptability to participate smoothly.

Timeliness of Feedback Mechanisms

Feedback is a key link in the interactive closed loop and directly affects learners' motivation and self-efficacy. Some scholars have pointed out that when feedback is paired with effective classroom instruction, it can be highly effective in improving learning (Hattie & Timperley, 2007). The system should not only support personalized feedback from teachers through various forms, such as text, voice, and annotated images, but also incorporate intelligent reminders to automatically notify teachers of unanswered questions or pending assignments to prevent missed interactions. Furthermore, the platform could incorporate incentive mechanisms, such as displaying a "reply received" status, awarding "active participation" badges, and generating weekly interaction reports, to help students feel valued and recognized, thereby increasing their motivation for continued participation.

Recommendations for Optimizing Interaction Strategies ***Integrate and Enrich Interactive Modules***

Introduce real-time interactive tools, such as chat rooms, live microphone functions, and real-time question-answering plug-ins, to meet the needs of synchronous interaction. Set up a "learning check-in wall" to encourage daily learning records, and "shared collaborative documents" to facilitate group project collaboration. By integrating multiple interactive tools into a unified platform, users can avoid frequent switching between multiple applications, improving user continuity and immersion.

Design Gamified and Task-Based Interaction Mechanisms

Reward mechanisms help activate and stimulate college students' enthusiasm for course exploration, and when they are confronted with both spiritual and material incentives, their

intrinsic learning motivation can be effectively aroused (Guo, 2021). Break down interactive tasks according to course progress, such as "Daily Question" and "Chapter Discussion Challenges," and incorporate incentives such as points, badges, and leaderboards. For example, learners can earn points by participating in discussions. Accumulating enough points can be redeemed for course materials or privileges. The top scorer in the weekly leaderboard is awarded an "Interaction Star" and displayed. This design aligns with users' need for achievement, transforming passive interaction into active exploration and effectively enhancing sustained engagement.

Optimize Operation Paths and Interface Visualization

To improve user efficiency, interactive functions scattered across modules (such as questions, discussions, assignments, and feedback) should be centrally integrated into an "Interaction Center" or "Learning Dashboard" for one-stop access and management. Intuitive icon identification (e.g., speech bubbles representing discussions, bells representing notifications, and lightbulbs representing questions) combined with color coding (green for completed, blue for pending, and red for urgent) will help users quickly identify function status and reduce cognitive load. Furthermore, responsive layout optimization should be implemented for different devices (e.g., PCs, tablets, and mobile phones) to ensure that the interface remains clear and easy to use on small screens, with key buttons readily accessible.

Develop Learning Communities and Collaborative Spaces

Adopting approaches that encourage active engagement seems to contribute to enhanced perceived learning and can yield higher levels of learner satisfaction with the virtual learning environment (Rovai & Barnum, 2003). Interaction is not only a supplementary part of the learning process, but also a key factor in improving learning quality and satisfaction. Encouraging students to spontaneously form study groups or join themed communities based on course content. These groups can engage in ongoing, multi-round exchanges and collaboration around specific knowledge points, project tasks, or academic topics. This model can aggregate the originally scattered individual learning forces, and transform the learning process from "individual learning" to "shared learning", thereby stimulating stronger learning motivation. The platform should provide comprehensive collaborative support features, such as cloud-based file sharing and real-time collaborative document editing, enabling group members to communicate effectively, divide work, collaborate, and jointly produce learning outcomes. This community-based learning model not only facilitates the co-construction and sharing of knowledge, but also enhances students' sense of belonging, responsibility, and teamwork, stimulating their learning motivation and fostering a positive and mutually supportive learning ecosystem.

Conclusion

Based on learner experience and teaching effectiveness, this article analyzes the key issues in the interactive design of some current online course platforms and proposes design principles and strategic recommendations for optimizing these features. In the future, with the in-depth integration of technologies such as artificial intelligence, big data, and virtual reality, the interactive features of online course platforms will become even more intelligent. Platform designers should continuously focus on learner needs and teaching feedback, continuously

iterating and optimizing interface interactive design to achieve a more efficient learning process and steadily improve educational quality.

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CIRCULAR ECONOMY EMPOWERMENT AT UD CIGUNDI IN INCREASING ECONOMIC VALUE AND GO GLOBAL POTENTIAL

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Abstract: *UD Cigundi in Lebak, Banten, faces challenges in maximizing digital technology for market expansion. This community service program aimed to integrate digital technology into operational and marketing activities to enhance business growth potential globally. The program included training and mentoring on organizational structure, value-added product development (coconut oil), digital marketing, circular economy management, and business legality preparation. Collaboration with Thaksin University, Thailand, facilitated market exploration in Thailand. Year one focused on organizational capacity building and initial product trials, while year two emphasized technology adoption, certification, and global marketing strategies. Results showed significant improvements in partner knowledge (SDM +80%), marketing skills (+90%), and management capabilities (+71%). This initiative demonstrates that circular economy-based empowerment can increase economic value, improve competitiveness, and open opportunities for local businesses in the global market.*

Keywords: *International Community Service Collaboration; UD Cigundi; Circular Economy; Empowerment*

Introduction

Indonesia, as the largest archipelago in the world, possesses abundant and diverse natural resources that can serve as a foundation for sustainable economic growth. The agricultural and plantation sectors, in particular, hold strategic importance for rural communities, as they not only supply raw materials but also create opportunities for value-added processing and market expansion. Micro, Small, and Medium Enterprises (MSMEs) in Indonesia play a crucial role in driving rural economies by creating employment, fostering entrepreneurship, and distributing income more evenly among the population (Herissuparman, Apuk Ismane, & Ashari, 2024). In many cases, MSMEs act as intermediaries between raw material producers and end consumers, transforming local resources into products with higher market value (Tambunan, 2011).

One such example can be found in Cigundi Village, located in Lebak Regency, Banten Province. This village is well known for its abundant coconut production, supported by fertile land and a favorable climate. Despite this potential, most coconuts are sold in their raw form, resulting in low profit margins for local farmers. The lack of value-added processing and limited access to broader markets have constrained the village's economic growth (Zarin Zakkiatul Fauziah, Cindy Rahmawati, Nayla Salsabila, Raysha Zahra Rigandi, & Tamara Icha Nadine Saragi Turnip, 2025). Moreover, UD Cigundi, a newly established village enterprise aimed at managing these resources, faces several challenges: the absence of a formal organizational structure, limited product diversification, reliance on traditional production methods, lack of digital marketing skills, and the absence of legal business status (Andika, Jennifer, Huang, & Sebastian, 2021).

Applying a circular economy model presents a promising solution for maximizing the economic value of coconuts while promoting environmental sustainability (Supriadi, Fatchurrohman, & Sari, 2025a). In this model, all parts of the coconut are utilized coconut oil is produced as the primary product, coconut water is processed into beverages like nata de coco, the husk is used for handicrafts or rope, and the shell is turned into charcoal briquettes. Even the coconut residue from oil production can serve as animal feed or organic compost. By adopting such practices, the village can minimize waste, optimize resource utilization, and open new streams of income (Vieira et al., 2024).

Recognizing this potential, the Community Partnership Program (Program Kemitraan Masyarakat) was designed to empower UD Cigundi through structured training and mentoring. This program addresses three main areas: (1) human resources developing an effective organizational structure and defining clear job descriptions; (2) marketing creating value-added coconut products with improved packaging and promoting them through digital platforms; and (3) management integrating circular economy principles into operations and obtaining necessary legal business documentation. The program also includes international collaboration with Thaksin University, Thailand, to explore cross-border market opportunities.

Through this initiative, UD Cigundi is expected to strengthen its internal capacity, improve product quality, expand its market reach, and position itself competitively in both domestic and international markets. Ultimately, the project aims not only to increase economic value but also to serve as a model of sustainable rural enterprise development based on circular economy principles.

Literature Review

Circular economy is an economic model that focuses on keeping resources in use for as long as possible, extracting the maximum value from them while in use, and recovering and regenerating products and materials at the end of each service life (Geissdoerfer, Savaget, Bocken, & Hultink, 2017). This approach reduces waste, optimizes resource usage, and supports sustainable economic growth. In the context of rural development, circular economy strategies can transform agricultural communities by turning raw materials into multiple value-added products (Merli, Preziosi, & Acampora, 2018). For example, coconut-based MSMEs can produce coconut oil, nata de coco, briquettes from shells, and handicrafts from husks. Such diversification not only increases economic value but also minimizes environmental impact (Supriadi et al., 2025a).

Previous studies highlight that MSMEs in rural areas often face challenges in accessing modern technology, digital marketing tools, and structured business management (Nugroho, 2024). According to the World Tourism Organization (UNWTO) and rural development research, capacity building through training and mentoring is essential for improving business sustainability (Rinto Andrianto & Supardi Supardi, 2023; UNWTO (World Tourism Organization), 2023). Digital marketing, in particular, offers opportunities for MSMEs to expand beyond local markets. Social media platforms, e-commerce sites, and online branding can connect rural producers to national and global consumers, enhancing competitiveness and market reach (Andika et al., 2021).

In Indonesia, government programs such as SINTESA UMKM aim to create an integrated ecosystem for MSMEs, offering training, incubation, and financial facilitation (Tangguh Pribadi, 2024). These initiatives align with the Sustainable Development Goals (SDGs), especially Goal 8 (Decent Work and Economic Growth) and Goal 12 (Responsible Consumption and Production). For UD Cigundi, integrating circular economy concepts with digital marketing is a strategic step toward achieving long-term business sustainability and global competitiveness (Supriadi, Fatchurrohman, & Sari, 2025b).

Methodology

This program applied a Participatory Rural Appraisal (PRA) approach, which involves the active participation of the community at all stages of the project (Narayanasamy, 2008). The main steps included:

1. **Identifying key issues** through discussions and surveys.
2. **Designing appropriate solutions** in collaboration with partners.
3. **Implementing training and mentoring sessions** focused on human resources (organizational structure and job descriptions), marketing (value-added product development, branding, and digital promotion), and management (circular economy practices and business legality preparation).
4. **Conducting evaluations** to measure impact.

The instruments used in this program included pre- and post-training questionnaires to assess knowledge improvement, observation checklists to monitor practical implementation, and interviews to capture qualitative insights. Partners were actively involved in scheduling,

providing venues, mobilizing participants, and offering feedback during mentoring sessions. To ensure sustainability, the program emphasized skills that could be applied independently after the training period, such as creating social media marketing content, managing digital platforms, and processing coconut products into marketable goods.

Result and Discussion

The implementation of the program resulted in significant changes in the three main focus areas: human resources, marketing, and circular economy-based management.

Human Resources (HR)

Prior to the program, most members of UD Cigundi had little understanding of the role and function of an organizational structure. This led to unclear task distribution and overlapping responsibilities. After the training, comprehension levels rose dramatically from 16% to 96%, representing an 80% improvement.

The establishment of a formal organizational structure with positions such as chairperson, secretary, treasurer, and marketing division created a more organized flow of coordination. This change also had a direct impact on decision-making speed and team efficiency. For example, product packaging design approvals, which previously took several days, can now be decided in short internal meetings. Furthermore, communication among members improved significantly due to the clarity of roles and responsibilities (Daft & Armstrong, 2021).

Marketing

Knowledge of value-added concepts, the importance of branding, and digital marketing strategies increased by 90%. Training participants are now capable of identifying their product strengths and presenting them through appealing promotional messages.

Tangible results include the creation of a new brand logo and more professional packaging designs. Coconut oil is now packaged in transparent bottles with labels containing nutritional information, the brand logo, and contact details, enhancing consumer trust.

Additionally, UD Cigundi has begun actively using social media platforms such as Instagram and Facebook, as well as the e-commerce platform Tokopedia, to reach wider markets. Promotional content comprising photos and short videos—has been uploaded regularly, showcasing hygienic production processes and the health benefits of coconut oil. These activities have not only boosted sales but also strengthened the brand's image as a quality local producer (Keller & Swaminathan, 2020).

Management and Circular Economy

Understanding of circular economy principles and business legality increased by 71%. Before the training, coconut waste such as husks and shells was often discarded. Now, these by-products are processed into value-added items such as coir doormats, rope, and charcoal briquettes, which can be sold or used internally.

On the legal side, UD Cigundi has initiated the process of obtaining a Business Identification Number (NIB) and a deed of establishment—prerequisites for securing halal certification and BPOM distribution permits. These steps are crucial for accessing modern retail markets and potential export channels (Tambunan, 2011).

Impact Analysis and Challenges

Overall, the combination of technical training, direct mentoring, and digital marketing support proved effective in enhancing partner capacity. The improvement in HR capabilities and digital marketing skills positively impacted sales volume and market expansion opportunities.

However, several challenges remain, including:

1. **Production consistency** ensuring quality and quantity remain stable to meet growing market demand.
2. **Financial management** requiring further training in bookkeeping and production cost analysis to maintain profitability.
3. **Product certification** this process takes time and involves costs, necessitating a dedicated financing strategy.

Collaboration with Thaksin University presented a strategic opportunity for international networking. Trial marketing in Thailand indicated interest in Cigundi's coconut oil products, but also highlighted the need for label adjustments and quality standards compliance in line with export destination regulations.

Participatory Rural Appraisal (PRA) Evaluation

The training and mentoring program for circular economy empowerment at UD Cigundi was conducted from March to August 2025, following official approval from the partner. The event ran smoothly and exceeded expectations in terms of participant attendance and enthusiasm. Of the 20 participants, most arrived earlier than scheduled. The training concluded at 14:00, followed by pre- and post-event questionnaires to measure the program's impact. The activities covered institutional strengthening, improving promotional skills through mobile-based social media marketing, enhancing the quality, pricing, and packaging of Enye-Enye products, and utilizing mobile phones for promotion and operational purposes.

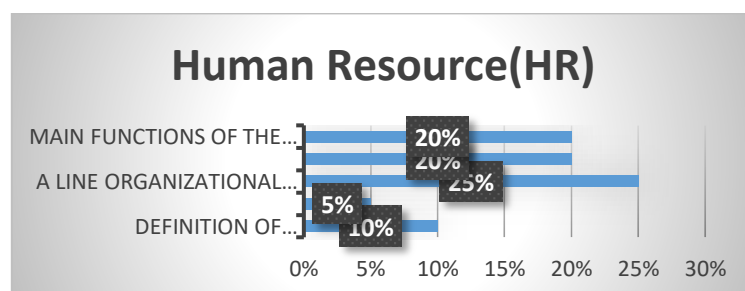


Figure 1: Evaluation of Human Resources Aspect Activities (Before Mentoring)

Source: (Processed data 2025)

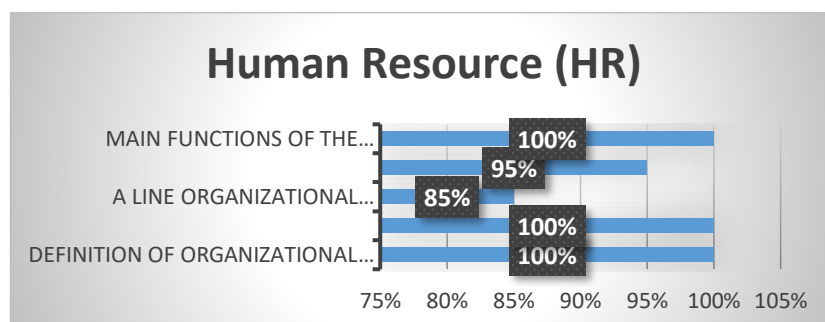


Figure 2: Evaluation of Human Resources Aspect Activities (After Mentoring)
Source: (Processed data 2025)

Evaluations showed a significant improvement in participants' understanding after the training and mentoring sessions. Knowledge of organizational structure, its importance, and the main functions of marketing increased to full comprehension among all 20 participants. Other topics, such as the functions of a line organizational structure and the treasurer's job description, also showed substantial gains, though a small number of participants still lacked full understanding. Overall, the program effectively enhanced knowledge across all topics.

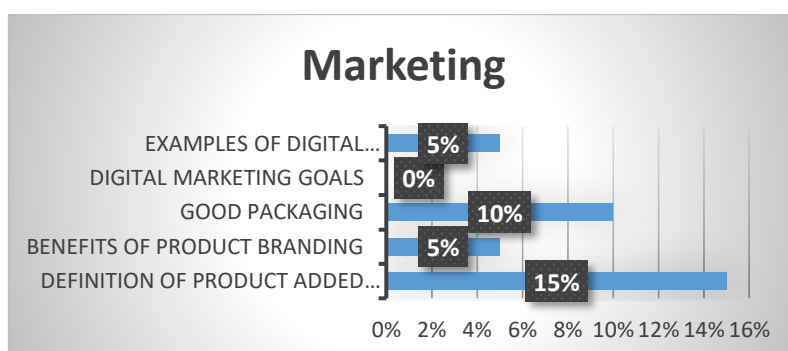


Figure 3: Evaluation of Marketing Aspect Activities (Before Mentoring)
Source: (Processed data 2025)



Figure 4: Evaluation of Marketing Aspect Activities (After Mentoring)
Source: (Processed data 2025)

The training and mentoring activities had a positive impact on participants' understanding of digital marketing. Knowledge of product value-added concepts, the benefits of branding, good packaging practices, the objectives of digital marketing, and examples of trust-building marketing content all showed substantial improvement. In several topics, understanding rose from little or no prior knowledge to full comprehension among all 20 participants. Only a small

number of participants remained with partial understanding in certain areas, indicating that overall, the program significantly enhanced knowledge across all topics delivered.

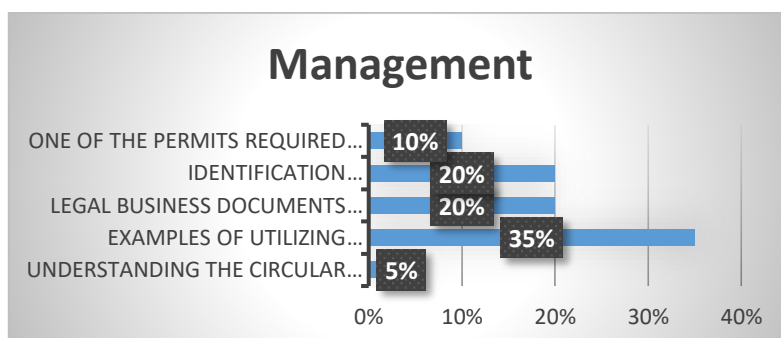


Figure 5: Evaluation of Management Aspect Activities (Before Mentoring)
Source: (Processed data 2025)

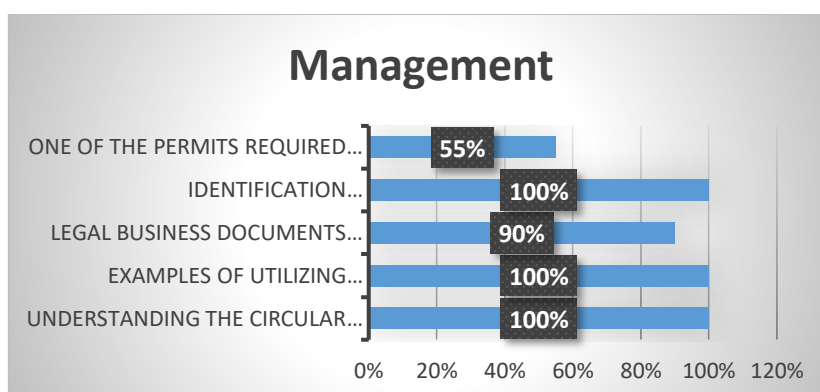


Figure 4: Evaluation of Management Aspect Activities (After Mentoring)
Source: (Processed data 2025)

The training and mentoring significantly improved participants' understanding of circular economy concepts and business legality. Knowledge of the definition of a circular economy, examples of economically valuable waste utilization, and the importance of business legality increased to near or full comprehension among participants. While understanding of specific legal documents and certain licenses for home-based food businesses also improved, some participants still required further guidance. Overall, the program had a positive impact, though additional support is needed for certain topics.

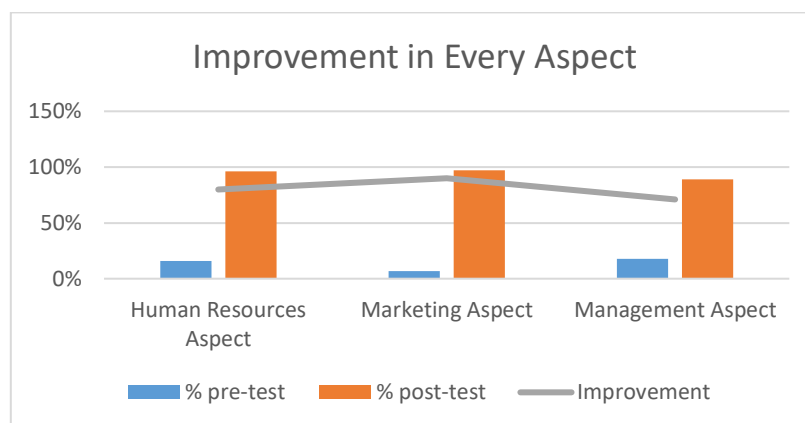


Figure 7: Summary Regarding Evaluation of Several Partner Understanding Activities

Source: (Processed data 2025)

Evaluation results showed significant improvements in the three main focus areas: human resources, marketing, and management. In human resources, understanding rose from 16% (3 participants) before training to 96% (19 participants) after, an 80% increase, indicating that topics on organizational structure, task distribution, and team roles were well comprehended. Marketing saw the highest improvement of 90%, with understanding growing from 7% (1 participant) to 97% (19 participants), reflecting enhanced practical skills in product marketing, branding, packaging, and digital marketing techniques. Management improved by 71%, from 18% (4 participants) to 89% (18 participants), covering business planning, operations, and legality, though some participants still require further guidance in these areas.

The Circular Economy Empowerment program at UD Cigundi has proven effective in enhancing human resource capacity, marketing skills, and management practices, while also introducing sustainable resource utilization strategies. Through structured training, direct mentoring, and digital marketing integration, UD Cigundi successfully developed value-added coconut-based products, improved branding, and expanded market reach both domestically and internationally. The collaboration with Thaksin University further opened opportunities for global market entry, positioning UD Cigundi as potential exporter of quality coconut products.

This initiative demonstrates that applying circular economy principles in rural enterprises not only increases economic value but also promotes environmental sustainability and community empowerment. To maintain and build upon these achievements, continuous capacity building, financial management training, and product certification processes are recommended. Ultimately, UD Cigundi's transformation serves as replicable model for other rural-based MSMEs aiming to compete in the global market.

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INVESTIGATING THE INFLUENCE OF STUDENT IDENTITIES ON SENSE OF COMMUNITY IN ONLINE LEARNING COMMUNITIES

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Abstract: *This study explores the relationship between students' identities and their sense of community in the context of online learning among undergraduate students at Malaysian public universities. It investigates whether students' professional and learner identities influence their level of connectedness within online learning environments. Adopting a correlational research design and Structural Equation Modeling (SEM) analysis with a sample of 367 students, data were collected using the Students' Identities Questionnaire and the Classroom and School Community Inventory (CSCI). The findings indicate that while students demonstrate strong professional and learner identities, these identities do not significantly influence their sense of community. The study suggests that efforts to foster a sense of community in online learning should emphasize social interaction and inclusive engagement strategies rather than focusing solely on individual identity traits. The implications highlight the importance of lecturer facilitation and institutional support in building meaningful connections among students in virtual learning spaces.*

Keywords: *Student Identities, Sense of Community, Online Learning, Professional Identity, Learner Identity, Malaysian Higher Education*

Introduction

Online learning has been practiced in higher education institutions since the 1990s. Over the past two decades, online learning has been activated in some global institutes (Mahyoob, 2020). Through these years until now, the evolution of online learning has never stopped. Online learning has become a best friend of higher education institutions for some years, and its transformation is not a novel phenomenon anymore (Kopp et al., 2019; Leszczyński et al., 2018). Hence, higher education institutions should always prepare for any challenge or circumstance by developing strategies and new kinds of offerings in online learning for their students, including recruiting potential professionals to provide solutions (Sandkuhl & Lehmann, 2017).

The current trend in teaching and learning has shown that many higher education institutions in the world have digitised their course content and assessment, which will be used in the teaching and learning processes. According to Grosseck et al. (2024), the integration of digital assessment tools can improve learning outcomes and align higher education practices with 21st-century educational goals. This trend showed significant growth over the last decade, as the Internet and education are combined to provide people with the opportunity to gain knowledge and skills.

Even though knowledge matters in an online course, it is crucial for students unlikely to feel isolated during that course. The nature of online learning, especially during COVID-19, where

students are physically isolated from their peers, should emphasise that each student should feel connected, belong, and be part of a particular group in the online class. Some literature has found that online learning can provoke anxiety, loss of identity, and disorientation in learning (Kop et al., 2011; Mackness, 2013; Knox, 2014).

McGuire (2013) stated that the encouragement in the sense of community from the lecturer in classes can foster deep learning due to interaction among students. When students can reformulate the class material to support and challenge one another, they are more likely to retain and apply those lessons in the future. Similarly, Drouin (2008) found that students' sense of community played an important part in their level of satisfaction with online courses. Hence, students are more willing to participate in future online courses.

Furthermore, instead of students participating only in online learning platforms, they also created Facebook and Twitter groups outside of the online classroom as a means of peer support. Although a relatively small number of students participated in the groups, the creation of these outside groups indicated a need, at least for some of the students, for the community beyond the forums provided within the course proper (Blackmon & Cullen, 2016; Saadatdoost et al., 2019). The in-course discussion forum area was the only area for open discussion between the students in the class. Instead of using a forum within an online platform alone, they also used other social networking outlets.

Background of Problem

One major problem encountered in the online learning environment is the separation between the instructor and the student and between the students. Students face phenomena such as dropout rate and loss of motivation due to separation in online learning (Stoytcheva, 2021) and disconnection with classmates or losing human touch (Khalili, 2020). This situation worsens during the COVID-19 pandemic because students are prohibited from leaving their houses and lack interaction with their peers (Irawan, Dwisona & Lestari, 2020). The feeling of isolation is due to a lack of awareness and understanding of presence (Khodabandelou, 2013). Presence is the main aspect that provides the structure of the community of inquiry. However, understanding presence in online learning is complex due to the separation of the physical space of the real world and the online space, as our sense of presence is felt and experienced in different ways. In the physical space, presence is easier to recognize through observation and perception, but in the online space, presence needs to be intentionally created (Lehman & Conceicao, 2010).

Limited research has been found to explore the sense of community in a completely online format especially during the COVID-19 pandemic. Most research focused on blended courses with face-to-face instruction (Lin & Gao, 2020). Likewise, some research on the sense of community in online learning found to examine the relationship between a sense of community with social media such as Facebook (Al-Omoush, Orero-Blat & Ribeiro-Soriano, 2021; Yilmaz & Yilmaz, 2022) without trying to examine the effects of online learning platform such as Zoom, Google Meets and Microsoft Teams.

Additionally, limited work has been carried out to examine how identity is expressed within diverse online learning contexts (Delahunty, 2014; Luzon, 2018). Ke et al. (2011) posited that limited work has also been conducted to examine how identity relates to the knowledge-

building processes within the online educational space. An overall observation from the literature suggests that the dimensions of identities remain debatable (Khalid, 2018). The majority of previous research has been conducted in other countries, with only a few in Malaysia. The investigation of research papers on students' identities in Malaysia within the primary international databases such as Google Scholar found only a few studies related to students' identities in online learning. The studies found are by Shafie, Nayan and Osman (2012), which focused on constructing identity through Facebook profiles, and by Khalid (2019), which focused on students' identities and engagement in an online learning community.

Objective

1. Determine the extent of sense of community and students' identities in online learning among undergraduate students in Malaysian public universities.
2. Determine whether the students' identities significantly influence sense of community in online learning among undergraduate students in Malaysian public universities.

Literature Review

Students' Identities

Traditional conceptions identify an individual within perceivable social identity groups, such as those based on age, gender, ethnicity, socio-economic status, class, nationality, disability, and religion (Abrams & Hogg, 1990; Turner & Haslam, 2001). Identity can also be defined by self-categorization of educational background, work or professional experience or differences in language and culture (Turner et al., 1987). Ke et al. (2011) identified identity as a presence of sociocultural position or self-categorization trajectory expressed or revealed by students in online discourses. Tomlinson (2010) stated that identity is also a fluid and flexible process, depending on the individual's ability to shape, adapt, and apply the self to the needs of a particular role not only once but many times throughout life.

From a sociocultural perspective, human activity is mediated by language in interacting moments, which is intrinsically linked to consciousness and higher mental functioning (Vygotsky, 1978). Although Vygotsky did not talk about identity as much, a sociocultural approach to forming identity is considerable when individual functioning is inseparable from sociocultural processes. The centrality of dialogue in the community and the co-construction of knowledge coupled with its centrality in the construction of identity in continual negotiations between oneself and others. Identity formation is, therefore, as much about sociocultural processes as the individual (Delahunty, Verenikina, & Jones, 2014).

When applied to the context of the online classroom, the discourses in various online discussion forums are composed by learners as a means of presenting identity by communicating who they are and how they see others, alongside discussing content-related issues. Hyland (2011) mentioned that in most written academic genres, academic identity relates to the construction of a credible academic persona by using the discourses and language forms of the community. Consequently, when social interactions occur in the online community, the text is where knowledge and the writer's identities are constructed, negotiated, and created. When dealing with academic writer identities, Lo, Othman and Lim (2024) mentioned that students engage

in complex processes of self-representation, drawing on their personal backgrounds and prior experiences to align with the norms and expectations of academic discourse communities.

Khalid (2019) identified students' identities in online learning as consisting of four (4) identity dimensions: personal, professional, learners, and community members. According to Durante (2011), the construction of personal identity is always the result of competition (both internal with ourselves and external with others) between what is disclosed and hidden about us. For example, people usually hide their age. It is sensitive for some people to reveal their age to others. Thus, from this standpoint, personal identity is predetermined as the unending result of a selection of information that forges a meaningful difference (i.e., the self) between what we wish to unfold and what we wish to keep secret.

Developing a professional identity is influenced by cultural identity and acculturation processes. Individuals integrate personal and professional identities over time, navigating cultural nuances to establish a cohesive professional self (Hyun, Song & Yang, 2023). Jackson (2017) described the professional identity of students as pre-professional identity, which is an understanding of and connection with the skills, qualities, conduct, culture, and ideology of their intended profession. In terms of learner identities, Lawson (2014) mentioned how individuals feel to the extent of how they describe themselves as a learner. Thus, this may be affected by intrinsic and extrinsic factors, such as personal motivation, a sense of belonging, support and encouragement from others, and previous educational experiences.

Meanwhile, Wann (2006) mentioned that community identification is present when team members relate well with their partners, thus enabling social connection development as they understand mutual interests. Ratanakosol, Pathumcharoenwattana and Kimpee (2016) argued that it is important to individuals, groups, and communities as the driving force that can create pride, self-respect, unity, a sense of belonging, and social responsibility, which leads to participation in community activities. Hence, in order to construct community identity in an online learning environment, participants must be aware of their roles as members of that online community and their openness to sharing knowledge, discussions, topics, and comments from others.

Sense of Community

Even though knowledge matters in an online course, it is crucial for students unlikely to feel isolated during that course. The nature of online learning where students are physically isolated from their peers, should emphasise that each student should feel connected, belong, and be part of a particular group in the online class. Some literature has found that online learning can provoke anxiety, loss of identity, and disorientation in learning (Kop et al., 2011; Mackness, 2013; Knox, 2014).

McGuire (2013) stated that the encouragement in the sense of community from the lecturer in classes can foster deep learning due to the interaction among students. When students can reformulate the class material to support and challenge one another, they are more likely to retain and apply those lessons in the future. Similarly, Drouin (2008) found that students' sense of community played an important part in their level of satisfaction with online courses. Hence, students are more willing to participate in future online courses.

Furthermore, instead of students participating only in online learning platforms, they also created Facebook and Twitter groups outside of the online classroom as a means of peer support. Although a relatively small number of students participated in the groups, the creation of these outside groups indicated a need, at least for some of the students, for the community beyond the forums provided within the course proper (Blackmon & Cullen, 2016; Saadatdoost et al., 2019). The in-course discussion forum area was the only area for open discussion between the students in the class. Instead of using a forum within an online platform alone, they also used other social networking outlets.

Students' Identities and Sense of Community

Exter (2009) stated that the sense of community would be negatively impacted if students felt unknown or anonymous. The need for recognition is intrinsically linked to being able to portray who we are. Identity construction has potential ramifications on motivation to participate, the extent of self-disclosure, as well as on self-confidence and self-assurance. Feelings of belonging to a community have been identified as a core element in the construction of salient and robust working and student identities (Caravallo Johnson & Watson, 2004). Luzon (2018) stated that the discussion forums are the vehicle through which insights into feelings of belonging or isolation, legitimacy of self, or lack thereof, will become apparent.

Kear, Chetwynd and Jefferis (2014) studied the use of personal profiles and photos in online learning. The result indicated that personal profiles and photos help the other students feel connected with each other, while on the other hand, some students are concerned about privacy when sharing their profiles and photos. In their study of the isolation of online graduate students, Phirangee and Malec (2017) expressed that students feel more socially connected if their identity is appreciated and valued by others. Furthermore, a study by Verdin et al. (2018) revealed that the engineering identity of first-generation college students has a positive direct effect on students' sense of belonging since they believe in themselves as engineering people and living with people with the same interests, they can feel a sense of belonging in that field.

Jaiswal, Magana and Ward (2022) used a pre-and post-test survey to examine students' perceptions about identity formation and sense of belonging in the data science learning community. Both the pre-and post-test surveys demonstrated that students' identity formation and sense of belonging improved as they progressed through the semester. Meanwhile, McNamara et al. (2021) investigated community identity with social support, loneliness, and well-being. The result indicated that neighbourhood belonging is a positive predictor of well-being and social support while a negative predictor of loneliness. Furthermore, Ratanakosol et al. (2016) concluded in their study that community identities are crucial in creating pride, self-respect, unity, a sense of belonging, and social responsibility for all parties in the community. Thus, it is hypothesized that:

H1: Students' identities are significantly influencing sense of community in online learning among undergraduate students in Malaysian public universities.

Methodology

This study adopted a correlational research design to investigate the possibility of relationships between these variables without any attempt to influence or manipulate them (Fraenkel et al.,

2015). This study was conducted at Malaysian public universities under the Ministry of Higher Education. These public universities are categorised into three (3) groups: five (5) research universities, four (4) comprehensive universities, and 11 focused universities. Thus, the selected universities in this study were based on those groups.

The targeted population for this study were undergraduate students who were studying online learning courses at Malaysian public universities. According to the data given by the university administration on the number of active undergraduate students, there was a total of approximately 13,701 undergraduate students.

Stratified random sampling was used as the sampling technique. The selected universities were contacted via e-mail and phone calls. However, only three (3) universities from research, one (1) university from comprehensive, and four (4) universities from focused universities responded, respectively. Subsequently, only one (1) faculty was randomly selected from each responding university using the fishbowl technique.

To confirm the sample size, Cochran's formula (1977) for continuous scale was used and the estimated final sample size was 262. Salkind (1997) recommended increasing the sample size by 40% to 50% if the researcher is mailing out the surveys in order to account for lost mail and non-response answers. Therefore, the researcher has decided to add 40% (105 more respondents) to the sample size, making the final total recommended sample size for this study 367. Structural Equation Model (SEM) analysis was used to determine the influence of students' identities on sense of community.

Research Findings

Extent of Sense of Community

This study used the Classroom and School Community Inventory (CSCI) by Rovai, Wighting, and Lucking (2004) to measure the respondents' sense of community. The CSCI comprises two constructs, known as the classroom and the university. The mean summated sense of community scores was computed as a mean ranging from 0 to 4. The mean above 2.5 indicates the respondents are more inclined, while below 2.5 indicates the respondents are less inclined.

As presented in Table 1, the respondents' overall perception of a sense of community is more inclined ($M = 2.593$; $SD = 0.638$). The results also indicated that the respondents are more inclined to go to university ($M = 2.663$; $SD = 0.757$), while in the classroom, their perception is slightly more inclined ($M = 2.522$; $SD = 0.763$). The results reflect that students feel closer to the university than their classmates. They feel that the university can satisfy their educational goals and their learning. During the pandemic, universities are active in updating students about guidelines and standard operating procedures to make them feel like they belong to the university.

Table 1: Extent of Sense of Community

Construct	Sub-constructs	Mean	Standard Deviation
Sense of Community	Classroom	2.522	0.763
	University	2.663	0.757
	Overall	2.593	0.638

Extent of Students' Identities

The students' identities were assessed using the Students' Identities Questionnaire developed by Khalid (2010). The mean summated students' identities were computed as a mean score ranging from 1 to 5. The mean above 3.5 indicates the respondents are more inclined, while below 3.5 indicates the respondents are less inclined.

Table 2 shows that the respondents' overall perceptions of students' identities are more inclined ($M = 3.992$; $SD = 0.565$). The results also indicate that the respondents expressed more inclinedness towards both sub- constructs, namely professional identities ($M = 4.008$; $SD = 0.605$) and learner identities ($M = 3.970$; $D = 0.649$). Thus, it indicated that students have professional identities in their online learning. They can participate in online learning groups to get new ideas; they know how to search for online learning course groups, and online learning can give them extra support to improve themselves.

Table 2: Extent of Students' Identities

Construct	Sub-constructs	Mean	Standard Deviation
Students' Identities	Professional Identities	4.008	0.605
	Learner Identities	3.970	0.649
Overall		3.992	0.565

For learner identities, students expressed that they could manage their assignments better through sharing experiences in online learning since they are being provided with guidelines and exposure from lecturers and friends on how to manage the task. Students also feel that engaging in online learning is beneficial for their professional development, expands their networks, and enhances their computer skills.

Students' Identities and Sense of Community

H1: Students' identities significantly influence a sense of community in online learning among undergraduate students in Malaysian public universities.

As illustrated in Table 3, there was a negative yet no significant influence of students' identities on sense of community in online learning ($\beta = -0.068$; C.R. = -0.620; $p = 0.535$). Based on the structural model, H1 was not supported in this study.

Table 3: The Regression Weights in the Hypothesise Direct Model on Effect of Students' Identities on Sense of Community

Hypothesised Relationship	B	S.E.	β	C.R.	p
Students Identities → Sense of Community	-0.066	0.106	-0.068	-0.620	0.535

Note: B (unstandardized regression weight); S.E. (standard error); β (standardized regression weight); C.R. (critical ratio); p (level of significance)

In this study, students' identities did not serve as a mechanism to improve a sense of community in online learning. This is because students do not view their identity as a shared identity that blends them as one with other people, which can hinder the feeling of unity, belonging,

togetherness, and community spirit. As Byrd (2016) posited, sharing a part of your identity with someone else will increase your connection and cohesion with others. In compliance with what Exter (2009) stated, if students fail to portray themselves, it will negatively impact the sense of community.

It should be noted that the current findings are at odds with a significant body of literature. Kear, Chetwynd, and Jefferis researched online learning and the usage of personal profiles and images in 2014. The result indicated that personal profiles and photos help the other students feel connected with each other, while on the other hand, some students are concerned about privacy when sharing their profiles and photos. In their study of the isolation of online graduate students, Phirangee and Malec (2017) expressed that students feel more socially connected if their identity is appreciated and valued by others.

Meanwhile, McNamara et al. (2021) investigated community identity with social support, loneliness, and well-being. The result indicated that neighbourhood belonging was a positive predictor of well-being and social support, while it was a negative predictor of loneliness. Furthermore, Ratanakosol et al. (2016) concluded in their study that community identities are important in creating pride, self-respect, unity, a sense of belonging, and social responsibility for all parties in a community.

Discussion and Conclusion

The results of the study illustrated that the students' identities were more inclined overall. The results also indicated that both professional identities and learner identities were high. Based on these results, it might be that students feel that they have good identities, either as professionals or as learners, in online learning. They can participate in online learning groups to get new ideas; they know how to search for online learning course groups, and online learning can give them extra support to improve themselves.

The findings indicate that students' perceptions of a sense of community were less inclined. As a sense of community is a crucial element in guaranteeing the success of an online learning environment, it has been suggested that lecturers establish a social presence so students can feel that they are interacting with real people. Thus, this is practicable by instructing students to create an introductory video using video applications or something as simple as PowerPoint, where everyone introduces themselves and shares facts about themselves. Besides, the lecturer must be available during the online class.

Hence, this requirement is attainable by turning on the camera and microphone. However, the lecturers need to be more perspective with voice tone and vocal functions since body language and facial expressions are limited during online learning. By slowing down the speech, students can capture the essential points of the topic discussed (Mahmood, 2021; Bao, 2020).

The findings also revealed the moderation level of the sense of community in the classroom. Hence, the suggestion is to assign students to smaller groups. They can use the learning management system to work together and associate with their peers. Some students may be hesitant to share if there are many members in the group. These smaller groups can provide more personal experience and connect individuals with similar interests. Besides, this allows the lecturer to be more focused-oriented in a small group (Vollbrecht, Porter- Stransky &



Lackey-Cornelison, 2020). On top of that, exposure to collaborative learning techniques during online class sessions can help the students since getting to know their peers in an online class can help them reduce feelings of isolation. For example, a lecturer can ask students to make assignments in groups collaboratively by using applications such as Google Docs or Google Sheets so they can discuss, edit, and comment on the assignment synchronously.

The active involvement of the university in online learning will lead to the successful creation of a sense of community among students. This is based on the result of this study, which indicated that the level of sense of community at the university is high. Hence, it is suggested that universities use their existing communication tools when in-person engagement is impossible. Universities can use their official social media, such as Facebook or Instagram, websites, email, and learning management systems, to keep students updated on the latest news or announcements. In addition, the university's learning management system also enables campus-wide announcements. Therefore, using the right communication platform can strengthen connections with students and build a sense of community among students and universities.

In order to feel connected to the institution and to develop a sense of community, students have to apprehend that their opinions and feedback are heard, especially during this strenuous period. Universities or administrators should organise regularly scheduled meetings, workshops, and other events to check students' well-being and remind students that universities are always there to support them.

Some universities advise their students to move to activities such as maintaining studies, reading a book or virtual book, listening to podcasts, figuring out a new hobby or skill, joining a movie club, an online group, or a peer forum while staying at home (Gamage et al., 2020). Apart from that, universities can also support students according to their needs. As it is known, students' requirements differ based on their programme, years of study, or location. For example, first-year students need more support in establishing the course programme and peer connections, while last-year students need access to industry and career development counselling. Under the economic lockdown and recession, more final-year students may have difficulties finding jobs or internships, which could negatively affect their engagement in learning and lower their well-being (Plakhotnik et al., 2021).

The results of the study illustrated that the students' identities were more inclined overall. The results also indicated that both professional identities and learner identities were high. Based on these results, it might be that students feel that they have good identities, either as professionals or as learners, in online learning. They can participate in online learning groups to get new ideas; they know how to search for online learning course groups, and online learning can give them extra support to improve themselves.

In an online class, it is difficult for the lecturer to identify if the students understand the topic and material, especially when they turn off the camera. There is no expression of confusion if they are not visible, even if they do not understand the topic or content. As such, students must be willing to approach the lecturer with questions. For instance, if a student does not understand the discussed topic, they can use the raise-hand function to ask the question so the lecturer can provide the answer.



Students could also give their best commitment to online learning. Most students fail their online courses due to a lack of commitment. For example, they are joining the Zoom session during an online class, but the truth is they are not sitting in front of the laptop to participate in the class. As a student, they must be proactive, ask lots of questions, and participate in all learning activities. This will lead to a self-motivated personality in which students will give their best and be eager to accomplish a goal.

The findings of this study also found no significant influence between students' identities and sense of community in online learning. This could probably be because, in order to increase a sense of community, a strong relationship in the community should be developed rather than solely focusing on individual identity. Lecturers or course instructors need to come up with ideas on how to include the different identities of students in socially engaged learning that may help to increase students' engagement behaviourally, emotionally, and cognitively, thereby positively creating a well-bonded online learning community.

Students' identities did not serve as a mechanism to improve a sense of community in online learning. This is because students do not view their identity as a shared identity that blends them as one with other people, which can hinder the feeling of unity, belonging, togetherness, and community spirit. As Byrd (2016) posited, sharing a part of your identity with someone else will increase your connection and cohesion with others. In compliance with what Exter (2009) stated, if students fail to portray themselves, it will negatively impact the sense of community.

Recommendations for Future Research

Several recommendations are suggested for future research to overcome the limitations of this study. This study employed a quantitative approach, and the data collection was obtained through an online survey using a questionnaire. Therefore, a comprehensive perspective is achievable if considering a qualitative approach, such as interviews, observations, and recordings in future research. Hence, extensive qualitative research can support and accurately interpret the quantitative data.

The current study focused on knowledge building and a sense of community among undergraduate students in Malaysian public universities. The target population can be further studied at private universities to determine the similarity of the results.

Future research may also need to examine the mediating effect of possible determinants to expand on more empirical findings. Likewise, future research is crucial to explore how sense of community and students' identities could work together with moderating factors such as motivation and self-efficacy to determine more conclusively the impacts of sense of community.

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EMPOWERING WOMEN IN THE PAGODA WOMEN FARMERS GROUP BY IMPROVING THEIR UNDERSTANDING OF GLOBAL MANAGEMENT CONCEPTS FOR THE PRODUCTION OF AROMATHERAPY CANDLES

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Abstract: *This paper presents the results of an international participatory role appraisal project targeting the Pagoda Women Farmers Group (KWT Pagoda) in Kampung Cigundi, Lebak Regency, Banten, Indonesia. The initiative aims to transform irregular household candle-making into a structured microenterprise producing aromatherapy candles, thereby promoting women's economic empowerment and environmental sustainability. Between March and November 2025, 25 members participated in integrated capacity-building activities covering production techniques, organizational management, and financial literacy. Training methods included workshops, hands-on demonstrations, and mentoring sessions. Assessments conducted after the activities indicated significant improvements in participants' technical skills, adoption of basic financial recording, and understanding of organizational planning. While progress was evident, challenges remained in establishing Standard Operating Procedures (SOPs), securing stable raw-material supplies, and obtaining legal business registration. These findings highlight the importance of combining technical, managerial, and financial interventions to support rural women's microenterprise development.*

Keywords: *International Service Collaboration; Pagoda Women's Group; Women Empowerment; Aromatherapy Candles; Economic Improvement*

Introduction

Micro, Small, and Medium Enterprises (MSMEs) are a critical driver of economic growth and employment in Indonesia, contributing to more than 60% of GDP and engaging a substantial share of the workforce (BPS, 2023). In rural communities, MSMEs often emerge from home-based industries that rely on locally available resources. The Pagoda Women Farmers Group (Kelompok Wanita Tani, KWT Pagoda) in Kampung Cigundi exemplifies this potential. Initially engaged in agricultural processing, the group later expanded into candle-making using recycled cooking oil and coconut oil. However, production has been sporadic, lacking standardized processes, quality control, financial documentation, and market-oriented branding.

Empowering rural women through structured microenterprise development aligns with both national economic priorities and Sustainable Development Goals (SDGs), particularly those concerning gender equality, decent work, and responsible consumption. Yet, sustainable transformation requires more than technical know-how, it demands improvements in organizational capacity, supply-chain stability, and financial literacy (Kabeer, 2012; UN Women, 2018).

To address these gaps, Universitas Pembangunan Nasional Veteran Jakarta (UPNVJ), in collaboration with Thaksin University and Walailak University, Thailand, initiated an international participatory role appraisal project focusing on the development of an aromatherapy candle business. The program seeks to improve production quality through standardized procedures, enhance organizational effectiveness, and implement proper financial management systems.

This paper discusses the program's background, conceptual basis, and field implementation results, along with the observed changes in production, financial, and management aspects. It also identifies the challenges encountered and proposes strategies for strengthening the group's business capacity for future sustainability.

Literature Review

Production Improvement in Rural Microenterprises

Production quality and consistency are central to the competitiveness of rural microenterprises. Standard Operating Procedures (SOPs) play a key role in ensuring uniformity in raw material preparation, processing steps, and final product quality (FAO, 2020). Inconsistent production schedules and irregular raw material supply often hinder the growth of small-scale enterprises, making it difficult to meet market demand (Tambunan, 2019). Diversification of raw material sources, such as partnering with local businesses, can stabilize production inputs and reduce reliance on a single supply channel. Quality control measures, including inspections of raw materials and finished goods, are essential for maintaining consumer trust and securing repeat purchases.

Beyond technical improvements, market-oriented production also requires adaptation to consumer preferences and trends. Studies have shown that rural enterprises producing value-added goods, such as scented or decorative candles, can achieve higher margins when products are tailored to target markets (Porter, 1985). Packaging and branding are equally important, as

they not only protect products but also enhance their perceived value. Integrating these market-driven elements into SOPs helps ensure that production quality supports brand reputation and customer loyalty, both of which are crucial for business sustainability.

Organizational Management for Community-Based Enterprises

Effective management structures are crucial for the sustainability of community-based enterprises. Clearly defined roles and responsibilities improve operational efficiency, facilitate decision-making, and reduce conflicts among members (Dyer & Handler, 1994). The absence of formal planning and management systems often results in missed business opportunities and uncoordinated activities (UN Women, 2018). Legal registration of a business entity not only legitimizes operations but also opens access to funding, institutional partnerships, and formal markets (ILO, 2017). Organizational strengthening, including formalization of roles and establishment of an operational plan, enables rural enterprises to expand beyond subsistence-level production.

Additionally, organizational development fosters resilience against market and supply-chain disruptions. Research indicates that community enterprises with documented operational procedures and contingency plans recover more quickly from challenges such as raw material shortages or sudden changes in demand (Bryson, 2011). Participatory management models, where members are actively involved in decision-making, can also increase commitment to shared goals and encourage innovation. For rural women's groups in particular, leadership development and conflict-resolution training are valuable in maintaining group cohesion and operational effectiveness over time.

Financial Literacy and Cost Control for Microenterprises

Financial literacy is a foundational skill for business sustainability. Accurate cost recording allows entrepreneurs to calculate the Cost of Goods Sold (COGS) and set competitive yet profitable prices (Mazzarol, 2014). Without proper bookkeeping, enterprises risk underpricing, overestimating profits, or losing track of expenses. Both manual and digital record-keeping systems can be used to track income, expenses, and cash flow. In community enterprises, shared financial management systems foster transparency and collective accountability, which are critical for trust and long-term collaboration among members (World Bank, 2020). Training in financial literacy enables microenterprises to plan budgets, evaluate performance, and make informed investment decisions.

Furthermore, integrating financial literacy into daily operations can help rural enterprises access external financing. Microfinance institutions and government grant programs often require applicants to present financial statements and business plans, which are only possible with systematic record-keeping (Ledgerwood, 2013). By understanding cost structures and cash flow patterns, enterprises can better negotiate with suppliers, forecast seasonal variations in demand, and make strategic investments in equipment or marketing. These practices ultimately strengthen the enterprise's ability to grow and remain competitive in evolving markets.

Methodology

The program adopted a participatory action research (PAR) approach, emphasizing active involvement of KWT Pagoda members in problem identification, solution implementation, and evaluation. This approach ensured that activities were context-specific and fostered a sense of ownership among participants.

A total of 25 members of KWT Pagoda, all women from Kampung Cigundi, Mekaragung Village, Lebak Regency, Banten, took part in the program. The participants were engaged in small-scale agricultural processing and informal microenterprises, including household-level candle-making.

Program delivery combined **training** and **mentoring** components to build both knowledge and practical skills. Training was conducted through: classroom-style sessions introducing concepts in production management, financial literacy, and organizational planning; practical exercises where participants engaged directly in aromatherapy candle production, raw material processing, and packaging techniques; and interactive sessions encouraging members to share experiences, identify problems, and propose solutions collectively.

Mentoring was provided in the form of ongoing technical guidance and advisory visits. Trainers and facilitators conducted regular follow-ups to observe participants' application of new skills, provide corrective feedback, and help troubleshoot challenges in production, management, and finance. This continuous support was designed to strengthen the adoption of good practices and ensure sustainability beyond the training period.

Stages of Implementation

The activities were organized into three focus areas:

1. **Production and Quality Management**

- a. Introduction to aromatherapy candle production using recycled cooking oil and coconut oil.
- b. Guidance on developing Standard Operating Procedures (SOPs) and setting production schedules.
- c. Recommendations for diversifying raw material sources and implementing quality control.

2. **Organizational and Operational Management**

- a. Workshops on defining roles and responsibilities within the group.
- b. Guidance on preparing operational plans and documentation.
- c. Support for initiating the legal registration process as a formal business entity.

3. **Financial Literacy**

- a. Training on recording raw material costs, production expenses, and sales revenue.
- b. Calculation of Cost of Goods Sold (COGS) for both standard and aromatherapy candles.
- c. Use of manual ledgers and spreadsheet tools for transparent financial management.

Data Collection

Data were collected through:

- a. **Observation**, such as direct monitoring of production activities before, during, and after training.
- b. **Pre- and post-training assessments**, roll out questionnaires to measure changes in participants' knowledge and skills.
- c. **Informal interviews**, open discussions with members to gather qualitative feedback on the program's impact.

Evaluation Method

Outcomes were evaluated using both qualitative and quantitative indicators:

1. **Qualitative**, to observe changes in production methods, organizational practices, and financial recording.
2. **Quantitative**, to analyze increases in knowledge assessment scores and the number of participants applying new management and financial practices.

Results and Discussion

The program implementation produced substantial progress across the three targeted areas: production improvement, organizational management, and financial literacy. Each area demonstrated notable changes, although certain challenges remain for future development.

Production Improvement

Before the program, candle production by KWT Pagoda was irregular, lacked standardized procedures, and relied heavily on household-sourced waste cooking oil. This dependence on inconsistent raw material supply hindered production continuity. Moreover, the absence of Standard Operating Procedures (SOPs) resulted in inconsistent product quality, (both in burn time and aroma) which limited the candles' potential in commercial markets.

Through hands-on demonstrations and mentoring, members learned to purify waste cooking oil, mix it with base wax and paraffin in the correct ratios, heat the mixture to an optimal temperature, and infuse essential oils for aroma. The training also emphasized proper cooling, molding, and packaging techniques. As a result, members began developing draft SOPs that could guide production in a consistent and repeatable manner. Recommendations for raw material diversification (such as partnering with local restaurants and hotels) were well-received, though formal partnerships have yet to be established.

Based on the photo below, it shows the results of the production of aromatherapy candles by KWT Pagoda in the early stages, where the production process is still carried out in a simple manner using whatever materials are available. The quality of the candles at this stage is not yet optimal, both in terms of neatness and cleanliness, so the results are not yet sterile and do not have high aesthetic value. Additionally, the products produced have not been equipped with packaging or a brand logo, so the appearance does not yet reflect the product's identity or attract market interest. This stage serves as a foundation for learning before they receive training to

improve quality, hygiene standards, and add packaging and labels to enhance the product's market appeal.



Figure 1: KWT Pagoda's Scented Candle Before Training

Source: (Documentation 2025)

After the training, KWT Pagoda gained new knowledge and skills in making higher quality aromatherapy candles. They were taught how to use the right materials, such as paraffin, soy wax, hardeners, wicks, and attractive packaging. Additionally, their products now feature an official logo as a brand identifier. In product development, KWT Pagoda is recommended to produce aromatherapy candles in four premium fragrance variants: jasmine, lavender, peppermint, and lemongrass. Each variant offers benefits for relaxation, air freshening, and creating a comfortable atmosphere, thereby enhancing the product's market value and appeal.



Figure 2: KWT Pagoda's Scented Candle After Training

Source: (Documentation 2025)

Organizational Management

Initially, KWT Pagoda operated without a defined organizational structure or clear division of responsibilities. This lack of structure led to uncoordinated activities, inefficient workflows, and difficulties in decision-making. The absence of legal registration as a business entity also restricted the group from entering formal markets or accessing institutional support.

During the program, participants engaged in workshops and group discussions to design an organizational structure with clear role assignments for production, finance, and marketing. Members also began compiling operational plans to guide production scheduling, procurement, and sales. Mentoring sessions highlighted the importance of legalizing the enterprise to enable broader market access and potential partnerships. While the legal registration process has been initiated, it remains incomplete and will require follow-up in subsequent program phases.

Financial Literacy

Prior to the intervention, KWT Pagoda had no formal financial recording system, making it impossible to track raw material costs, operational expenses, or revenue. Without such data, the group could not calculate the Cost of Goods Sold (COGS) or set competitive prices. This created a risk of underpricing products and reduced potential profit margins.

The financial-literacy training introduced both manual ledger and spreadsheet-based bookkeeping systems. Members practiced recording daily expenses, calculating COGS for different candle types, and determining appropriate selling prices. Mentors provided guidance on how to use financial data for decision-making, such as identifying profitable product lines and evaluating cost-saving measures. Early results show that several members have begun applying these practices, although consistent and group-wide adoption will require continued monitoring and support.

Impact Analysis and Challenges

Overall, the combination of technical training, direct mentoring, and organizational guidance proved effective in enhancing the operational capacity of KWT Pagoda. Improvements in production skills, basic financial recording, and organizational planning have laid the foundation for more structured and market-oriented microenterprise activities. These advancements are expected to contribute to better product quality, improved cost control, and greater readiness to enter broader markets.

However, several challenges remain, including:

1. Production consistency, ensuring that the quality and quantity of aromatherapy candles remain stable, especially if demand increases.
2. Financial management, requiring continued assistance to ensure all members apply bookkeeping and Cost of Goods Sold (COGS) calculation consistently.
3. Legal registration, formalizing the enterprise's status to enable participation in formal markets, access to financing, and compliance with regulatory requirements.

The collaboration with Thaksin University and Walailak University created valuable opportunities for international networking and knowledge exchange. While the program focused primarily on local market readiness, discussions with international partners indicated potential interest in eco-friendly candle products. However, any future export initiatives would require compliance with product safety standards, attractive packaging, and clear labeling in accordance with target market regulations.

Evaluation of Training and Mentoring Activities

The training and mentoring program for KWT Pagoda was implemented from March to November 2025, following coordination and agreement with the partner organization. Activities proceeded smoothly, with active participation and enthusiasm from members. Out of 25 registered participants, the majority arrived punctually and fully engaged in the sessions.

Training sessions covered the development of Standard Operating Procedures (SOPs) for candle production, raw material quality control, basic financial management, and the

establishment of an organizational structure. Mentoring activities involved periodic visits and continuous technical guidance to reinforce skills learned during training, assist with problem-solving, and encourage the application of new practices in daily operations.

At the conclusion of the program, pre- and post-training assessments were used to evaluate knowledge improvement, showing a significant increase in participants' understanding of production techniques, financial recording, and organizational planning. While enthusiasm and adoption rates were high in the early stages, sustaining these practices will require ongoing follow-up, especially in financial documentation and raw material procurement strategies.

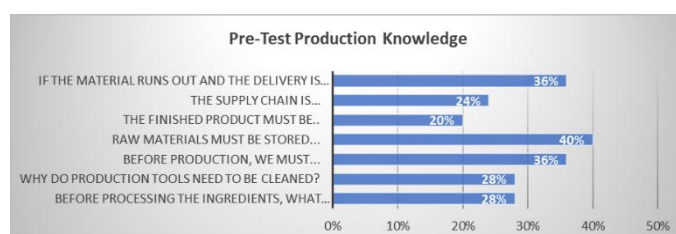


Figure 3: Evaluation of Production Aspect Activities (Before Mentoring)

Source: (Processed data 2025)

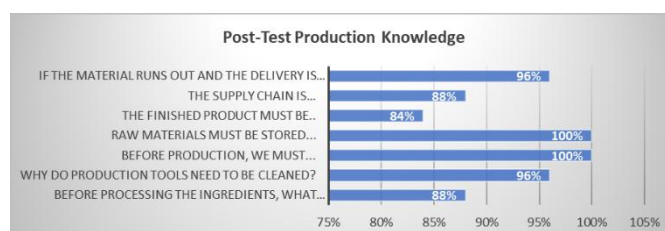


Figure 4: Evaluation of Production Aspect Activities (After Mentoring)

Source: (Processed data 2025)

Evaluation results indicated a substantial increase in participants' understanding of production-related procedures after the training and mentoring program. Pre-test scores showed low comprehension levels, with most topics ranging between 24% and 40%. Following the program, post-test results rose dramatically to 96–100% for key areas such as raw material storage, production tool cleaning, and pre-production preparation, alongside major gains in supply chain management and finished product handling. These findings confirm that the intervention effectively strengthened participants' technical knowledge, enabling them to implement more consistent and quality-focused production practices.

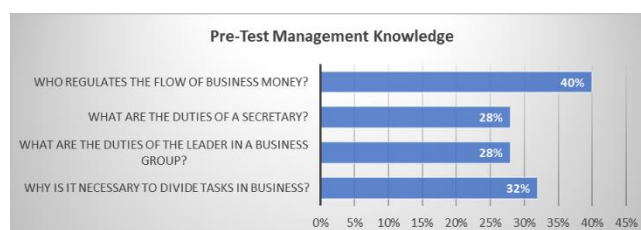


Figure 5. Evaluation of Management Aspect Knowledge (Before Mentoring)

Source: (Processed data 2025)

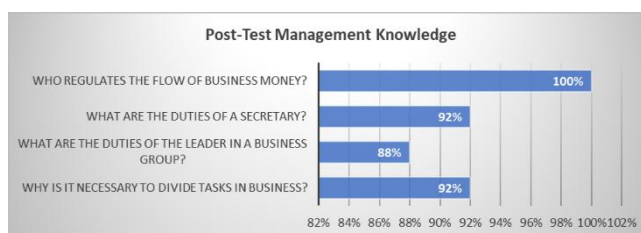


Figure 6. Evaluation of Production Aspect Knowledge (After Mentoring)

Source: (Processed data 2025)

Evaluation results for the management aspect showed a significant improvement in participants' understanding after the program. Pre-test scores indicated relatively low comprehension, ranging from 28% to 40% across topics such as the duties of a secretary, the leader's responsibilities, and the importance of task division. Post-test results demonstrated substantial gains, with 100% of participants correctly identifying the role of regulating business finances, 92% understanding the secretary's duties, and 88% recognizing the leader's responsibilities. Awareness of the importance of task division also rose markedly to 92%. These outcomes confirm that the training and mentoring effectively strengthened participants' managerial knowledge, enabling clearer role distribution and more structured group operations.

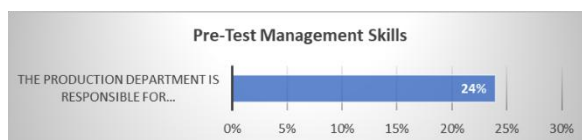


Figure 7. Evaluation of Management Aspect Skills (Before Mentoring)

Source: (Processed data 2025)

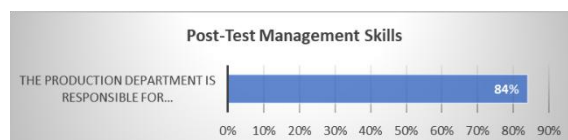


Figure 8. Evaluation of Management Aspect Skills (After Mentoring)

Source: (Processed data 2025)

Evaluation results for the management aspect mentorings howed a significant improvement in participants' understanding after the program. Pre-test scores indicated relatively low comprehension, ranging from 28% to 40% across topics such as the duties of a secretary, the leader's responsibilities, and the importance of task division. Post-test results demonstrated substantial gains, with 100% of participants correctly identifying the role of regulating business finances, 92% understanding the secretary's duties, and 88% recognizing the leader's responsibilities. Awareness of the importance of task division also rose markedly to 92%. These outcomes confirm that the training and mentoring effectively strengthened participants' managerial knowledge, enabling clearer role distribution and more structured group operations.



Figure 9. Evaluation of Financial Aspect Knowledge (Before Mentoring)

Source: (Processed data 2025)

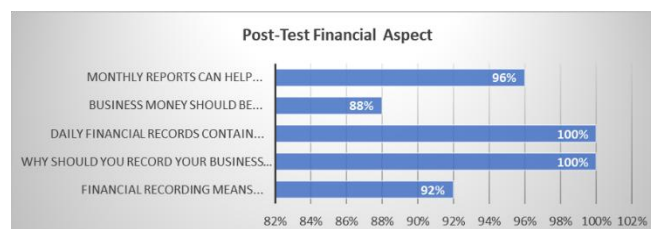


Figure 10. Evaluation of Financial Aspect Knowledge (After Mentoring)

Source: (Processed data 2025)

Evaluation of the financial aspect revealed notable progress in participants' understanding following the training and mentoring sessions. Pre-test results showed low comprehension levels, with most topics scoring between 20% and 40%, particularly in areas such as the purpose of monthly reports, the importance of recording daily transactions, and the meaning of financial records. Post-test results demonstrated significant improvements, with 100% of participants correctly identifying the content of daily financial records, 92% understanding the role of financial documentation, and 88% recognizing the benefits of monthly reports. These findings indicate that the program successfully enhanced financial literacy, equipping participants with essential skills for accurate bookkeeping and informed decision-making.



Figure 11. Evaluation of Financial Aspect Skills (Before Mentoring)

Source: (Processed data 2025)

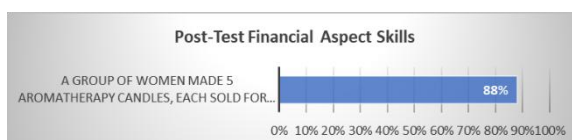


Figure 12. Evaluation of Financial Aspect Skills (After Mentoring)

Source: (Processed data 2025)

Evaluation of financial aspect skills further confirmed the positive impact of the mentoring program. In the pre-test, only 20% of participants were able to provide the correct calculation related to candle sales, showing a limited grasp of practical financial applications. After the program, post-test results rose substantially to 88%, indicating that most participants had developed the ability to perform basic revenue calculations accurately. This improvement highlights the program's role in strengthening participants' confidence and competence in

applying financial knowledge to real business contexts, ultimately supporting better decision-making and profitability.

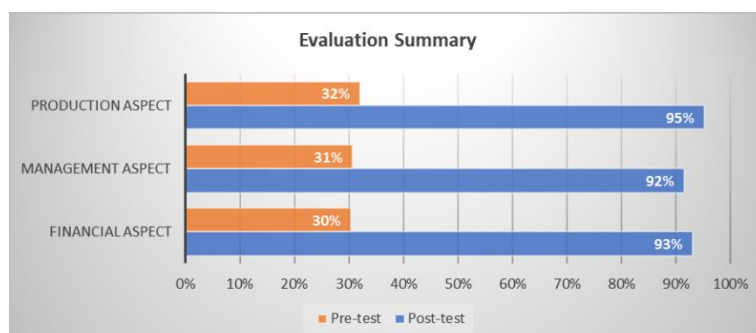


Figure 13. Summary Regarding Evaluation of Several Partner Understanding Activities
Source: (Processed data 2025)

The overall evaluation results across the three assessed aspects (production, management, and financial) demonstrated substantial improvement in participants' knowledge and skills after the training and mentoring program. Pre-test scores were relatively low, with averages of 32% for production, 31% for management, and 30% for financial aspects, indicating limited prior understanding of essential concepts and practices in each area. These initial findings highlighted the need for a comprehensive capacity-building approach that addressed both technical and managerial competencies.

Following the program's implementation, post-test results showed significant gains, with the production aspect achieving an average score of 95%, management at 92%, and financial at 93%. These increases reflect the effectiveness of combining theoretical instruction, hands-on demonstrations, and continuous mentoring in reinforcing participants' learning. The improvements in production knowledge suggest that participants are now better equipped to implement Standard Operating Procedures (SOPs) and maintain consistent product quality. Similarly, advancements in management understanding point to greater clarity in organizational roles and operational planning, while financial literacy gains enable more accurate record-keeping and informed pricing strategies.

The marked improvements across all three areas underscore the program's success in delivering integrated capacity-building tailored to KWT Pagoda's needs. The results indicate that participants not only acquired new knowledge but also demonstrated readiness to apply it in daily operations. However, sustaining these outcomes will require ongoing monitoring, follow-up mentoring, and opportunities for advanced training to address more complex challenges, such as scaling production, diversifying markets, and achieving legal business registration. This continued support will be critical in ensuring that the skills gained translate into long-term business sustainability and growth.

Conclusion

The implementation of the training and mentoring program for KWT Pagoda successfully enhanced participants' capacity in three key areas: production, management, and financial literacy. Initial pre-test results indicated limited understanding across all aspects, with averages of 32% for production, 31% for management, and 30% for financial skills. Post-test evaluations

showed significant improvements, with scores rising to 95%, 92%, and 93% respectively. These results demonstrate that the integrated approach, combining technical training, organizational strengthening, and financial management guidance, was effective in addressing the group's primary challenges.

The improvements in production skills have equipped participants to apply Standard Operating Procedures (SOPs), ensuring consistent quality and efficiency in candle-making. Enhanced management knowledge has fostered clearer role distribution, structured operational planning, and initiated steps toward legal business registration. Gains in financial literacy have enabled accurate record-keeping, cost calculation, and informed pricing strategies, laying the groundwork for sustainable profitability.

Sustaining these positive outcomes will require continued follow-up, advanced training, and monitoring to ensure the consistent application of newly acquired skills. Future program phases should focus on strengthening raw material supply chains, finalizing legal registration, and exploring new market opportunities, both locally and internationally. With ongoing support, KWT Pagoda has strong potential to evolve into a competitive, sustainable, and market-oriented rural microenterprise.

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THE IMPLICATION OF WINDING UP DEVELOPERS ON STRATA OWNERSHIP IN MALAYSIA: A CRITICAL REVIEW

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Abstract: *The process of obtaining strata titles in Malaysia involves four procedural stages, yet many purchasers remain without formal ownership, as their properties are still held under master titles. As of June 2020, over 440,000 parcels across 1,528 schemes in Peninsular Malaysia had not been issued individual strata titles. This issue is compounded when developers undergo winding-up proceedings, leaving purchasers in a legally uncertain position. With 296 recorded cases of developer insolvency since 1984, the implications for strata ownership are significant. This critical review examines the legal, financial, and administrative consequences of winding-up developers on strata title issuance. Using a systematic analysis of statutory provisions, regulatory frameworks, and existing literature, the study identifies five key implications: increased financial burden on purchasers, restrictions on property transactions, weakened management structures, unsecured creditor status, and inheritance complications. To address these challenges, the study recommends legislative reforms, including the establishment of dedicated guarantee funds, implementation of project account systems, and enhanced regulatory oversight. These measures aim to protect purchasers' rights and ensure the continuity of strata title administration, even in cases of developer insolvency.*

Keywords: *Winding Up, Developer, Strata Ownership, Implication*

Introduction

The process of applying for strata titles in Malaysia is not straightforward and involves four main procedural stages. It begins with the preparation and approval of planning and building plans by the Local Authority (Marzukhi et al., 2019). Next, the developer must apply for a Certificate of Share Unit Formula from the State Land and Mines Office (PTG) (Zana et al., 2018). Subsequently, the proposed strata plan is submitted to the Department of Survey and Mapping Malaysia (JUPEM) to get the Certificate of Proposed Strata Plan (CPSP). Finally, the application for subdivision of building or land is sent to the PTG for the issuance of strata titles (Izanda, Samsudin, & Mohsin, 2022). These procedures are mandatory to ensure that purchasers obtain strata titles as mandated under the Strata Titles Act 1985 (Act 318).

Despite these clear procedures, many strata property purchasers still do not possess their strata titles. A significant number of these properties remain under a master title, leaving purchasers without formal ownership of their units (Bakri et al., 2023; Izanda, 2023; Izanda et al., 2021; Izanda, Samsudin, & Mohsin, 2022; JKPTG, 2021a; Mahazir & Suid, 2022; Rejak Habib, 2024; Suid, 2021). As of June 2020, a total of 440,470 parcels and 1,528 schemes in Peninsular

Malaysia remain under master titles (JKPTG, 2021a). The situation becomes more complicated when a developer, whose building is under a master title, undergoes winding-up proceedings. The primary factors contributing to developer insolvency often include limited cash flow (Sensini, 2016), poor financial performance and managerial inefficiency (Heracleous & Werres, 2016), fraudulent activities (Lokman et al., 2021), weak relationships with clients or the Government (Lokman et al., 2021), and fluctuations in lending rates (Abd Halim et al., 2008).

Purchasers of units under a master title do not initially hold individual strata titles. Instead, their only evidence of ownership is the sale and purchase agreement (SPA) and loan agreement. The SPA remains the sole proof of ownership until the strata titles are issued and transferred. This leaves purchasers without secure legal ownership and the indefeasibility guarantee provided under Section 340 of the National Land Code (Act 828). The winding up of a company is the formal dissolution process involving the disposal of assets, repayment of debts, and distribution of remaining assets to shareholders. (Rastogi & Dixit, 2023; S. Zainudin et al., 2015). Under the Companies Act 2016 (Act 777), there are two types of winding up in Malaysia which are voluntary and compulsory. A compulsory winding up is a statutory process to dissolve a company in severe financial distress through court proceedings, while voluntary winding up occurs through a resolution passed by shareholders. Indeed, when a developer is wound up, all its administrative affairs and assets, including land registered under a master title, are taken over by an appointed liquidator. These assets are vested in the Director General of Insolvency, who act as a receiver and manages all matters related to strata title applications (Hussin & Haji Pardi, 2003).

This study is guided by the lens of *Legal Pluralism*, which recognizes the coexistence of multiple legal systems within a single jurisdiction. As highlighted by Chevallier-Govers (2010), Malaysia's legal landscape is shaped by overlapping statutory, administrative, and religious laws that often create fragmentation in governance. In the context of strata ownership, this pluralism manifests in the interplay between land law, corporate law, and insolvency procedures. Complementing this is the *Property Rights Theory*, which emphasizes the importance of clearly defined and enforceable ownership rights. As discussed by N. H. Zainal et al. (2024), the complexity of strata lease schemes and title issuance in Malaysia underscores the need for legal clarity and institutional safeguards. Together, these frameworks provide a critical lens to evaluate the implications of developer winding-up on strata title security and purchaser protection.

Strata Ownership

Ownership is a fundamental legal concept that defines an individual's relationship to property (Rathi, 2021). According to Abdipour Fard et al. (2022), an ownership exists when an individual has a legally recognized dominion over an object or property. Ownership is considered the highest form of property rights and is one of the most essential rights in the structure of property ownership (Vivian Chinelo Arinze, 2022). In Malaysia, strata ownership is generally categorized into two types which are Master Title and Strata Title as discussed below.

Strata Title

The legal framework governing property ownership known as the strata title system is widely applied in many countries, albeit under different terminologies and with variations in implementation. In the United States, the equivalent term is condominiums, while in France it is referred to as copropriété. In Australia, Singapore, Indonesia, and Malaysia, the system is known as strata title. In Germany, the term Wohnungseigentum is used, in South Africa, it is sectional title and in England, the equivalent framework is known as commonhold (Troy et al., 2017). According to Zainal et al. (2022), strata title specifically refers to a strata development where each unit is held under an individual title. This system facilitates multi-ownership arrangements by subdividing a property vertically and granting an individual title for each unit (Izanda, 2023).

However, this research focuses on master titles because of its interest in buildings that have been occupied but have not yet been issued with strata titles due to the winding up of the developer. The absence of strata titles in such cases is often the result of a developer's failure to prepare or submit the necessary application

Master Title

A Master title is an ownership document issued during the initial stage of property development and is typically registered under the name of the landowner or the developer (Yung Huei & Samsudin, 2024). According to Rejak Habib (2024), the Master title serves as the official legal proof of ownership for the entire land parcel and all transactions related to it are controlled by the developer as the registered proprietor (Leffers & Wekerle, 2020).

The Strata Titles Act 1985 (Act 318) was established to protect the interests of purchasers and regulate developers (Ahmad Shuhaimi et al., 2022). Despite legislative amendments imposing a statutory obligation on developers to apply for strata titles, many have failed to do so, especially when the company is winding up (Izanda et al., 2021; JKPTG, 2021a; Tuan Hadi, 2023). Figure 1 below illustrates the three categories of strata buildings that can be remained under a Master title.

Strata Special Building

Special Building is a building occupied between June 1996 and 11 April 2007 or those occupied before June 1996. The purpose of this category was to allow the issuance of strata titles for developments facing documentation constraints, such as missing Certificate of Fitness for Occupation (CF) or lost original building plans (Suid, 2021).

Old- Stratified Building

Old Stratified Buildings refer to multi-story developments occupied between April 12, 2007, and the enforcement date of Act A1450 (in 2016) that still not had strata title applications submitted. The introduction of Act A1450 mandated the simultaneous issuance of Vacant Possession (VP) and the strata title.

New Stratified Building

The *New Stratified Building* category refers to Multi-story developments constructed after the 2017 amendment of Act A1450 that still lack strata titles. This occurs when the landowner or developer fails to proceed with the subdivision of the building and the registration of strata titles as required by the Strata Titles Act 1985.

Winding Up of a Developer

Winding up of a company refers to the formal process of dissolving a company through a series of prescribed steps, including the disposal of assets, repayment of debts to creditors, and distribution of any remaining assets (if applicable) to shareholders (Rastogi & Dixit, 2023). This process is crucial to ensure that the company is legally terminated and that all administrative affairs are comprehensively settled. According to Vengsarkar (2021), winding up is a procedure whereby the company's assets are realised by a liquidator, and the proceeds are used to settle all debts and liabilities.

The Companies Commission of Malaysia (2018), defines winding up as the termination of a company's existence pursuant to statutory provisions, during which all of its assets are gathered for the purpose of satisfying the company's debts and obligations. The process of collecting and disposing of these assets by the appointed liquidator is referred to as liquidation.

In the context of the housing development industry, the winding up of a developer has significant implications, particularly for strata developments that remain under a master title. Hilal & Dahlan (2011) explain that when a housing developer is wound up, all business affairs and assets of the company are taken over by either a Private Liquidator, a Provisional Liquidator, or the Official Receiver (OR) under the supervision of the Insolvency Department of Malaysia. The Department acts as the Provisional Liquidator or as an appointed Liquidator in accordance with the provisions of the Companies Act 2016 (Act 777) and the Companies (Winding Up) Rules 1972.

The absence of strata titles in such cases often results from the failure of the winding up developer to complete the subdivision and registration process. Consequently, individual purchasers face substantial challenges in securing legal ownership of their respective parcels. This scenario not only delays the transfer of legal ownership but also creates a chain of legal, administrative, and financial repercussions that directly affect strata ownership rights. The following section examines these implications in greater depth, with particular attention to winding up developer on strata ownership.

The Role of the Liquidator in Facilitating Strata Title Transfer

The liquidator, whether a private professional or the Director General of Insolvency, plays a critical yet often complex role in facilitating the issuance and transfer of strata titles for wound-up developers. While their primary duty is to manage the developer's assets and settle its liabilities in the interest of all creditors, their responsibilities extend to completing the legal requirements for strata title issuance, a task that often falls outside the scope of traditional liquidation.

Legal and Administrative Responsibilities

Upon appointment, the liquidator assumes full control over all of the developer's assets, including the master title land. Their responsibilities include:

- **Asset Tracing and Verification:** The liquidator must first identify and verify all assets, liabilities, and outstanding obligations of the developer. This includes locating and reviewing all project-related documents, such as building plans, Certificates of Completion and Compliance (CCC), and a comprehensive list of all purchasers and their respective Sale and Purchase Agreements (SPAs).
- **Completing Statutory Requirements:** This is a crucial and challenging aspect of their role. The liquidator is responsible for completing all the necessary procedural steps under the **Strata Titles Act 1985 (Act 318)** that the developer failed to perform. This includes appointing a licensed surveyor to conduct the land survey, submitting the necessary plans to the Department of Survey and Mapping Malaysia (JUPEM), and applying for strata titles with the State Land and Mines Office (PTG).

Financial and Operational Challenges

The liquidator's effectiveness in facilitating strata title transfer is often hindered by significant financial and operational challenges.

- **Lack of Funds:** The most common obstacle is the lack of available funds. The liquidator must use the developer's assets to cover the costs of liquidation, including professional fees for legal work, land surveying, and administrative tasks. If the developer's assets are insufficient, the liquidator may be unable to pay for these services, bringing the strata title application process to a halt. In such cases, purchasers may be asked to contribute additional funds, placing an unforeseen financial burden on them.
- **Missing Documentation:** Liquidators frequently face the problem of missing or incomplete project documentation. The developer may not have a complete set of building plans, as-built drawings, or other crucial documents required for the strata title application. Re-creating these documents can be a costly and time-consuming process, further delaying the title issuance.

The liquidator's role is inherently conflicted. They are an agent of the court, tasked with a statutory duty to settle the developer's debts and distribute assets fairly among all creditors. This duty can sometimes be at odds with the purchasers' interests, as the liquidator may prioritize the claims of secured creditors (such as banks) over those of unsecured purchasers. The liquidator's legal mandate is not primarily to ensure every purchaser receives their strata title, but to manage the liquidation process efficiently. Therefore, while they are the sole legal entity authorized to act on the developer's behalf, their actions are bound by the constraints of insolvency law, which often subordinates the interests of strata purchasers. This highlights the need for legislative reform to create a clearer, more direct pathway for strata title issuance in such cases, rather than relying on a process designed for corporate dissolution.

Implication of Winding Up Developer on Strata Ownership

In this research, five primary implications of winding up developer on strata ownership were identified. Table 1 below shows the implication of winding up developer on strata ownership encompassing financial, legal, and administrative dimensions.

Table 1: Implications of Winding Up Developer on Strata Ownership

No.	Implications of Winding Up Developer on Strata Ownership
1.	Substantial additional costs
2.	Restriction on Future Transaction
3.	Management Inability
4.	Unsecured Purchaser
5.	Inheritance Barrier

Substantial Additional Costs

The winding up of a developer may imposes substantial additional costs on purchasers. In the absence of a functioning developer, buyers are compelled to bear legal expenses associated with appointing a liquidator, obtaining court orders, or engaging professional services to process the strata title application on their behalf (Izanda, Samsudin, Mohsin, et al., 2022). These unanticipated financial burdens can also extend to administrative fees, surveyor charges, and compliance costs required to meet statutory procedures under the Strata Titles Act 1985 (Act 318) and related regulations (Hussin & Haji Pardi, 2003). JKPTG (2021a) contends that the cost of preparing all necessary plans and related documentation is significantly higher than the preparation of an as-built plan. When parcel purchasers experience financial constraints, these elevated costs exacerbated by the circumstances of a winding up developer can delay the strata title application process, eventually leading to arrears. As a result, the buyer of the parcel who is required to provide the cost of the strata title application which should be the responsibility of the developer as stated in Section 8 of Act 318.

In addition, the appointed liquidator may impose substantial administrative fees on parcel purchasers for verifying the strata title application documents and completing the instruments of transfer. Studies have shown that liquidators are legally entitled to charge a service fee, which can range from RM500 to as much as 2% of the property's market value, to execute the strata title transfer in favor of the purchaser (JKPTG, 2021a; Suid, 2021; A. L. Zainal, 2024).

Restriction on Future Transaction

According to (Hussin & Haji Pardi, 2003; Tuan Hadi, 2023), the purchaser is the most adversely affected party, as they will have difficulties in future transactions. The purchaser is unable to transfer their parcel to a subsequent purchaser or engage in any other transactions such as lease and charge because the developer as original proprietor was in the process of winding up while the application for the issuance and transference of strata title to parcel owner had not yet been finalized (Izanda, Samsudin, & Mohsin, 2022; Rejak Habib, 2024).

Under Section 8 Act 318, the legal ownership of the development remains with the developer as the original proprietor until the strata titles are issued and transferred. When a developer is winding up prior to completing this process, the master title remains unsplit, and all dealings

with it fall under the authority of the appointed liquidator. Consequently, no transfer, lease, or charge can be lawfully registered at the land office without the liquidator's consent and the settlement of any outstanding obligations, including debts, taxes, and administrative fees. Similarly, Sal et al. (2020) reported that, winding up developer causes inconvenience for purchasers attempting to sell their properties to another buyer, as they must first obtain the liquidator. In line with A. L. Zainal (2024), present studies recognize that purchaser cannot sell their parcel at the market price if the grant still under master title and all collateral for bank loans will experience problems.

Management Inability

The winding up of a developer prior to the issuance and transfer of strata titles leaves the Joint Management Body (JMB) in a precarious operational position. According to Hussin & Haji Pardi (2003), JMB cannot be established until the issuance of strata titles. The absence of strata titles limits the JMB's statutory enforcement powers under the Strata Management Act 2013 (Act 757), as parcel owners' interests are not yet individually registered. Consequently, outstanding maintenance charges and sinking fund contributions from parcels still under the developer's name often remain uncollected due to the liquidator's delayed settlement of liabilities. The maintenance fee is an amount of money collected by JMB to maintain the building and all provided facilities. Maintenance works for damage recovery need to be carried out to ensure the building and provided facilities are in good condition (Abas et al., 2021).

As emphasised by A. L. Zainal (2024), due to winding up developer, the strata building cannot be well maintained especially when residents are likely not to cooperate well with the JMB in terms of maintenance works. Zakiah & Khadijah (2016) compelling argument that, JMB often face difficulty in obtaining consensus on various aspect of managing the strata development. As a consequence of winding up developer, this will impact in physical terms, the buildings that become obsolete and will affect the residents or unit owners in aspects of safety, comfort, healthy living and sustainability.

Parallel to this argument, Kathitasapathy et al. (2023) finds that developer's last contribution of a strata development would end upon setting up the first annual general meeting of the Management Corporation (MC) and handing over the baton from the JMB to the MC. However, in these cases, the MC cannot be formed due to winding up developer and failures in the issuance and transfer of strata titles. Fundamentally, JMB is intended to function as a temporary entity responsible for the administration and management of the building until the establishment of the MC, which occurs once at least 25% of strata titles have been successfully transferred from the developer to the purchasers (JKPTG, 2021b; A. Z. Zainudin et al., 2022). However, in cases where the developer is winding up, this transfer process often fails to be completed. Consequently, the ownership of parcels remains registered under the developer's name, and the JMB is compelled to continue managing the building beyond its legislated mandate.

Unsecured Purchaser

According to JKPTG (2021a), the purchaser in such circumstances is categorised as an unsecured creditor Without the strata title, the purchaser's ownership is not legally perfected, and their rights are subordinated in the liquidation process. As a result, if the developer's assets

are insufficient to meet all liabilities, these unsecured purchasers may not receive any financial restitution, further compounding the detriment caused by the non-transfer of the strata title. A. L. Zainal (2024), similarly argues that, leftover assets after the payment of creditors will likely not be enough to cover the expenses of issuing the strata title.

Inheritance Barrier

In circumstances where a developer has been wound up and the strata title has not been issued, the administration of inheritance may experience significant delays. Such delays can adversely affect the property, including the potential imposition of an estate freeze by the competent authorities (Rejak Habib, 2024). Hence, the property owned cannot be inherited because the property is still under the name of the developer.

Comparative Legal Analysis: Lessons from Singapore and Australia

While Malaysia faces significant challenges when developers are wound up, particularly concerning the issuance of strata titles, other common law jurisdictions such as Singapore and Australia have implemented more robust mechanisms to protect purchasers' interests. Examining these models offers valuable insights for potential legislative reforms in Malaysia.

Singapore's Project Account System

Singapore's *Housing Developers (Control and Licensing) Act 1965* offers a powerful safeguard through its "Project Account" system. Developers are required to open a separate project account for each housing project, into which all purchase monies must be deposited. These funds can only be withdrawn for specific, pre-approved project costs. Crucially, the monies in the project account are deemed not to be part of the developer's property in the event of bankruptcy or liquidation (Teo Keang Sood, 2020).

In contrast, Malaysia's approach, where purchasers are typically considered unsecured creditors, leaves them at the bottom of the liquidation priority list, making it highly improbable for them to recover their financial contributions. The Singaporean model effectively ring-fences purchasers' funds, ensuring they are used solely for the completion of the project and shielded from other creditors' claims.

Australia's Insurance and Bond Schemes

Australia, particularly New South Wales (NSW), provides a different but equally effective layer of protection through mandatory insurance and bond schemes. These includes:

- **Home Owners Warranty Insurance:** This is a compulsory insurance policy that builders must take out. It protects homeowners against financial loss due to a builder's insolvency, death, or disappearance.
- **Strata Building Bond and Inspection Scheme (NSW):** For strata buildings, developers are required to lodge a bond (e.g., equivalent to 2% of the building costs in NSW) with a government body like NSW Fair Trading. This bond serves as a financial guarantee that can be used to fund the rectification of defects identified during final inspections.

These mechanisms shift the risk from the individual purchaser to a collective, managed insurance or bond fund. The existence of these funds ensures that there is a pool of money specifically dedicated to addressing building completion issues or defects, even if the developer is no longer solvent.

The legal frameworks in Singapore and Australia highlight a fundamental difference in policy: a proactive focus on purchaser protection from the outset, rather than a reactive, post-insolvency approach. Malaysia's current system places the burden on purchasers to navigate a complex and costly legal process, with a high risk of recovering neither their money nor their property. The Singaporean and Australian models provide clear blueprints for implementing a more robust system, such as a mandatory project account system or a compulsory insurance/bond scheme, that would provide a definitive legal and financial buffer for purchasers, thus mitigating the dire consequences of developer winding-up.

In-depth Discussion of Recommendations

This critical review's findings underscore the urgent need for a multi-faceted approach to address the legal vacuum affecting strata purchasers in Malaysia. The following recommendations, informed by the comparative analysis with Singapore and Australia, propose concrete pathways for legislative and administrative reform.

Legislative Reforms: Implementing a Project Account System

The current legal framework, which positions purchasers as unsecured creditors, is a major systemic flaw. Following Singapore's successful model, Malaysia should introduce a legislative amendment to the Housing Development Act to mandate a project account system. This would involve:

- **Establishing Fiduciary Duty:** Legally establishing that all purchaser funds are held in a trust-like capacity, separate from the developer's general assets.
- **Centralized Oversight:** Empowering a regulatory body (e.g., the Ministry of Housing and Local Government) to monitor these accounts and ensure withdrawals are strictly for project-related expenses.
- **Legal Insulation:** Enshrining a provision that explicitly states these funds are not to be considered part of the developer's assets in the event of liquidation, thereby protecting them from being seized by other creditors.

Establishment of Dedicated Funds

Beyond the project account, Malaysia could explore the establishment of a dedicated guarantee fund, similar to Australia's bond schemes. This fund could be financed through a small, mandatory contribution or bond from all housing developers. The primary purpose would be to act as a financial safety net to cover critical costs related to developer insolvency, such as the completion of a partially finished project or the rectification of major defects.



Enhanced Regulatory and Administrative Oversight

Legislative changes are only effective with strong enforcement. The government should enhance the administrative oversight of the housing development sector. A digital system could be implemented to track the progress of every housing project and the status of strata title applications in real-time. The relevant authorities should have the power to conduct compulsory financial audits of developers. For cases where winding-up is unavoidable, a specialized task force or court division could be created to handle developer insolvency cases.

Conclusion

The winding-up of developers in Malaysia presents a multifaceted challenge that directly undermines the rights and security of strata property purchasers. This research highlights five critical implications escalating financial burdens, restrictions on property transactions, weakened management structures, the precarious status of purchasers as unsecured creditors, and complications in inheritance processes. These issues converge on a central concern: the delay or failure in the issuance and transfer of strata titles, which deprives owners of legal certainty and full proprietary rights.

The findings underscore an urgent need for systemic reform. Without robust legal safeguards and administrative coordination, strata purchasers remain vulnerable to the consequences of developer insolvency. Drawing lessons from Singapore and Australia, Malaysia must adopt proactive mechanisms such as project account systems, dedicated guarantee funds, and enhanced regulatory oversight to ensure that property ownership is protected even in the face of corporate dissolution. Only through such reforms can confidence in the governance of strata developments be restored and the rights of purchasers fully upheld.

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STUDY ON THE ACCESSIBILITY OF TELEVISION AND RADIO SERVICES FOR PERSONS WITH DISABILITIES

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Abstract: *This study investigates the accessibility of television and radio services for Persons with Disabilities (PWDs) in Malaysia, focusing on the technological, social, and regulatory factors that influence equitable media access. The research addresses the gap between policy intent and practical implementation of accessible broadcasting, aiming to understand the barriers faced by PWDs and to provide recommendations for inclusive media environments. Anchored in three (3) theoretical frameworks of the Technology Acceptance Model (TAM), the Social Model of Disability, and the Policy Analysis Framework, the study adopts a mixed-methods approach, integrating both quantitative and qualitative data collection. The research design revolves around five (5) core objectives: benchmarking existing accessibility services and policies, identifying challenges experienced by users, exploring relevant emerging technologies, evaluating policy effectiveness, and proposing actionable solutions. Data was gathered from over 100 respondents, including individuals with various disabilities, media practitioners, and policy stakeholders, complemented by a focus group discussion and ongoing engagements with NGOs and government agencies. Preliminary findings reveal that while Malaysia has developed foundational policies such as the Persons with Disabilities Act (PWDA) 2008 and MCMC's accessibility guidelines, their non-mandatory nature leads to inconsistent enforcement and limited broadcaster compliance. Key barriers identified include outdated infrastructure, insufficient captioning and interpreter services, low awareness among content creators, and a lack of standardised practices. Comparison with countries like the United States, Australia, and Japan shows that stronger legal enforcement, advanced technologies, and coordinated policy implementation have led to more inclusive media systems. The study concludes that systemic improvements are urgently needed in Malaysia, including policy mandates, funding mechanisms, technical capacity-building, and co-designed solutions with disability stakeholders. These steps are essential to ensure that accessible communication becomes a national priority and that no one is excluded from the digital broadcasting landscape due to disability.*

Keywords: Media Accessibility; Persons with Disabilities (PWDs); Inclusive Broadcasting; Policy Implementation; Disability; Technology

Introduction

Television and radio are powerful mediums of communication, entertainment, and education, serving as essential tools for information dissemination in modern societies. For PWDs, these media play a crucial role in ensuring they remain connected to the world around them. However, despite significant technological advancements and policy initiatives, many PWDs in Malaysia still face substantial barriers to accessing television and radio services.

In Malaysia, the switch from analogue to digital terrestrial television (DTT) in 2019, marked by the completion of the Analogue Switch Off (ASO) by the Malaysian Communications and Multimedia Commission (MCMC), introduced potential enhancements such as improved image resolution, enhanced audio quality, and interactivity. These advancements hold promise for improving accessibility for PWDs, yet their full potential is still largely unrealised.



Source: Bernama reports, Ministry of Communications and Multimedia & MCMC

Bernama Infographics

Figure 1: Malaysia Digital TV Broadcast

Source: Bernama (2019)

Globally, the International Telecommunication Union (ITU) has highlighted the need for broadcasting services to be more accessible to PWDs, emphasising the role of technologies such as real-time closed-captioning, speech rate conversion, and multimedia browsing systems. As Malaysia continues to evolve its digital broadcasting landscape, it is imperative to explore and implement these technologies to ensure that PWDs have equal access to television and radio content, in line with the provisions of the Persons with Disabilities Act (PWDA) 2008.

This study explores the accessibility of television and radio services for PWDs in Malaysia, highlighting their importance not only for entertainment and information but also for education, civic participation, and emergency awareness. Despite legal obligations under the PWDA 2008, many PWDs still face significant structural, technological, and institutional barriers to accessing broadcast media. Following Malaysia's DTT transition in 2019, the research investigates whether these advancements have translated into more inclusive broadcasting. Using a holistic approach anchored in the Technology Acceptance Model, Social Model of Disability, and Policy Analysis Framework, the study reveals that features such as closed captioning, sign language interpretation, and audio descriptions remain inconsistently implemented. Through both user experience analysis and policy evaluation, the study offers practical, evidence-based recommendations to bridge this accessibility gap. Benchmarking against international best practices, the research underscores the need for stronger policy enforcement, increased stakeholder collaboration, and integration of accessible technologies. It contributes to national efforts toward digital inclusion. It supports Malaysia's commitments under the UN Convention on the Rights of Persons with Disabilities (UNCRPD), aiming to ensure no citizen is excluded from the country's media and communication ecosystem.

This research primarily aims to identify gaps in the accessibility of television and radio services for PWDs in Malaysia by evaluating the effectiveness of current technologies and regulatory frameworks and proposing actionable recommendations to enhance inclusivity. Specifically, the study seeks to benchmark existing services, technologies, policies, and regulations in Malaysia and selected countries (RO1); determine the key challenges and barriers faced by PWDs in accessing TV and radio (RO2); identify current and emerging technologies that can support accessibility (RO3); evaluate policy and regulatory gaps and explore ways to integrate inclusive practices (RO4); and provide targeted, data-driven recommendations to improve media accessibility for PWDs (RO5).

Literature Review

Media accessibility is a critical issue for PWDs as it ensures equal access to information, education, and entertainment. Television and radio, as two of the most pervasive forms of media, play a vital role in the daily lives of many individuals. For PWDs, these media can serve as essential tools for staying informed, learning new skills, and enjoying recreational activities. However, accessibility barriers can significantly limit their ability to fully engage with these media, leading to a disparity in information access and social participation (Azmi & Saaid, 2023).

Television and radio are not only sources of entertainment but also crucial platforms for information dissemination and education. Broadcast media serve as primary channels through which the public receives news, emergency alerts, and educational content. For PWDs, accessible television and radio services are life-changing, enhancing their quality of life by

providing important information in formats that cater to their specific needs. Equitable access to television and radio is vital for ensuring that PWDs are not excluded from societal developments and can contribute to positive social change, including in the community's cultural and civic life (Njuguna, 2016).

As mandated by Section 30(1) of the PWDA 2008, the government and service providers of broadcast media are duty-bound to ensure that information, communication, and technology are provided in accessible formats for PWDs at no additional cost. However, implementing assistive technologies for PWDs is not without costs and other challenges, which reflects its slow uptake and upscale in television and radio. Such challenges highlight the need for ongoing research and policy reforms to address accessibility and equity gaps in Malaysia's media landscape (Attuh & Kankam, 2024).

Global Perspectives on Media Accessibility for PWDs

The UNCRPD serves as a foundational international framework promoting the rights of PWDs, including access to media and communication technologies. Article 9 of the UNCRPD mandates equal access to information and communications, both in physical and digital forms, such as television and radio, reinforcing the idea that PWDs are entitled to full societal participation (Hendriks, 2007; United Nations, 2014). Malaysia, as a signatory to the UNCRPD, is obligated to uphold these rights by fostering the availability of accessible formats and technologies at minimal cost.

Supporting this vision, the ITU, a specialised UN agency, plays a central role in promoting accessibility standards in broadcasting. Through its initiatives, the ITU advocates for the integration of closed captioning, audio descriptions, and sign language into broadcast content to ensure inclusivity. In addition, the ITU conducts training and outreach programmes for broadcasters and policymakers, equipping them with the tools and awareness necessary to implement accessible services effectively (ITU, 2024).

Globally, several countries exemplify best practices in advancing accessible broadcasting. In the United States, regulations such as the Americans with Disabilities Act (ADA) and the 21st Century Communications and Video Accessibility Act (CVAA) have mandated real-time closed captioning and audio description for internet video content, leveraging technology to deliver inclusive programming (Kent & Ellis, 2015). Australia has similarly prioritised accessibility by transitioning to broadband-based television, incorporating user-friendly features like customisable text, captions, and audio support. The Australian Communications and Media Authority (ACMA) further guides this process by setting standards and providing training resources for content creators (United Nations Economic and Social Commission for Asia and the Pacific [UN-ESCAP], 2019). Meanwhile, Japan's policy efforts include mandating sign language and captioning in news and emergency broadcasts and implementing speech rate conversion and multimedia integration to cater to cognitive and sensory needs (Bernama, 2019; Davis, 1989; Oliver, 1983). In Malaysia, media accessibility initiatives have emerged through efforts by MyASLI. MyASLI is a Malaysian initiative dedicated to promoting and professionalising sign language interpretation, with a focus on empowering the deaf and indigenous (Orang Asli) communities through inclusive communication. Policy frameworks such as MS1184. MS1184 is a Malaysian Standard titled "Universal Design and Accessibility in the Built Environment – Code of Practice" outlines requirements and recommendations to

ensure buildings and public spaces are accessible, safe, and usable for all people, including those with disabilities. However, limitations persist, particularly in the widespread implementation of real-time accessibility features like audio description and interactive subtitles. Bridging this gap will require stronger adoption of international standards, policy reforms, and increased collaboration among regulators, broadcasters, and NGOs (Ramli, Zainol, & Yaacob, 2023; UNDP, 2024; Venkatesh & Davis, 2000).

Recent research also highlights the role of advanced technologies in media accessibility. For instance, the News Accessibility Platform (NAP) leverages AI tools like text-to-speech and sign language integration to make news content more accessible for visually and hearing-impaired users (Brahmah, 2024). Similarly, a Korean study showed that platforms like YouTube can effectively disseminate inclusive content, especially among older and white-collar audiences, by promoting educational and cultural programming through trusted influencers (Lee & Lee, 2025). Other global insights, such as those from Zimbabwe, underscore how intersecting challenges, like gender and poverty, further restrict access to essential services, including information, for women with disabilities during crises like COVID-19 (Chadambuka, Muridzo, Hungwe, & Mugari, 2024). Meanwhile, in Portugal, the MEO4ALL project identified key gaps in interactive television (iTV) for visually impaired users and proposed improvements like voice control and contextual help to enhance usability (Oliveira, Júlio, & Oliveira, 2024).

Together, these international case studies demonstrate the diversity of approaches and innovations being used worldwide to promote inclusive media environments for PWDs. They also highlight the ongoing need for collaborative, technology-driven, and rights-based strategies to ensure that media accessibility becomes a universal standard rather than a privilege.

Table 1: Benchmark Comparison: Malaysia vs Global Leaders

Feature	Malaysia	US	Australia	Japan
Real-time captions	Partial	☑	☑	☑
Audio descriptions	Rare	☑	☑	☑
Sign language integration	Some news	☑	☑	☑
Regulators	MCMC	FCC	ACMA	MIC
Innovation in accessibility	Low	High	High	High

Media Accessibility for PWDs in Malaysia

Malaysia has legal and regulatory frameworks in place to promote media accessibility for PWDs. The PWDA guarantees equal access to information, communication, and technology. It calls for media providers, such as TV and radio stations, to include features like closed captioning, audio descriptions, and sign language interpretation. The MCMC plays a key role in regulating this space, issuing policies that encourage broadcasters to adopt accessibility standards in line with international practices.

In practice, accessibility features are available on Malaysian television and radio, but their implementation is inconsistent. Closed captioning is offered on some channels, helping viewers with hearing impairments. Audio descriptions, which describe visual content for those with



visual disabilities, are available but not widely adopted. Sign language interpretation is even more limited, often restricted to selected news programmes or special broadcasts. The completion of the DTT rollout in 2019 provided technical capabilities for improved accessibility, but many broadcasters have yet to fully utilise these tools.

Several challenges hinder progress. Technological barriers, such as outdated equipment and a lack of expertise, prevent broadcasters from adopting advanced assistive features. There is also a lack of awareness and commitment from media providers, coupled with weak enforcement of existing regulations. Beyond technical issues, socio-economic and cultural barriers, like limited access to affordable assistive technology and societal attitudes toward disability, also limit accessibility. For Malaysia to achieve inclusive media access for all, there must be stronger policy enforcement, greater investment in accessible technology, and a cultural shift toward prioritising the rights of PWDs.

Recommendations for Policy Improvement

Malaysia's current legal and policy frameworks offer a foundation for accessible media, but several gaps limit their effectiveness. Although the MCMC has issued guidelines promoting accessibility features such as closed captioning and audio descriptions, the implementation of these features across broadcasters varies (ITU, 2024; UN-ESCAP, 2019). While the shift to digital broadcasting provides the technical capacity for enhanced accessibility, actual usage remains inconsistent across media platforms. This reflects broader challenges in industry-wide adoption and compliance, which may stem from differing levels of awareness, resource availability, and prioritisation among broadcasters. As the regulatory body, MCMC provides the framework and guidance, but effective implementation depends largely on the commitment and capacity of individual broadcasters.

Key issues include the absence of uniform standards for implementing accessibility features and limited oversight to ensure broadcaster compliance. Media providers are not equally investing in or applying assistive technologies, which results in significant variations in service quality (Kent & Ellis, 2015). Additionally, there are few incentives or support structures for broadcasters to adopt more accessible practices, further slowing progress in this area.

To bridge these gaps, several policy improvements are needed. Malaysia should implement clear, uniform standards requiring all broadcasters to include closed captioning, sign language interpretation, and audio descriptions (UN-ESCAP, 2019). Policies should also make better use of digital technology capabilities and include financial or technical support to help broadcasters upgrade their systems (ITU, 2024). Stronger enforcement, through regular audits, compliance checks, and penalties for non-adherence, is critical to ensure consistent service delivery (Kent & Ellis, 2015). Innovative solutions could also improve accessibility, particularly for the hearing-impaired community. For instance, Smart TVs and broadcasting platforms could allow viewers to adjust the size of the sign language interpreter's window, making interpretation clearer and more user-friendly. A flexible viewing ratio, such as 1:2, would help viewers prioritise the interpreter screen when necessary.

Finally, there is a need to professionalise the role of sign language interpreters in the media sector. Recognising this work as a formal career, through certifications, training programmes, and industry standards, would raise the quality and consistency of interpretation services. This

not only improves access for PWDs but also creates meaningful employment opportunities in the broadcasting industry.

Methodology

This study employs a mixed-methods approach that integrates both quantitative and qualitative strategies to comprehensively examine media accessibility for PWDs in Malaysia. The quantitative component consists of structured questionnaires administered to two (2) main respondent groups: individuals with disabilities and professionals working in television and radio broadcasting. For the PWD population, a stratified random sampling technique is applied to ensure fair representation across seven (7) disability categories, namely visual, hearing, speech, physical, mental, learning, and multiple disabilities. A sample size of 100 respondents was calculated based on a 5 per cent margin of error and a 95 per cent confidence level, with proportional distribution across all disability types. For broadcasting professionals, a separate structured questionnaire is used to capture current practices, challenges, and attitudes toward accessibility features in media services. Data collected through these instruments address three (3) core research objectives: RO1 (to benchmark the accessibility of current television and radio services), RO3 (to explore the adoption of emerging technologies for PWD accessibility), and RO4 (to evaluate the effectiveness of current regulatory frameworks). The quantitative data will be analysed using descriptive and correlation statistics to identify patterns and relationships relevant to media accessibility.

$$n = Z^2 \times p \times \frac{1-p}{e^2},$$

where:

n = Required sample size

Z = Z-value (1.96 for a 95 per cent confidence level)

p = Estimated proportion of the population (0.5 is used when the exact proportion is unknown)

e = Margin of error (commonly 0.05)

Complementing the quantitative phase, the qualitative component involves semi-structured interviews and focus group discussions (FGDs) to explore deeper insights into lived experiences and institutional challenges. This phase supports RO2 (to identify the real-world challenges faced by PWDs in using TV and radio), RO3 (to explore broadcasters' perspectives on technology adoption), and RO4 (to assess policy implementation from the viewpoint of regulators and stakeholders). A purposive sampling technique is used to select 14 PWD participants, two (2) from each of the seven (7) disability categories, as well as media practitioners from RTM, TV3, Astro Awani, Bernama TV, and radio stations such as IKIMfm and Negeri FM. Special accommodations are made to ensure accessibility in data collection, including the use of sign language interpreters, voice recordings, simplified questions, assistive communication devices, and caregiver-assisted interviews where necessary. Additionally, focus group discussions are conducted with policymakers and representatives from Jabatan Kebajikan Masyarakat (JKM) to capture institutional perspectives on policy challenges. All qualitative data are analysed thematically using NVIVO software, enabling the identification of recurring themes related to media accessibility. This mixed-methods design ensures a holistic understanding of both user experiences and systemic factors affecting inclusive media access for PWDs in Malaysia.

Findings

Findings for Research Question 1

The investigation into the current state of television and radio accessibility for PWDs in Malaysia, in comparison with international benchmarks, reveals both progress and persistent gaps. Case studies from developed countries such as the United States, Australia, and Japan illustrate how a comprehensive approach, integrating legal mandates, regulatory enforcement, and technological innovation, can significantly enhance media accessibility. In the United States, accessibility is supported by strong legal frameworks like the Americans with Disabilities Act (ADA) and 21st Century Communications and Video Accessibility Act (CVAA), which require real-time closed captioning and audio descriptions for both traditional and digital media. Australia has embedded accessibility within its national disability strategy, using broadband TV to support customizable features and training content creators to ensure inclusive media. Japan mandates accessibility through legislation, with advanced features like speech rate conversion and integrated multimedia accessibility tools, especially in critical broadcasts.

In contrast, Malaysia has made notable efforts, including the enactment of the PWDA 2008 and the issuance of guidelines by the MCMC. Standards like MS1184 provide a supportive backdrop for accessibility efforts. However, implementation remains inconsistent across broadcasters. Closed captioning, audio descriptions, and sign language interpretation are available only on selected programmes and are not uniformly applied. Although the DTT transition in 2019 provided technical potential for improvement, its benefits have yet to be fully leveraged. Challenges include a lack of standardised requirements across media providers, limited enforcement mechanisms, and outdated infrastructure. Socio-economic barriers, such as the affordability of assistive technologies and limited awareness among broadcasters, further complicate accessibility efforts.

A comparative analysis underscores a crucial gap, not in Malaysia's policy intentions, but in execution and integration. Unlike benchmark countries that enforce compliance through law, performance metrics, and investment in emerging technologies, Malaysia lacks clear industry-wide mandates or accountability systems. Innovations seen elsewhere, such as AI-driven accessibility tools or user-customisable interpreter windows, have yet to be adopted. Furthermore, case studies like the News Accessibility Platform (NAP) highlight the transformative role AI can play in real-time content adaptation, while research into YouTube and social media platforms shows the potential of digital tools to enhance inclusive broadcasting. Other studies emphasise the need to address intersecting vulnerabilities, such as gender and disability, particularly in crisis contexts, as seen in Zimbabwe. Even in technologically advanced settings like Portugal, continual upgrades are needed to meet the needs of users with visual impairments, indicating that accessibility is a dynamic, ongoing goal.

In conclusion, Malaysia has established a solid legal and regulatory foundation for media accessibility, but significant gaps remain in implementation, enforcement, and technological advancement. Learning from global best practices, Malaysia must move beyond awareness to actionable reforms, integrating accessibility into the core of media production and regulation. Doing so will require cross-sector collaboration, technological investment, and a commitment to inclusive design, not as an afterthought, but as a fundamental right for all citizens.

Findings for Research Question 2

The study revealed multiple, interrelated barriers affecting the accessibility of television and radio services for PWDs in Malaysia. These challenges were categorised into three (3) broad themes: limitations in service effectiveness, user-related difficulties, and systemic gaps in policy, technology, and awareness. Firstly, the majority of respondents expressed dissatisfaction with the helpfulness of TV and radio services. Only 12 per cent rated the services as highly helpful, while 61 per cent gave low-to-moderate ratings (ranging from “Disagree” to “Neutral”). Similarly, accessibility features such as captions and sign language interpretation were rated as effective by just 13.6 per cent of respondents. A striking 89.1 per cent found these features to be inconsistent, difficult to activate, or unfriendly, indicating a lack of standardization and poor user interface design.

Usability barriers further contributed to limited engagement. Approximately 26.6 per cent of respondents found accessibility tools hard to use, and only 13.1 per cent agreed that activating accessibility features was easy. These findings underscore the disconnect between available features and their practical usability for end-users. Issues such as poor menu design, non-intuitive controls, and a lack of personalisation options contribute to this gap. Respondents also noted broader issues concerning social inclusion, content satisfaction, and perceived accessibility. Only 12.5 per cent felt that current media content met their needs, citing particular dissatisfaction with the entertainment and advertising segments. Additionally, participation in social and community discourse via media was reported to be limited, with only 14.7 per cent strongly agreeing that television and radio played a role in inclusion. Perceived accessibility of content was rated neutral by a large majority (68.1 per cent for TV), suggesting that while some efforts exist, they remain insufficient and inconsistently applied.

From a technical standpoint, the DTT transition, intended to enhance media access, has not significantly improved the experience for PWDs. Only 14.7 per cent of respondents noted improvements in accessibility post-transition, with most responses remaining at mid-level satisfaction scores. Adjusting basic settings such as brightness, subtitles, and audio levels was reported to be unintuitive, with only 13.6 per cent finding these features easy to configure. Content types such as news and advertisements were particularly inaccessible, with only 9.8 per cent saying news was fully accessible and just 10.9 per cent considering ads to be inclusive. The challenges also extend into systemic issues. Three (3) major gaps were identified: policy and regulatory gaps, technological barriers, and limited awareness among broadcasters. Many respondents highlighted the lack of uniform standards across networks and the absence of real-time compliance audits. Outdated broadcast technology, particularly with regard to audio description capabilities, further hinders accessibility. Moreover, many PWDs struggle to activate assistive features due to poor platform design. Importantly, a lack of training among media personnel and low prioritisation of accessibility were cited as key reasons for the continued exclusion of PWDs from mainstream media access.

Table 2: Theme and Findings

Theme / Area	Findings	% of Respondents
Service Effectiveness	Rated TV/radio services as highly helpful	12%
	Gave low-to-moderate ratings (Disagree– Neutral)	61%
	Found captions/sign language effective	13.6%
	Found accessibility features inconsistent/difficult/unfriendly	89.1%
Usability Barriers	Found accessibility tools hard to use	26.6%
	Agreed activating accessibility features is easy	13.1%
Content & Inclusion	Felt media content meets their needs	12.5%
	Strongly agreed TV/radio support inclusion	14.7%
	Rated TV content accessibility as neutral	68.1%
Digital TV Transition (DTT)	Reported improved accessibility post-transition	14.7%
	Found adjusting brightness, subtitles, and audio easy	13.6%
	News is fully accessible	9.8%
	Advertisements are inclusive	10.9%

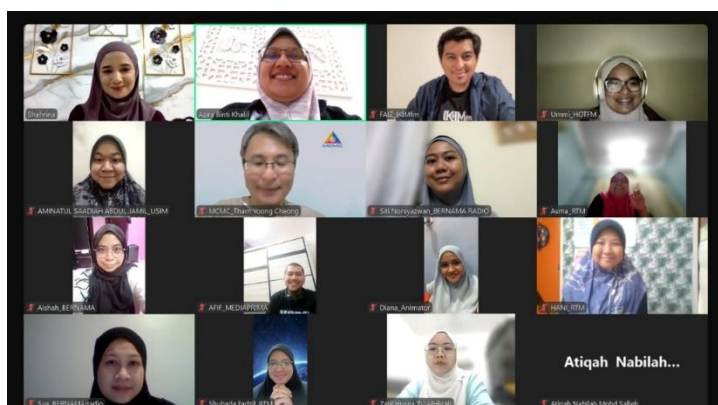


Figure 2: FGD session with Radio/TV Station Respondents

Findings for Research Question 3

This research question was addressed through both quantitative and qualitative approaches. The quantitative component involved 198 respondents from TV and radio stations, while the qualitative data was derived from in-depth interviews with 11 media professionals representing various organizations, including WOWSHOP Sdn Bhd (TV3, TV9, 8TV, TV AlHijrah), Bernama TV, a YouTube channel, IKIMfm, RTM, Bernama Radio, Hot FM, and TV Al-Hijrah. The quantitative findings reveal widespread limitations in the current use of assistive technologies within Malaysian broadcast media. Key challenges include inaccessible user interfaces, where complex menu designs and a lack of screen reader support hinder usability for blind and visually impaired individuals. Respondents also highlighted inconsistent accessibility features, such as unreliable captions and the absence of real-time audio descriptions or sign language interpretation across platforms. Radio services were reported as particularly inaccessible due to the lack of simplified or descriptive audio formats.

Another significant issue identified was limited staff competence, with many broadcasters acknowledging that staff are not adequately trained in using or delivering disability-inclusive tools and services. In tandem with this, customer support was rated poorly, particularly for its lack of disability-specific guidance or responsiveness, further compounding the accessibility gap. In contrast, the qualitative interviews provided insights into emerging technologies and innovative practices with the potential to transform the accessibility landscape. Among the most promising solutions is the use of AI-powered closed captioning, which enables real-time and accurate subtitles across TV and online channels. Respondents also cited text-to-speech and voice navigation tools as crucial developments for visually impaired users, allowing independent access and interaction with content.

Another notable advancement is the development of integrated sign language avatars, virtual interpreters that provide real-time sign translation on-screen, offering a scalable solution to the limited availability of human interpreters. Furthermore, accessible streaming interfaces that offer intuitive subtitle toggles, audio description menus, and simplified layouts are being explored by some broadcasters as part of their future plans. Awareness campaigns in the form of user guidebooks, on-screen prompts, and training videos are also emerging as low-cost yet impactful strategies to bridge knowledge gaps for PWDs and promote effective use of existing tools.

From the qualitative data, several systemic barriers to implementation were also uncovered. These include human resource gaps, such as the shortage of trained sign language interpreters, particularly those fluent in Arabic or Jawi. Technical limitations were common, including outdated hardware, poor infrastructure, and the inability to support real-time captioning or translation. Platform limitations, especially for radio, were seen as a core issue due to the medium's lack of visual content. Furthermore, policy enforcement gaps were noted, with the absence of clear KPIs or compliance audits contributing to low prioritisation of accessibility. Respondents also pointed to budget constraints, citing the high cost of producing accessible content and limited sponsorship interest. Additionally, low awareness and editorial restrictions hindered progress, as accessibility was not seen as a production priority, and complex animated or religious content was deemed difficult to adapt.

While Malaysian broadcasters recognise the potential of emerging technologies to improve accessibility, current efforts are constrained by a combination of infrastructural, financial, and regulatory challenges. Moving forward, there is a need to integrate new technologies with dedicated policy support, staff training, and collaborative efforts with PWD communities to ensure sustainable and inclusive media practices.

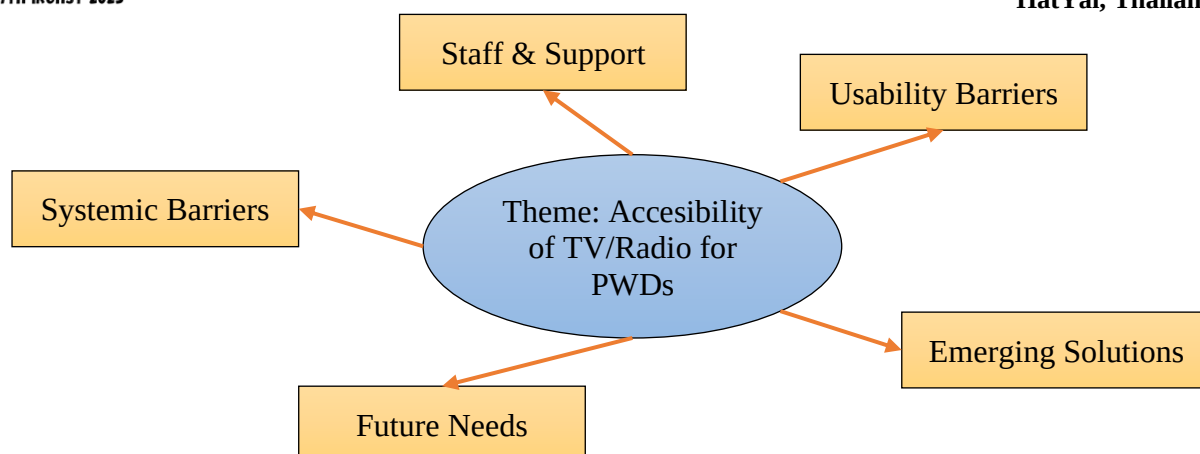


Figure 3: Simplified Thematic Analysis – Accessibility of TV & Radio for PWDs

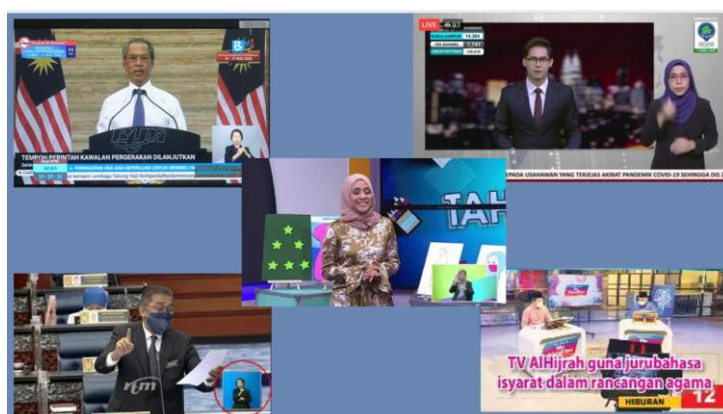


Figure 4: Examples of TV shows using Sign Language Interpreter

Findings for Research Question 4

To evaluate the effectiveness of current policies and regulatory frameworks in Malaysian broadcasting, this study engaged both quantitative and qualitative methods. The quantitative component involved responses from 189 officers affiliated with Jabatan Kebajikan Masyarakat (JKM) and other relevant government and regulatory bodies, collected through a structured questionnaire. Complementing this, the qualitative component included in-depth interviews with two (2) key NGO representatives:

1. Puan Zaharatul Sophia binti Mohamed Amir Abas, Secretary of Yayasan Pendidikan Al-Quran Bagi Anak Istimewa (Yayasan FAQEH) and a parent of a child with autism; and
2. Encik Amin Zuhaili bin Mansor, President of Persatuan Orang Pekak Negeri Sembilan (NESDA), a person with hearing disability and a cochlear implant user.

Findings from the survey indicate low confidence in current policy effectiveness. Only 7.9 per cent of respondents strongly agreed that the policies in place are effective, while a significant portion expressed skepticism, 30.2 per cent disagreed, and 33.3 per cent remained neutral. This reflects a general uncertainty regarding the impact of existing frameworks on improving media

accessibility for PWDs. Several policy and implementation gaps were identified. Notably, 28.6 per cent of respondents felt that current policies fail to meet actual accessibility needs, and an equal percentage believed that existing policy structures actively limit full media access. Many pointed to the absence of detailed provisions on digital accessibility, with 30.7 per cent calling for improvements in this area. These concerns were compounded by perceptions of weak enforcement, as only 10.6 per cent viewed enforcement as strong, and nearly 28.1 per cent disagreed that compliance is well-monitored.

Respondents also highlighted limited collaboration between government and broadcasters, with only 9 per cent strongly agreeing that cooperation is effective. This suggests a need for more structured, cross-agency engagement to implement and uphold accessibility standards. Additionally, broadcasters reportedly lack sufficient incentives and prioritisation, with 24.9 per cent disagreeing that accessibility is incentivised and many noting that it is not treated as a production priority. The qualitative interviews supported these findings. Both NGO representatives emphasised the importance of engaging PWDs and advocacy groups in policy formation and review processes. Encouragingly, 30.2 per cent of survey respondents agreed, and 20.1 per cent strongly agreed, that PWD engagement adds value and is key to reform. However, awareness campaigns were criticised as ineffective, with 31.2 per cent indicating that outreach efforts do not sufficiently raise awareness or drive implementation.

Despite these challenges, the study also identified key strengths in the current legal and institutional setup. These include the promotion of inclusivity through sign language and captioning in selected programmes, mandated interpretation for critical news updates, and visible government recognition of PWD rights. However, implementation remains fragmented and largely limited to specific broadcasts, with entertainment and radio content often excluded. The policies, while symbolically significant, require stronger operational mechanisms to fulfil their intended purpose. While Malaysia has laid an important legal foundation for accessibility in broadcasting, the effectiveness of these policies is undermined by inconsistent application, weak enforcement, limited collaboration, and low awareness. There is strong support, both from stakeholders and data, for policy reforms that ensure broader content coverage, clearer content guidelines, regular inclusion of PWD feedback, and balanced implementation across all disability groups. These actions are essential to transform accessibility from principle into practice.

Table 3: Theme and Findings

Area	Finding	% of Respondents
Policy Effectiveness	Strongly agreed policies are effective	7.9%
	Disagreed policies are effective	30.2%
	Neutral on effectiveness	33.3%
Policy Gaps	Policies fail to meet actual accessibility needs	28.6%
	Policies actively limit full media access	28.6%
	Need more detailed digital accessibility provisions	30.7%
Enforcement	Viewed enforcement as strong	10.6%
	Disagreed compliance is well-monitored	28.1%



Collaboration	Strongly agreed gov-broadcaster cooperation is effective	9.0%
Incentives & Prioritisation	Disagreed accessibility is incentivised	24.9%
PWD Engagement	Agreed PWD engagement adds value	30.2%
	Strongly agreed PWD engagement adds value	20.1%
Awareness Campaigns	Said outreach efforts are ineffective	31.2%

Findings for Research Question 5

To ensure greater inclusivity and equal access to television and radio services for PWDs, the study identifies several key recommendations drawn from both qualitative insights and quantitative findings. These recommendations are structured to address current system limitations while aligning with global best practices. First, it is imperative to standardise and expand accessibility features across all types of content. Accessibility tools such as closed captions, sign language interpretation, and audio descriptions should not be limited to news or special events. Still, they must be incorporated across a broader range of programmes, including entertainment, drama, and religious segments. Furthermore, these features should be customisable to accommodate various disability needs, such as adjustable subtitle fonts and the ability to change sign language box sizes, to support a more user-centric approach.

Second, enforcement and monitoring mechanisms must be strengthened to ensure that existing policies translate into consistent action. This includes developing clear enforcement protocols, instituting routine compliance checks, and introducing penalties for non-compliance. Broadcasting stations should also be required to report on key performance indicators (KPIs) related to accessibility, offering measurable insights into their inclusivity efforts. Third, there is a need to enhance both technical and human resource capacity within the broadcasting sector. This involves investing in the training and recruitment of qualified personnel, such as sign language interpreters, particularly those with domain-specific expertise, such as religious programming, as well as providing regular capacity-building workshops for producers and content creators. These initiatives can foster a deeper understanding of disability inclusion and equip industry professionals with the necessary tools to implement best practices.

Fourth, broadcasters should be encouraged to implement AI and digital accessibility innovations, including speech-to-text, real-time captioning, and text-to-speech applications. These tools can help automate accessibility processes and broaden the reach to diverse PWD communities. However, the use of such technologies must be guided by clear ethical standards to ensure that accessibility is achieved without compromising content accuracy or quality. Fifth, content policies must be made more inclusive and PWD-sensitive. In particular, attention should be given to filtering inappropriate language or confusing visual elements, especially for individuals with cognitive impairments. At the same time, the representation of PWDs in media content should be positive and non-stereotypical, to foster greater social inclusion and counter stigma.

Sixth, there is a strong rationale to formally engage PWDs and caregivers in both content development and policy-making processes. Feedback mechanisms, such as advisory panels, focus groups, and regulatory consultations, should be institutionalised to ensure that lived experiences directly inform decisions. This participatory approach strengthens relevance and

builds trust between stakeholders. Seventh, public awareness and accessibility literacy need to be increased. Many users, including PWDs themselves, are unaware of the features currently available on TV and radio platforms. Therefore, national awareness campaigns, user tutorials, and on-screen guidance tools should be developed to educate audiences on how to activate and utilise accessibility options effectively.

Eighth, the study highlights the importance of cross-sector collaboration. Media agencies should work in close partnership with government institutions, NGOs, disability associations, and technology providers to co-develop innovative solutions and optimise resource sharing. Initiatives such as volunteer-based interpreter programmes or subsidised services via universities and sign language bodies could help bridge existing service gaps. Lastly, the regulatory landscape must remain adaptive through regular policy review cycles. This ensures that guidelines remain responsive to emerging technologies and the evolving expectations of PWD communities. Reviews should include benchmarking against global models, such as those practiced in the United States, Japan, and Australia, to raise standards and future-proof local policies. In summary, enhancing media accessibility for PWDs in Malaysia requires a multi-pronged approach involving regulatory reform, technological investment, inclusive design, and stakeholder engagement. Implementing these recommendations holistically would help bridge current accessibility gaps and move the sector closer to achieving media equity for all.

Discussion

Research Question 1 Summary

This study addressed Research Question 1 through a content analysis of international and local policies, technologies, and practices related to media accessibility for PWDs. Benchmarking focused on the United States, Australia, and Japan, countries known for their inclusive media legislation and innovations such as real-time captioning, audio descriptions, sign language interpretation, and AI-based tools. Findings revealed that while these countries have strong regulatory frameworks and enforcement mechanisms (e.g., ADA and CVAA in the US, ACMA in Australia), Malaysia's implementation remains limited. Despite having policies like the PWDA 2008 and MCMC guidelines, accessibility features in Malaysia are inconsistently applied, often limited to news segments, and lack industry-wide enforcement. Technological gaps, outdated infrastructure, and limited user capacity further hinder accessibility. To bridge these gaps, Malaysia must move beyond policy intent to actionable reforms. Key priorities include standardising accessibility features across all broadcasters, adopting advanced technologies, strengthening monitoring mechanisms, and involving PWDs in the design and evaluation of inclusive media. Global best practices also emphasise the importance of cross-sector collaboration and digital innovation, elements Malaysia can leverage to ensure more equitable media access.

Research Question 2 Summary

To investigate the challenges faced by PWDs in accessing television and radio services in Malaysia, the study gathered insights from 184 PWDs and caregivers through surveys and interviews. The findings reveal a range of barriers spanning technology, content, awareness, and design. One (1) of the most significant issues was the inconsistent availability of accessibility features such as closed captions, sign language, and audio descriptions, often

limited to news programmes and largely absent in entertainment or religious content. As a result, many PWDs turned to mobile devices and online platforms, which offered more flexible features, though this shift raises equity concerns, especially among low-income and rural users. Technical barriers such as outdated TVs, lack of digital interfaces, and inaccessible remote controls further constrained access, particularly for those with physical disabilities. Respondents also reported a lack of tailored content, especially for those with cognitive impairments, and limited awareness of how to activate accessibility settings. This gap in media literacy was most apparent in underserved communities. Disability-specific challenges varied: visually impaired users lacked audio descriptions, hearing-impaired users faced limited and language-restricted subtitles, cognitively disabled users were exposed to inappropriate content, and physically disabled users struggled with device navigation. These findings also align with the Technology Acceptance Model (TAM), where inconsistent accessibility and usability issues reduced the perceived usefulness and ease of use of broadcast media, leading to lower adoption among PWDs. In conclusion, the study highlights the need for targeted, disability-specific interventions and improved awareness strategies. Inclusive broadcasting must go beyond policy declarations and involve PWDs in the design, delivery, and evaluation of accessible media solutions.

Research Question 3 Summary

This part of the study looked at the current and emerging technologies used by TV and radio stations in Malaysia to support accessibility for PWDs. Data were gathered from 198 media professionals through surveys and focus group discussions. The findings show that while some broadcasters have started using accessibility features like closed captions and sign language interpretation, these are often limited to news or official events. Features like audio description for the visually impaired are rarely available. Accessibility is usually added only for special occasions, rather than being part of regular programming. Several barriers were identified. Many stations face budget limitations, a lack of trained staff, and outdated equipment. Accessibility is often treated as an afterthought, not something planned from the beginning. There are also no clear performance targets or checks to ensure consistent use of these features. Insights from media professionals revealed that not all disability groups are well-served. Hearing-impaired users often struggle with subtitles that are only in English. Visually impaired users have limited options due to the lack of audio descriptions. People with cognitive or learning disabilities are often left out completely, as content is rarely simplified or structured for their needs. These issues reflect the Social Model of Disability, which suggests that it is the design of systems, not the disabilities themselves, that creates barriers. Accessibility in broadcasting is still limited by how media is planned, funded, and delivered. However, there are signs of progress. Some broadcasters are starting to explore new technologies like AI-generated captions, automated transcription, and mobile-friendly platforms like RTM Klik. Social media streaming has also opened new ways to reach PWDs, although improvements in accuracy and customisation are still needed. While awareness of accessibility is improving, more action is needed. Broadcasters must plan for accessibility from the start, invest in technology and training, and work closely with disability organisations. Real progress will come from making accessibility a core part of how media is created, not just something added on later.

Research Question 4 Summary

This section evaluated how effective current policies and regulations are in supporting accessibility to television and radio services for PWDs in Malaysia. Data were collected from 189 NGO respondents and two (2) in-depth interviews with disability advocates. Findings show that while legal frameworks like the PWDA 2008 and MCMC guidelines exist, many stakeholders, especially from NGOs, are not fully aware of their details or how they are applied. There is a disconnect between written policies and actual practice. Respondents were also unclear about who is responsible for monitoring enforcement or how PWD feedback is used in policy reviews. Some positive efforts were acknowledged, such as the inclusion of sign language interpretation during national news and closed captions during specific broadcasts. These examples show that policy intent exists, but implementation is inconsistent. Most accessibility features are limited to major events, leaving regular programmes inaccessible to many PWDs. Key weaknesses include the lack of standard enforcement mechanisms, such as KPIs or regular audits, and minimal consultation with disability communities during policy development. Feedback from PWDs and caregivers is often overlooked or only gathered during formal events, limiting its impact on meaningful policy changes. Respondents stressed the importance of cross-agency collaboration between media providers, NGOs, regulators, and tech partners to ensure accessibility is treated as a shared responsibility. Current efforts are fragmented, with some broadcasters proactive and others citing a lack of resources or guidance. There is strong support for policy reform and innovation, including the use of AI tools for real-time captioning or sign language avatars, bilingual subtitles, and expanded interpreter services. Concerns were also raised about content regulation, especially for children with cognitive disabilities, calling for better control over ads and non-verbal content cues. While the legal foundation for accessible media in Malaysia is in place, actual implementation is inconsistent and underdeveloped. More collaboration, regular policy updates, and active engagement with PWD communities are needed to ensure that accessibility becomes a lived reality, not just a policy goal.

Research Question 5 Summary

This study's final research question aimed to identify actionable recommendations to improve the inclusivity and accessibility of television and radio services for PWDs in Malaysia. Findings from the preceding sections highlighted several critical issues, ranging from inconsistent implementation of accessibility features to limited policy enforcement, technological gaps, and lack of stakeholder engagement. In response, the study proposes a multi-dimensional approach to reform. Firstly, policy enforcement needs to be strengthened. Although frameworks such as the PWDA 2008 and MCMC guidelines exist, their impact remains uneven due to the absence of standardised Key Performance Indicators (KPIs) and routine audits. Establishing clear enforcement mechanisms and offering incentives to compliant broadcasters would promote industry-wide accountability. Equally important is the standardisation of accessibility features. Features such as closed captions, sign language interpretation, and audio descriptions must be uniformly available across all programmes, not just during news or special events, and should be culturally and linguistically appropriate. Engaging PWDs and advocacy groups in content planning is another essential recommendation. Their direct feedback can help ensure services are designed around real needs. Regular dialogue through feedback platforms, town halls, or advisory committees should become an integral part of broadcast planning. Additionally, broadcasters must embrace

assistive and AI-driven technologies like real-time transcription, speech-to-text, and sign language avatars to enhance accessibility. However, adopting these tools requires capacity building. Therefore, training programmes should be expanded to include technical staff, sign language interpreters with subject-matter expertise, and media professionals. Content inclusivity must also be prioritised. Beyond technical access, programming should be cognitively appropriate and culturally sensitive, particularly for children and individuals with learning difficulties. Finally, long-term improvement depends on cross-sector collaboration and systematic evaluation. A national accessibility council, involving media agencies, NGOs, and technology partners, is recommended to lead this effort. Monitoring systems must be put in place to track accessibility metrics, review policies regularly, and ensure continued responsiveness to the evolving needs of the PWD community. In sum, creating an inclusive media ecosystem requires not just policy reform, but a cultural shift toward valuing accessibility as a core component of public service.

Conclusion

In sum, this study provides a comprehensive overview of the current state of television and radio accessibility for PWDs in Malaysia. While legal frameworks and initial infrastructure are in place, the findings demonstrate a significant gap between policy aspirations and on-the-ground realities. Accessibility remains inconsistent and often limited to high-profile programmes, with insufficient enforcement, underutilised technologies, and minimal engagement with the very communities affected. The challenges are not only technical but also systemic, rooted in outdated practices, budgetary constraints, and a lack of stakeholder collaboration. As evidenced through the lens of the Technology Acceptance Model and Social Model of Disability, the usability and usefulness of broadcasting platforms are compromised when inclusive design is not prioritised from the outset. To move forward, accessibility in media must be treated not as a supplementary feature but as an essential public good. This requires shifting from reactive to proactive strategies, where accessibility is integrated from the planning stage, supported by cross-sector partnerships, backed by regulatory mechanisms, and shaped by the lived experiences of PWDs. Malaysia has the legal and technological foundation to lead in this area, but success will depend on sustained commitment to inclusivity, innovation, and accountability. By embracing a user-centred and disability-specific approach, Malaysia can fulfil the promise of equal media access for all, reinforcing the values of dignity, participation, and universal design in the digital age.

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EVALUATION OF THE IMPLEMENTATION PROGRAM FOR DIPLOMA ACCOMPANYING CERTIFICATES AT UNIVERSITIES IN BEKASI CITY

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Abstract: *The implementation of the evaluation is to provide an understanding of the objectives of a policy, how it is implemented, and what impacts are obtained. Related research on the SKPI program carried out by universities in the Bekasi city area by conducting an evaluation using a combination of the CIPP and Kirkpatrick models which aims to determine the background, input, process, product and impact of the implementation of the program. This study uses a mixed method research design with the Explanatory Sequential Mixed Methods approach. The results of this study indicate that the implementation of the SKPI program received a very positive assessment and was considered to have a significant impact on improving the quality of graduates, preparing them for the global job market, and supporting the recognition of graduates at the national level. This program is also considered to be able to provide direct benefits in helping graduates get jobs that match their expertise. This reflects the importance of SKPI in increasing the relevance of education to industry needs and developing graduate competencies*

Keyword: *Diploma Accompanying Certificate Program, Implementation and Evaluation*

Introduction

The implementation of a curriculum that refers to KKNI actually clarifies what the profile of graduates from each study program is like and what learning outcomes (learning achievements) students get after attending lectures, so that the preparation of the curriculum is truly based on the needs and competencies desired by each study program. (Asis et al., 2023) Thus, the graduates produced will have abilities that are equivalent to the abilities (learning achievements) that have been formulated systematically in accordance with KKNI in each study program. (Aflahah, 2019)

The KKNI-based curriculum is also intended to reduce the gap between the competency needs of the workforce and the quality of graduates of an educational institution. (Aflahah, 2019) Synchronization of these matters has an impact on the absorption of workers effectively and in accordance with their respective fields and have the expected competencies. The impact of implementing the KKNI-based curriculum is that Indonesian society must have an Indonesian attitude and values, abilities, knowledge and at the same time receive responsibility and rights for the learning achievements they have made in accordance with the level in the KKNI. Meanwhile, in terms of institutional strengthening, the KKNI-based curriculum is useful for strengthening and improving the competence of lecturers and students and for improving the level of a university from all aspects and its environment.

Diploma Companion Certificate (SKPI) is a document issued by a university that contains information about the fulfillment of academic and vocational education graduate competencies. (Asis et al., 2023) One of the government policies that supports the fulfillment of graduate competencies is the Independent Learning-Independent University (MBKM) program. As per the Regulation of the Minister of Education and Education, participating in student exchanges, conducting research, conducting entrepreneurial activities, conducting independent studies/projects, and participating in humanitarian programs. (Hadi, 2019) The MBKM program aims to encourage students to master various sciences that are useful for entering the highly competitive world of work and encourage students to gain learning experiences, with various additional competencies outside their study program and/or outside their university. The main objective of MBKM is to improve graduate competencies, both in soft skills and hard skills, to better suit current needs and produce quality future leaders.

The MBKM policy is in line with Permendikbud No. 3 of 2020 concerning National Standards for Higher Education. Universities, faculties, study programs, students, and partners are involved in implementing this regulation. Universities need to provide options for students to take courses outside their study programs, and faculties must compile a list of cross-study program courses and collaboration with relevant partners. (Masithoh & Dwi Prasetyatama, 2023) One concrete way to describe student learning achievements is to use the issuance of a Diploma Companion Certificate or SKPI in accordance with the provisions of Permendikbud No. 73 of 2013. With the existence of SKPI, students' track records during lectures and MBKM programs with various forms of learning activities that become a portfolio of abilities and experiences can be accommodated in it.

In addition, by issuing SKPI, the implementation of the MBKM policy can substantially support the development and improvement of the quality of higher education in producing graduates who have soft skills and hard skills, are competent in leadership and personality aspects. (Almeida et al., 2016)

Several universities have implemented the issuance of SKPI, some are already based on information system technology and some are still manual using printed forms. And here are the problems in the implementation of SKPI, Limited understanding of many students, graduates, and even some parties in universities do not understand the purpose and benefits of SKPI. As a result, SKPI is often considered an additional document that is not important, and the process of compiling it is often missed and not prioritized, Lack of standardization. In addition, it was found that the Ministry of Education, Culture, Research, and Technology issued regulations on SKPI which regulate things in general so that the implementation in each university is different. (Asis et al., 2023) This causes diversity in format, content, and assessment, which can affect the credibility and ability of graduates to be read by the world of work, Long process.

In addition, the creation of SKPI can take a long time and involve several stages of verification, such as reviewing extracurricular activities, work experience, or additional certifications. Often, the issuance of SKPI is delayed due to complicated bureaucracy, Lack of recognition in the world of work, In addition, many companies and institutions in the world of work do not fully understand or recognize SKPI. (Hadi, 2019) They focus more on diplomas and transcripts only, so graduates feel that SKPI does not provide significant additional benefits in the recruitment process, Challenges of digitalization. Although some universities have started to

switch to digital systems, there are still obstacles in terms of infrastructure, data security, and compatibility between systems.

This can slow down the implementation of digital-based SKPI that is more efficient and easily accessible, Lack of collaboration with industry. Sometimes, the contents of the SKPI do not fully reflect the needs of industry or the job market. The lack of collaboration between universities and the industry makes SKPI less relevant in describing the competencies needed by employers, Weak validation and verification. There are concerns about the accuracy of SKPI data. (Kementrian Riset teknologi dan Pendidikan, 2018) Without a strong validation and verification mechanism, there is a risk of inaccurate or invalid data emerging.

Evaluation has steps, as Edward A. Suchman said. The following are the steps of policy evaluation: identifying program objectives, analyzing problems, describing and standardizing activities, measuring at each stage of change, determining the causes that create change, and indicators that determine the emergence of impact. Of the six stages, according to him, identifying problems is the most crucial stage.

The purpose of implementing an evaluation is to provide an understanding of the objectives of a policy, how it is implemented, and what impacts are obtained. There are three elements that must be carried out by the evaluator in implementing an evaluation, Explaining the policy output which is the result of the policy, Evaluation related to the ability of a policy to improve social problems and Evaluation related to each consequence of the policy in the form of reactions to government actions. (Yanti, 2020)

Based on the above, researchers are interested in conducting research on the SKPI program carried out by universities in the Bekasi city area by conducting an evaluation using a combination of the CIPP and Kirkpatrick models which aims to determine the background, input, process, product and impact of the implementation of the program. (Fauzobihi & Supriyati, 2021)

The research questions are Context, what is the background of the diploma supplementary certificate program, Reaction, how did the participants react to the training they attended, Process, how was the implementation of the diploma supplementary certificate program, Learning, how did the participants' attitudes change towards the diploma supplementary certificate program, Product, what decisions were made by the university regarding the program that had been implemented. (Mahmudi, 2011)

This evaluation model is widely used to evaluate training programs, developed by Kirkpatrick with four levels, namely: "reaction, learning, behavior, results". Reaction, evaluates the reactions of training participants by measuring participant satisfaction. (Anisa, 2013) The program is considered more effective if the training process is enjoyable and satisfying for training participants, so that participants are motivated to learn and practice. Conversely, if participants feel dissatisfied, participants will not be motivated to take further training. Learning, is defined as a change in attitude, improvement of knowledge, and improvement of participant skills after completing the program, Behavior, changes in participant attitudes after participants return to their respective workplaces. How participants can transfer the knowledge, attitudes and skills acquired during training to be applied in the workplace, Results, focused on

the final results which include increased productivity, increased quality, reduced costs, decreased quantity of work accidents, and increased profits.

The CIPP model is formed from four dimensions of evaluation, namely Context, Input, Process, and Product evaluation. These four evaluations are a series of wholeness, although in its implementation someone can only do one type or a combination of two or more dimensions of evaluation, but in fact the strength of the model lies in the series of activities of the four types of evaluation itself. In Stufflebeam's view, the most important goal is not to prove, but to improve. "the CIPP approach is based on the view that the most important purpose of evaluation is not prove but to improve" (Plate, 2012)

In this research, the author uses a combination of the KirkPatrick and CIPP models, with the aim of finding out the background, participants' reactions to the program, program implementation, changes in participants' attitudes after participating in the program, the decisions made by the university after the program was implemented.

Literature

One of the recognitions of higher education institutions to graduates of academic education regarding the learning achievements of their graduates is by providing documents in the form of diplomas. Based on (Permenristekditki Number 59 of 2018, 2018) in article 5 states that diplomas are issued by universities accompanied by Academic Transcripts and Diploma Accompanying Certificates (SKPI). Academic Transcripts are the grades for each course that students have obtained in each semester and SKPI is additional information about students' academic achievements and activities while actively attending college.

The implementation of SKPI is mandated by the curriculum based on the Indonesian National Qualification Framework (KKNI) for every new bachelor candidate or graduate. KKNI is implemented in a measurable and clear or transparent manner, starting from the process of describing the qualifications of graduates from an educational program so that producers and users can understand it at the national, international, and regional levels. Based on Permendikbud Number 73 of 2013 since August 2014, issuing SKPI is a concrete form of describing learning achievements. (Hiryanto, 2017)

SKPI or diploma supplement is a document issued by a university as an official statement containing information about the qualifications or academic achievements of university graduates. Graduate qualifications describe learning outcomes at the KKNI level in the form of descriptive narratives in a standard format so that the general public can easily understand them. SKPI is not a substitute for academic transcripts or diplomas and SKPI is not a means that guarantees that its holders will automatically receive recognition. In (Permenristekditki Number 59 of 2018, 2018), it is stated that SKPI contains the SKPI number, university data, and the identity of the SKPI owner. SKPI can also contain additional data or information about students' academic activities and achievements, both in extracurricular, co-curricular, and non-formal education.

The concept of implementing SKPI at Pertiwi University has its own background. In the Covid-19 conditions at that time, the implementation of SKPI at the Pertiwi School of Economics (before becoming a University) emphasized the competency of enriching knowledge on human



resource management, marketing, audit, tax, research data analysis, leadership training and teaching English of foreign language tests.

One of the educational problems, including at the higher education level, for which solutions are continuously being sought is related to the suitability of the competencies of graduates of educational units at certain levels of education with market needs and the readiness of graduates to enter the world of work. Efforts *link and match* between the implementation of education and the world of work continues to be pursued sustainably.

The government continues to strive to reduce the gap in the quality of graduate competencies with the needs of the market and the world of work by increasing the number and quality of graduates because of the open access to higher education for the wider community. On the other hand, the government is also trying to reduce the unemployment rate of graduates of educational institutions which is caused by the unpreparedness of graduates to enter the world of work. In other words, these graduates do not have the competencies or the competencies they have do not match the needs of the market and the world of work (Kemendikbud, 2012)

Fundamental efforts made by the Government include synchronizing the development of science and technology, the formation of attitudes, behavior, and work competencies, as seen from the birth of the Higher Education Law Number 12 of 2012. This law has adopted the importance of providing diplomas, academic transcripts, accompanying diploma certificates, competency certificates and professional certificates to college graduates. If previously, when students graduated from college they only received a diploma and academic transcript, then since the regulation was enacted, college graduates have the right to receive several other official documents in accordance with the provisions of the law. (Kementrian Riset teknologi dan Pendidikan, 2018)

The issuance and provision of competency certificates to college graduates has a significant meaning in order to complement the main competencies of graduates with certain competencies that can increase the competitiveness of graduates in responding to market needs and entering the world of work. Thus, the principle of relevance between the world of education and the world of work is increasingly solid and finds a meeting point so that graduates can enter the world of work. The competency certification program carried out by universities also contributes to increasing the absorption of graduates in entering the world of work and having a greater opportunity to get a job. (Pendidikan & Kebudayaan, n.d.)

The benefits of the competency certification program for college graduates include promoting competency in the industrial and labor market sectors, ensuring recognition of competency, and fulfilling work requirements. For universities, it is useful for ensuring that graduate competencies are in accordance with the needs of the world of work and measuring the effectiveness and efficiency in organizing education and training programs. Competency certification is the provision of certificates through competency tests that are in accordance with the Indonesian National Work Competency Standards (SKKNI) or other competency standards. Competency tests that are in accordance with the Indonesian National Work Competency Standards (SKKNI) are carried out by the National Professional Certification Agency (BNSP) through the Professional Certification Institute (LSP) that has been licensed (Nurisman & Syaodih, 2019)



Currently, graduates must have competency certification to become professional workers needed in the era of the industrial revolution 4.0. Competency certification, both national and international, is intended for college graduates. College graduates, in addition to getting a diploma, are now directed to have a competency certificate. This competency certificate can be used as one of the attachments to the Diploma Accompanying Statement (SKPI) which is useful for graduates when entering the workforce later.

In accordance with Government Regulation Number 4 of 2014 concerning the implementation of higher education and management of higher education, each higher education institution provides a competency certificate for its graduates, because a competency certificate is one of the important factors for the acceptance of employees and experts in the world of work. In other words, a competency certificate is intended as an acknowledgement of competency for the achievements of graduates that are in accordance with expertise in their field of science and/or have achievements outside their study program. In addition to receiving a diploma as proof that the student meets the scientific qualifications achieved through formal education and academic transcripts, college graduates also receive a competency certificate that proves mastery of competency in the field they are engaged in which includes aspectsskill, *knowledge* And *attitude*.

Lecturers at the Pertiwi School of Economics continue to try to provide guidance and have prepared many instruments to be applied to students during the training. The development and implementation of SKPI at the Pertiwi School of Economics in the future is intended to equip students to be able to compete according to their times, because the future of students is very different when compared to today.

The concept of implementing a certificate accompanying a diploma is related to character and competency education. One of the leading programs is the basic leadership training program. The program is a facility or place that provides leadership training, cooperation and games, organizational introduction, and basic leadership training is basically a place to equip new students before starting lectures, but more than that, the program can be a fairly appropriate medium to train student leadership. Another example of an excellent program is a demonstration of skills from each student. This means that the event is one of the programs that aims to train students' responsibility, discipline, and cooperation.

SKPI is a document that contains information about the fulfillment of graduate competencies in a study program at PTKI. SKPI is an additional document that states the work ability, mastery of knowledge, and attitude of graduates that is easier to understand by users both domestically and abroad compared to reading transcripts. SKPI is useful in explaining the objectives of the achievements and competencies of its holders, and increasing work eligibility (*employability*) regardless of the rigidity of the type and level of study program).

Information on the SKPI includes: SKPI Number, National Diploma Number, Pertiwi University logo, Pertiwi University name, BAN-PT Decree regarding study program accreditation, study program name, full name of SKPI owner, place and date of birth of SKPI owner, Student Identification Number, date, month, year of entry and graduation, academic degree awarded along with its abbreviation for educational program (bachelor, profession, master or doctor), graduate learning outcomes according to the Indonesian National Qualification Framework (KKNI), KKNI level, admission requirements, language of

instruction, assessment system, length of study, type and program of further higher education, scheme regarding the higher education system

The process of granting competency certificates is carried out systematically and objectively through competency tests, training and seminar activities. Specifications of each attitude, knowledge, skills and/or expertise and their effective application in work in accordance with the performance standards required by each UPPS. SKPI fulfillment activities carried out by each UPPS, Mandatory Student Seminars, BLT, Data Analysis Training, Brevet Training.

Explains that more specifically *program evaluation deals with collecting and documenting information about a particular program to enable valid decision-making pertaining to a particular aspect of that program*. Every program is always followed by evaluation activities that include assessment of the results and processes carried out. Various experts have provided definitions related to evaluation, including Grounlund and Linn, Ralph Tyler, Scriven, Lee Cronbach, Daniel Stufflebeam, and Malcolm Provus, who are known as important figures in the study of program evaluation. Studies on program evaluation have various approaches, which in turn influence the evaluation model used. From the various approaches, methods, and presentations of program evaluation, it can be concluded that all aim to provide information that supports the decision-making process by the authorities. (Sadler, 1985)

Program evaluation is an effort to provide information that is then conveyed to decision makers. In various fields, program evaluation functions to determine whether the objectives set can be achieved. Therefore, program evaluation is a series of activities carried out carefully to assess the effectiveness of each existing component. Based on the results of the evaluation, there are four policy options that can be taken, namely stopping the program, revising the program, continuing the program, or disseminating the program. (Sri Hardiyanti Samad, n.d.)

Of the many evaluation models that have been put forward, tests and measurements no longer occupy a determining position. Their use is only for certain purposes, no longer a necessity, as when the first model was presented. Tests and measurements are no longer parameters for the quality of an evaluation study that is carried out. Another interesting development in this evaluation model is the existence of an attempt to be eclectic in the use of approaches, *positivism* as well as the so-called *phenomenology paradigm of choice*. Although it does not produce a model in the limited sense, it provides a new alternative in evaluation.

Context evaluation is intended to assess needs, problems, assets and opportunities to help policy makers set goals and priorities, and to help other user groups understand the goals, opportunities and outcomes. Input evaluation is carried out to assess alternative approaches, action plans, staff plans and financing for the sustainability of the program in meeting the needs of the target group and achieving the stated goals. (Arikunto & Jabar, 2014)

This evaluation is useful for policy makers to choose the most appropriate design, form of financing, resource allocation, implementers and activity schedules for the sustainability of the program. Process evaluation is intended to assess the implementation of the established plan to help implementers in carrying out activities and then will be able to help other user groups to understand the performance of the program and estimate the results. Product evaluation is carried out with the aim of identifying and assessing the results achieved, expected and unexpected, short-term and long-term, both for the implementers of activities so that they can



focus on achieving program targets and for other users in gathering efforts to meet the needs of the target group. This outcome evaluation can be divided into assessments of impact, effectiveness, sustainability and transportability. The CIPP (Context, Input, Process, and Product) model is an evaluation model in which the evaluation is carried out as a whole as a system. (Mahmudi, 2011)

The CIPP model evaluation is a concept offered by Stufflebeam with the view that the important purpose of evaluation is not to prove but to improve. The CIPP model evaluation can be applied in various fields. translates each of these dimensions with the following meanings:

- a. Context: the situation or background that influences the planning of the coaching program.
- b. Input: the quality of input that can support the achievement of the coaching program.
- c. Process: the implementation of the program and the use of facilities in accordance with what has been planned.
- Product: the results achieved in the implementation of the program.

(Nurman, 2016) The uniqueness of this model is that each evaluation is related to the decision-making device concerning the planning and operation of a program. To better understand CIPP, it can be explained as follows: 1) Context evaluation includes analysis of problems related to the program environment or objective conditions that will be implemented

Method

Mixed methods research involves the combination or integration of qualitative and quantitative research. In mixed methods research, there are many research designs that researchers can choose from. Mixed methods research designs include Explanatory sequential mixed methods, multiphase mixed methods, convergent parallel mixed methods, and exploratory sequential mixed methods. (Suryana, 2013)

This study uses a mixed method research design with the Explanatory Sequential Mixed Methods approach. This design was chosen because it has a two-phase structure that makes it easy to implement, as explained by Creswell. This design model allows researchers to collect data in two separate stages, with quantitative data collected first, followed by qualitative data collection used to explain the results of the quantitative data. (Pakpahan et al., 2021) This approach allows for a clear separation between quantitative and qualitative data collection, so that researchers can provide a deeper focus on each type of data and the methods used.

Results

This study uses an explanatory sequential mixed methods design with the notation (QUAN → qual), where quantitative data is analyzed first, then continued with in-depth analysis using qualitative data.

The vision of organizing SKPI is in line with the goal of developing graduates' competencies and soft skills" (4.0926), which shows that respondents strongly support the vision of SKPI in terms of developing broader competencies, including interpersonal skills that are important in the world of work. In addition, the indicator "The implementation of SKPI provides significant benefits for national recognition of graduates" (4.1975) also obtained a very high score, indicating that SKPI has a major impact on the recognition of graduates at the national level.

A very high average is also seen in the indicator "The purpose of implementing SKPI can help improve the quality of graduates from universities" (4.1852), which indicates that respondents feel that SKPI plays an important role in improving the quality of graduates. Likewise, the indicator "The benefits of SKPI can help graduates in obtaining jobs according to their fields of expertise" (4.2099), which indicates that the SKPI program is considered to provide relevant added value for the world of work.

However, although the average score of most indicators is above 4, there is a slight variation in the standard deviation, reflecting differences of opinion among respondents. For example, the indicators "The purpose of implementing SKPI is clear and can be implemented well in all study programs" (0.78567) and "The vision of implementing SKPI supports graduates to be ready to compete in the global job market" (0.80298) have slightly higher standard deviations, indicating variation in respondents' views on the implementation and impact of SKPI in various study programs.

Overall, although there were some variations in the views of respondents, these data indicate that the implementation of the SKPI program received a very positive assessment and was considered to have a significant impact on improving the quality of graduates, preparing them for the global job market, and supporting the recognition of graduates at the national level. The program was also considered to provide direct benefits in helping graduates obtain jobs that match their skills. This reflects the importance of SKPI in increasing the relevance of education to industry needs and developing graduate competencies.

The average value of the SKPI implementation objective indicator can help improve the quality of graduates from higher education institutions

No	Statement Answer	Frequency	Mark	$\sum F(X)$	Mean	Criteria	Category
1	Strongly Disagree	0	1	0			
2	Don't agree	3	2	6			
3	Just normal	23	3	69			
4	Agree	77	4	308			
5	Strongly agree	59	5	295			
	Total	162		678	4.185	$x > 3$	Very high

Based on the data provided, most respondents gave a positive assessment to the statement "The purpose of implementing SKPI can help improve the quality of graduates from universities." As many as 77 people chose "Agree" and 59 people chose "Strongly Agree," which shows that the majority of respondents believe that the Diploma Companion Certificate (SKPI) program contributes to improving the quality of graduates. This shows that SKPI is considered to have a positive impact on the readiness of graduates to enter the workforce with better competencies, as well as providing added value to the quality of education received during the study period.

However, there were 23 respondents who chose "So-so" (Neutral), indicating that a small number of survey participants felt that even though they participated in the SKPI program, they had not felt a significant improvement in the quality of their graduates. This group may feel that the SKPI program is not structured enough or has not provided benefits that meet their expectations, so that its impact on the quality of graduates has not been seen directly.

Meanwhile, only 3 respondents chose "Disagree," indicating a minority view that may doubt the effectiveness of this program in improving the quality of graduates.

With an average value (mean) of 4.19, which indicates a very positive assessment overall, it can be concluded that the majority of respondents believe that the purpose of implementing SKPI has an important role in improving the quality of college graduates. Although there are a small number of respondents who gave a neutral or disagree assessment, this shows that there is still room for universities to further clarify the benefits of the SKPI program, both in terms of structure and support provided, in order to provide a more real impact on improving the quality of graduates. For this reason, universities need to continue to develop and improve the implementation of the SKPI program so that it is more relevant and effective for all students.

Review of the SKPI Implementation Vision Document

No	Aspects / Documents	Univ 1	Univ 2	Univ 3	Univ 4	Univ 5	Univ 6	Description / Notes
1	SKPI's vision is stated in the University Vision	✓	✓	✓	✓		✓	Campus 5 has not included the SKPI vision
2	SKPI's mission is listed in the University's Mission	✓	✓		✓	✓	✓	Campus 3 has not listed the SKPI mission
3	Official SKPI document (Rector's Decree or equivalent)	✓	✓	✓		✓	✓	Campus 4 does not yet have an official SKPI decree
4	Legality of the SKPI program (e.g. registered with BAN-PT or SK Kemenristekdikti)	✓	✓	✓	✓		✓	Campus 5 has not completed the legality
5	Compliance with government regulations on SKPI (Permenristekdikti, etc.)	✓		✓	✓	✓	✓	Campus 2 has not shown compliance
6	Legal supporting documents (e.g. deed of establishment, operational permit)	✓	✓		✓	✓		Campus 3 and 6 lack supporting documents
7	The existence of an official SKPI management team	✓	✓	✓	✓	✓	✓	All campuses have a management team

From the checklist table of SKPI implementation in the 6 campuses, it can be seen that most campuses already have a vision document that includes SKPI as part of the university's vision, except for Campus 5 which has not explicitly included the SKPI vision. In the mission document, Campus 3 still does not include SKPI, which indicates a lack of integration of the SKPI program into the campus's strategic goals.

The legality of the SKPI program in the form of a rector's decree or other official documents has been owned by the majority of campuses, except for Campus 4 which still does not have the official document. This is important to ensure that the SKPI program runs according to the rules and receives formal recognition. In terms of legal compliance and government regulations, Campus 5 has not completed the legality related to SKPI, and Campus 2 has not

shown full compliance with regulations such as the Permenristekdikti which regulates SKPI. This is a concern so that all campuses can meet the applicable legal requirements.

Supporting legal documents such as deed of establishment and operational permits are also incomplete at Campus 3 and Campus 6, which has the potential to hamper the smooth implementation of SKPI administratively. However, all campuses have formed an official SKPI management team as part of the program implementation, which is a positive step in supporting the sustainability and effectiveness of SKPI.

From the results of the survey, interviews and review of report documents, it can be concluded that the implementation of SKPI as a whole has great potential to improve the quality of graduates by providing broader recognition of student competencies, but the success of its implementation is highly dependent on the development of an objective and integrated assessment system and institutional compliance with applicable regulations.

Overall, the SKPI program has made an important contribution to the development of graduate competencies, especially in improving English language skills and communication skills. However, in order to make a greater and more sustainable contribution to the sustainability of graduate competencies in the long term, there needs to be an adjustment in terms of increasing academic challenges and focusing more on developing practical skills that are more relevant to the needs of the industrial world. Data on student ability qualifications from 6 universities shows that the majority of students are in the medium ability category, followed by high ability and low ability. University 6 shows the best performance in producing students with high ability and reducing students with low ability, while University 5 has the greatest challenge in this regard

Conclusion

Based on the research findings, most indicators show a positive assessment of the implementation of the SKPI program, especially in terms of developing graduates' competencies and soft skills and their impact on graduate recognition at the national level. The indicator with the highest score shows that the SKPI vision is in line with the goals of graduate development and provides significant benefits in improving the quality of graduates and making it easier for them to get jobs. However, there are variations in opinion regarding the implementation of SKPI in various study programs, indicating the need for increased socialization and training to ensure even understanding.

Counseling and Socialization of SKPI Program to Students, Universities need to immediately hold SKPI orientation for new and old students. Through this session, students will be given an explanation of the benefits and how to participate in the SKPI program. Universities also need to create a digital information module that can be accessed by all students, which contains a step-by-step guide on how to participate in non-academic activities recognized in SKPI and how to earn points., Integration of Non-Academic Activities in the Curriculum

Universities need to start integrating non-academic activities into the curriculum by creating courses or projects based on soft skills, such as leadership, communication, and teamwork. Activities that students participate in to fulfill these courses will be given SKPI points. In this way, students not only get academic grades, but also recognition for developing skills that are

relevant to the world of work. Improvement of the Non-Academic Activity Registration and Reporting System, Universities must immediately develop a more efficient and user-friendly non-academic activity registration system. Through this system, students can easily register the activities they participate in and upload evidence of activity. This system must be equipped with features that allow students to monitor their SKPI points in real-time and find out which activities they can still participate in to add points.

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ASSESSING BIM READINESS FOR FACILITY MANAGEMENT AMONG BUILDING OPERATORS IN SELANGOR, MALAYSIA

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Abstract: Building Information Modelling (BIM) offers a paradigm shift towards data-driven facility management (FM), yet its adoption in the operational phase remains limited in Malaysia. This study aims to quantitatively assess the readiness of building operators in Selangor, Malaysia, to adopt BIM for FM and to identify the critical barriers hindering implementation. A cross-sectional survey was administered to a purposive sample of 100 facility managers, technicians, and property executives. Data were analyzed using descriptive statistics, independent samples t-tests, one-way ANOVA, and Pearson correlation. The findings reveal a significant dissonance: while awareness of BIM is high (mean=3.25), overall readiness is moderate (mean=2.18). The Process dimension scored significantly lower than all other dimensions, identifying the lack of standardized handover protocols as the most critical barrier. A t-test confirmed that current BIM users reported significantly higher readiness ($p < .01$) than non-users. Correlation analysis revealed strong interrelationships ($r > .68$, $p < .01$) between Policy, People, and Process dimensions, indicating systemic barriers. The study concludes that the primary impediments are not technological but are deeply rooted in procedural, organizational, and human resource deficiencies. Recommendations are proposed for policymakers, educational institutions, and industry stakeholders to develop a holistic ecosystem conducive to BIM-FM integration, emphasizing the urgent need for standardized processes and targeted training.

Keywords: Building Information Modelling (BIM), Facility Management, Readiness Assessment, Malaysia, Operational Phase, Technology Adoption, TP3 Framework

Introduction

The Architecture, Engineering, Construction, and Operations (AECO) industry is undergoing a digital transformation, with Building Information Modelling (BIM) as a central pillar. BIM is not merely a 3D modelling tool but a holistic process for creating and managing digital representations of a building's physical and functional characteristics, serving as a shared knowledge resource throughout its lifecycle (Succar, 2009; Eastman et al., 2011). In Malaysia, national initiatives like the Construction Industry Transformation Programme (CITP) 2016-2020 and the BIM Strategic Plan 2021-2025 have spurred BIM adoption, primarily in the design and construction phases (CIDB Malaysia, 2021).



A significant gap exists in the operational phase, Facility Management (FM), which accounts for up to 85% of a building's total lifecycle cost but often relies on traditional, analog methods (Rahman et al., 2020). This creates a "digital cliff," where rich, structured data from design and construction fails to transition effectively into operations (Patacas et al., 2020). Facility managers typically inherit fragmented information in paper manuals, static PDFs, and disparate spreadsheets, rather than the dynamic, interoperable BIM models created earlier (Mohd Rahim et al., 2022). The integration of BIM in FM (BIM-FM) promises a transformative shift to data-driven management, optimizing space utilization, enabling predictive maintenance, enhancing asset management, and improving energy efficiency (Aziz et al., 2016; Pärn et al., 2017).

Despite these benefits, BIM-FM adoption faces significant hurdles, often non-technical and related to processes, people, and policy (Giel & Issa, 2014; Sawhney et al., 2020). A recent study by Olanrewaju et al. (2023) confirms that in developing nations, soft issues like leadership and training outweigh hard technological barriers. This study focuses on Selangor, Malaysia's most economically developed state. As the nation's economic hub with a high density of modern, complex buildings, Selangor represents a strategic context to assess BIM-FM readiness, as the potential benefits and consequences of implementation failure are magnified here. The critical research problem is the uncertain readiness level of the primary users—building operators—to adopt and utilize this technology effectively.

Therefore, this study aims to bridge this knowledge gap by pursuing three objectives:

1. To evaluate the current level of BIM knowledge among facility management operators in Selangor.
2. To assess their readiness for BIM-FM implementation across technology, process, policy, and people dimensions.
3. To identify the principal barriers and investigate the relationships between different readiness dimensions.

Literature Review

The Promise of BIM in Facility Management

The value of BIM is fully realized during a building's operational phase (Kassem et al., 2015). BIM-FM involves leveraging integrated data within a digital model to support daily operations, including asset management (e.g., warranty details, maintenance schedules), space planning, emergency response, and energy management (Becerik-Gerber et al., 2012). This can lead to substantial cost savings, extended asset lifespans, and improved occupant satisfaction (Liu & Issa, 2014). The shift towards data-centric FM is increasingly seen as a cornerstone for smart building management, though its adoption remains inconsistent (Bortolini & Forcada, 2023).

Readiness Assessment Frameworks

Successful technology implementation requires understanding organizational and individual readiness. The Technology-Organization-Environment (TOE) framework provides a robust lens for technological innovation adoption (Tornatzky & Fleischer, 1990). Specific to BIM, Giel & Issa (2014) developed a framework for evaluating facility owner competency, focusing on technology, process, and policy. Expanding on this, Ismail et al. (2020) proposed a comprehensive Technology-Process-Policy-People (TP3) model, which is highly relevant for

assessing the human and organizational factors critical to BIM-FM success. This study adopts the TP3 framework to structure its investigation.

Barriers to BIM-FM Implementation

Globally, BIM-FM integration is obstructed by interconnected barriers:

- **Process Barriers:** The most cited barrier is the lack of standardized protocols for BIM data handover from construction to operations, leading to data loss and incompatibility (Kassem et al., 2015; Matarneh & Hamed, 2017). This issue, often termed the "BIM-FM handover gap," remains a persistent challenge (Chen et al., 2024).
- **Policy and Organizational Barriers:** A lack of strategic top-down support, insufficient FM-phase funding, and absent contractual mandates for data deliverables are major impediments (Aziz et al., 2016).
- **People-Related Barriers:** This includes a shortage of personnel skilled in both BIM and FM, resistance to change, and a lack of awareness of BIM's operational benefits (Rahman et al., 2020).
- **Technical Barriers:** Challenges related to software interoperability, data storage, and system integration persist but are often less critical than process or people issues (Becerik-Gerber et al., 2012).

This study builds on this knowledge by applying a structured, multi-dimensional readiness assessment within the specific context of building operators in Selangor and statistically analyzing the relationships between these dimensions.

Method

Research Design

This study employed a quantitative, cross-sectional research design to assess BIM readiness levels among building operators in Selangor at a specific point in time. The research was descriptive and correlational, aiming to describe the current state and examine relationships between key variables.

Population and Sample

The study population comprised professionals involved in building management in Selangor, including facility managers, building technicians, property executives, and operational staff. A purposive sampling technique targeted individuals directly involved in FM operations. From 147 distributed questionnaires, 100 complete responses were obtained, yielding a response rate of 68%, which enhances the representativeness of the findings (Saunders et al., 2019).

Data Collection Instrument

A structured questionnaire was developed based on a comprehensive literature review, adapting items from Giel & Issa (2014) and Ismail et al. (2020). The instrument consisted of three sections:

- **Section A:** Demographic information (e.g., job role, experience, building type).
- **Section B:** BIM Knowledge Assessment (4 items).

- Section C: BIM-FM Readiness Assessment (12 items across four dimensions: Technology, Process, Policy, People).
A 4-point Likert scale (1=Strongly Disagree to 4=Strongly Agree) was used to minimize central tendency bias and encourage respondents to take a position (Croasmun & Ostrom, 2011).

Validity and Reliability

Content validity was ensured through a review by a panel of three academic experts and two industry practitioners. A pilot study (n=15) confirmed the instrument's clarity. Reliability analysis using Cronbach's Alpha demonstrated high internal consistency for the overall readiness scale ($\alpha = 0.87$) and for each dimension (Technology $\alpha=0.81$, Process $\alpha=0.79$, Policy $\alpha=0.84$, People $\alpha=0.82$), all exceeding the acceptable threshold of 0.70 (Nunnally, 1978).

Data Analysis

Data were analyzed using IBM SPSS Statistics version 28.0. The analysis proceeded in three stages:

1. Descriptive Statistics: Frequencies, means, and standard deviations were calculated to summarize demographic data, knowledge levels, and readiness scores.
2. Inferential Statistics:
 - Independent Samples t-test and One-way ANOVA: Used to compare readiness scores based on categorical demographic variables (e.g., current BIM use, job role, experience).
 - Pearson Correlation Analysis: Employed to examine the strength and direction of the relationships between the four readiness dimensions.
3. The mean scores were interpreted using the scale by Riduwan (2012): 3.51-4.00 (Very High), 2.51-3.50 (High), 1.51-2.50 (Moderate), 1.00-1.50 (Poor).

Finding

Demographic Profile

The respondent profile is summarized in Table 1. The sample was dominated by Facility Managers/Senior Technicians (68%), individuals with significant experience (72% had over 5 years in FM), and those managing commercial high-rises (45%). Crucially, only 18% reported currently using BIM in their FM practices, highlighting the adoption gap.

Table 1: Demographic Profile of Respondents (n=100)

Variable	Category	Frequency	Percentage
Job Role	Facility Manager/Senior Technician	68	68%
	Property Executive	22	22%
	Operational Staff	10	10%
Experience	< 5 years	28	28%
	5 - 10 years	37	37%
	> 10 years	35	35%
BIM Use	Yes	18	18%
	No	82	82%

Level of BIM Knowledge

As shown in Table 2, the overall level of BIM knowledge was high (Mean=3.25). Respondents were very familiar with BIM terminology but showed a relatively lower understanding of specific software and FM applications, indicating a conceptual rather than applied knowledge.

Table 2: BIM Knowledge Assessment

Item	Mean	Std. Deviation	Interpretation
1. Familiarity with BIM terminology	3.82	0.41	Very High
2. Understanding of BIM concepts	3.30	0.67	High
3. Awareness of BIM applications in FM	3.05	0.79	High
4. Ability to identify BIM software	2.83	0.92	High
Overall Knowledge	3.25	0.70	High

Readiness for BIM-FM Implementation

The overall readiness was moderate (Mean=2.18). As presented in Table 3, the Technology dimension ranked highest, while the Process dimension was the most significant barrier, scoring at the low end of the moderate range.

Table 3: BIM-FM Readiness by Dimension

Dimension	Mean	Std. Deviation	Interpretation	Rank
Technology	2.85	0.88	High	1
Policy	2.25	0.95	Moderate	2
People	2.10	0.82	Moderate	3
Process	1.70	0.77	Moderate	4
Overall Readiness	2.18	0.86	Moderate	

Inferential and Correlation Analysis

Group Comparisons: An independent samples t-test revealed a statistically significant difference in overall readiness scores between respondents who used BIM (M=2.65, SD=0.79) and those who did not (M=2.08, SD=0.83), $t(98) = 2.78$, $p < .01$. This confirms that actual users perceive themselves as more ready. A one-way ANOVA showed no significant differences in readiness based on job role, $F(2, 97) = 1.45$, $p = .240$, or experience level, $F(2, 97) = 0.92$, $p = .402$.

Correlation between Dimensions: Pearson correlation analysis (Table 4) revealed strong positive correlations between the Policy, People, and Process dimensions. The Technology dimension showed a weaker, though still significant, correlation with the others. This suggests that improvements in organizational policy are closely linked to improvements in human capital and operational processes.

Table 4: Correlations between Readiness Dimensions

Dimension	Technology	Process	Policy	People
Technology	1			
Process	.265*	1		
Policy	.301**	.712**	1	
People	.288*	.684**	.745**	1

* $p < .05$, ** $p < .01$

Discussion

This study provides empirical evidence of a significant "knowing-doing gap" (Pfeffer & Sutton, 2000) in BIM-FM adoption in Selangor. The high level of conceptual knowledge (Mean=3.25) contrasts sharply with the moderate level of implementation readiness (Mean=2.18).

The most critical finding is the pronounced weakness in the Process dimension (Mean=1.70). This strongly aligns with global literature identifying the handover stage as the primary bottleneck (Kassem et al., 2015). The absence of standardized protocols for data drop, validation, and integration into FM systems creates a fundamental disconnect between project delivery and facility management. This is a procedural and contractual issue requiring industry-wide standardization, as highlighted in recent studies (Patacas et al., 2020; Chen et al., 2024).

The strong, statistically significant correlations between Policy, People, and Process ($r > .68$, $p < .01$) are highly insightful. This indicates these dimensions are deeply intertwined systemic challenges. A lack of strong organizational policy (e.g., no BIM mandate or budget) contributes to a lack of training (People), which inhibits effective workflow development (Process). This finding resonates with Olanrewaju et al. (2023), who emphasized that leadership and strategic policy are prerequisites for overcoming process and people barriers in developing economies. This underscores the necessity of a holistic intervention strategy.

Contrary to assumptions, the Technology dimension was the strongest area of readiness. This suggests basic IT infrastructure is not the primary constraint. The weaker correlation of Technology with other dimensions implies that investing in software without strengthening policy, people, and processes will yield minimal returns, supporting the view that technology is an enabler whose success is determined by its surrounding systems (DeSanctis & Poole, 1994).

The significantly higher readiness reported by current BIM users validates the instrument and suggests that firsthand experience mitigates perceived barriers by demonstrating tangible benefits.

Conclusion and Recommendations

This study concludes that building operators in Selangor possess foundational BIM knowledge but face substantial readiness challenges rooted in non-technological factors. The most critical barrier is the lack of standardized processes for BIM handover, exacerbated by insufficient organizational policies and a significant FM personnel skills gap. The strong interrelationship between these dimensions highlights the problem's systemic nature.

Based on these findings, the following integrated recommendations are proposed:

- For Government and Policymakers: Lead the development and enforcement of national BIM-FM handover protocols aligned with ISO 19650. Introduce incentive schemes for projects demonstrating successful BIM-led FM and establish BIM competency certification for FM professionals.
- For Industry Stakeholders: Develop clear organizational BIM implementation strategies with budget allocation for technology and training. Partner with educational institutions for tailored programs and initiate pilot projects to build capacity and demonstrate ROI.
- For Educational and Training Institutions: Embed comprehensive BIM-FM modules into construction and FM curricula. Offer continuous professional development (CPD) courses focused on the process and people aspects of BIM implementation.

Limitations and Future Research

This study is limited by its geographical focus on Selangor. Future research could conduct a comparative analysis across different states in Malaysia. A longitudinal study tracking readiness evolution after interventions would be valuable. Qualitative follow-up studies are recommended to explore the contextual nuances behind the statistical relationships identified.

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CIRCULAR ECONOMY-BASED MANAGEMENT OF FARMER GROUPS TO ENHANCE HOUSEHOLD ECONOMY IN MEKARAGUNG VILLAGE

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Abstract: This paper shares the results of a participatory role appraisal initiative aimed at enhancing the capabilities of the “Surya Tani” Farmer Group in Mekaragung Village through comprehensive training in management and digital marketing, addressing challenges in operations, financial documentation, organizational structure, and market access for cassava-based agribusiness. Employing a participatory approach, the initiative commenced with field surveys and stakeholder discussions to pinpoint key challenges, succeeded by a series of interventions comprising workshops on management roles, operational and supply chain management, organizational restructuring, financial documentation, and hands-on mentoring. Information was collected via pre- and post-assessments that revealed substantial improvements: average knowledge rose from 6% to 92% (86% increase), and skills from 11% to 94% (83% increase), with major gains in management, operations, human resources, and financial literacy. Beyond capacity building, the program generated tangible economic outcomes—household income per harvest increased from an average of Rp31.6 million in 2024 to Rp120 million in 2025 (279% growth)—driven by a new partnership with local cassava processing SMEs. These results highlight that integrating management strengthening with



digital marketing and value-added production effectively transformed Surya Tani from a production-centered group into a structured, market-driven agribusiness. In summary, the initiative effectively shifted the farmer group from a production-centered organization to a well-organized, market-driven agribusiness, creating a model that can be replicated for rural economic empowerment, resource efficiency, and sustainable community growth.

Keywords: *Digital Technology, International Community Engagement Collaboration, Production Capacity Improvement, Operational Capacity Development, Economic Enhancement.*

Introduction

Indonesia, the largest archipelago globally, is deeply entrenched in its agricultural identity. Located in Southeast Asia, the nation greatly gains from a tropical climate, steady high rainfall, and plentiful water resources, all of which work together to produce remarkably fertile soil across extensive areas. This distinct landscape enables a diverse range of crops and reinforces the nation's agricultural durability. Agriculture is indeed an essential sector not just as the foundation of food security for more than 270 million Indonesians but also as a catalyst for rural incomes, regional economic development, and social stability. Smallholder farmers are the foundation of this system, supporting local economies in rural areas and playing a major role in the national GDP. Throughout the years, the agricultural sector has also nurtured agro-based industries, creating jobs, enhancing community welfare, and supporting trade both locally and globally (Banowati, 2020).

The Indonesian agriculture sector, despite being central, encounters many structural difficulties. Challenges like scattered land ownership, inconsistent access to funding, restricted technology use, and supply chain management inefficiencies impede productivity and value generation. In this context, initiatives aimed at empowering farmers especially through the establishment of cooperative groups or farmer collectives have been vigorously encouraged to enhance social and economic resilience. Both governmental and academic entities have backed the creation of farmer groups as avenues to improve farmers' abilities (research on empowering farmer groups). An example is the "Surya Tani" Farmer Group located in Mekaragung Village, Cibadak District, Lebak Regency, Banten, recognized for its rich cassava output. Even with this potential, fresh cassava is sold straight to local markets without being transformed into value-added products such as flour, chips, or other goods, resulting in unexploited opportunities in both local and export markets (value-added cassava processing study) (Achmad et al., 2024).

The "Surya Tani" Farmer Group encounters various difficulties: insufficient expertise and abilities in distribution, marketing, and business administration. Their failure to convert cassava into products with higher economic value diminishes their competitiveness in increasingly saturated markets. This scenario deteriorated during the COVID-19 pandemic, which hampered supply chains, restricted access to key markets, and decreased farmer earnings (Almtiri et al., 2021). Empirical research on management training and digital marketing for MSMEs or agricultural collectives shows that this training successfully enhances marketing skills, use of digital platforms, and fundamental financial management thereby boosting income and market access (Sulistiyowati & Rahmawati, 2024).

Initial observations highlighted key areas for enhancement to boost "Surya Tani"'s operational effectiveness: (1) management of operations (gathering and distributing produce), (2) financial tracking and clear profit-sharing strategies, (3) revisions to organizational structure and distribution of tasks, and (4) strategic planning for the long term. These difficulties correspond with research results highlighting the necessity to improve organizational and managerial abilities, allowing farmer groups to operate successfully as economic entities.

The Capacity Building Program for the "Surya Tani" Farmers Group has been formulated as a strategic intervention to address persistent challenges in agricultural management and marketing. The training emphasizes: (a) strengthening operational systems for collecting and distributing harvests, (b) establishing transparent financial documentation and profit-sharing mechanisms, (c) restructuring organizational management and clarifying member responsibilities, and (d) enhancing digital marketing strategies to promote processed cassava products such as tapioca flour or cassava chips. These actions are based on the current condition of the group, where abundant cassava harvests are still sold as raw produce without added value, resulting in limited income for farmers despite high production capacity. The program also highlights the potential of circular economy practices by utilizing cassava by-products for animal feed, compost, or alternative energy sources.

This initiative is planned to operate for eight months (May – December 2025) in Cigundi Hamlet, Mekaragung Village, Cibadak District, Lebak Regency, Banten. The program is expected to empower members of the "Surya Tani" Farmers Group by improving management capacity in the first phase (operations, finance, human resources, and organizational planning) and advancing technical capabilities in the second phase (digital marketing, product standardization, and legal status). Through this integrated approach, the group is anticipated to increase farmers' welfare, reduce dependency on middlemen, and broaden market access by transforming cassava into higher-value products for both local and regional markets.

Literature Review

Capacity Building And Management Training For Smallholders

Capacity building in agricultural settings involves organized initiatives aimed at enhancing the knowledge, skills, organizational methods, and supportive conditions that enable farmer collectives and agribusiness micro, small, and medium enterprises (MSMEs) to boost productivity, governance, and livelihood results (Mwadzingeni et al., 2025). Empirical assessments in various regions indicate that capacity building is multidimensional: technical training (production methods), managerial training (documentation, planning, SOPs), and social/organizational enhancement (leadership, responsibilities, collective efforts) are interdependent elements that need to be implemented concurrently for lasting effects. Recent evaluations emphasize that fragmented interventions targeting solely technical elements frequently do not produce lasting benefits unless paired with management and organizational training (Tarekegne et al., 2024).

Randomized control and quasi-experimental research show that effectively structured training initiatives can lead to significant enhancements in productivity, earnings, and the uptake of innovations although the magnitude of effects differs based on context and additional factors (such as access to irrigation, financing, or markets). An empirical study conducted in Tanzania revealed that training significantly boosted yields in irrigated areas, while it had minimal

effects in non-irrigated plots, highlighting the dependent nature of training outcomes on structural limitations. This indicates that program design ought to incorporate a context assessment and, when possible, connect training to supportive resources (Mgendi et al., 2021).

Aside from direct productivity impacts, enhancing managerial and governance-related capabilities often leads to better transparency (e.g., financial documentation), equity in profit distribution, and internal collaboration results that are particularly significant for collective organizations like farmer cooperatives. Systematic reviews and organizational case studies suggest that competency-based training, ongoing coaching, peer-to-peer (farmer-to-farmer) learning, and monitoring & evaluation frameworks are effective methods for transforming short-term knowledge improvements into lasting institutional change. These approaches are linked to increased adoption of entrepreneurial practices, such as group marketing and activities that enhance value (Balestri, 2024).

Digital Marketing, Value-Addition And Market Access For Agri-SMEs

Digital marketing and the wider digital transformation of agri-food value chains have become significant facilitators of market entry, customer interaction, and traceability for small agribusinesses. Empirical studies across various sectors indicate that even slight digital adoption (such as social media use, marketplace listings, and mobile payment acceptance) can decrease search expenses, broaden customer access, and reduce marketing costs, which in turn enhances sales and profit margins for SMEs when coupled with effective product positioning and quality management. Systematic assessments of digital advancements in Agri-SMEs highlight improvements in resource efficiency, customer insights, and innovative business models, while also emphasizing the necessity for capacity development to address the “digital skills” shortfall (Sharabati et al., 2024).

Enhancing staple crops like cassava (by transforming it into chips, flour, starch, or specialty foods) is a validated method for boosting farmer earnings and market stability. Research across various nations shows that mechanizing post-harvest processes and providing training on processing standards enhance product uniformity and facilitate access to more lucrative market segments. Specifically, research on the cassava value chain indicates that households involved in processing activities earn considerably more than those selling raw commodities, as long as producers can satisfy buyers' requirements for quality, packaging, and volume. These results highlight the interplay between technical processing abilities and market-focused training (which includes digital platforms that convey product value) (Iheyi & Kim, 2025).

Essential for integrated initiatives such as the Surya Tani Farmers Group program, research suggests that combining management capacity development (financial record-keeping, transparent profit-sharing, organizational structure) with digital marketing instruction and value-added technical assistance produces compounded benefits. For Surya Tani, strengthening management practices addresses the absence of systematic bookkeeping, clear distribution mechanisms, and structured responsibilities, thereby improving reliability in product quality and supply—factors that are crucial for establishing a sustainable digital market presence (Abass et al., 2017). At the same time, digital marketing increases the profitability of cassava-based products by opening access to wider markets and niche segments willing to pay higher prices for processed goods such as tapioca flour or premium cassava chips. Empirical case studies and systematic reviews thus support integrated program designs that address both



the “supply side” (production/processing/quality) and the “demand side” (marketing/channels/pricing) (Sun et al., 2025).

Methodology

This initiative utilized a participatory action research (PAR) method, focusing on cooperation between the service providers and the community to recognize issues, create solutions, and execute effective interventions. The PAR model was chosen as it supports a continuous cycle of planning, action, observation, and reflection, guaranteeing that the interventions are contextually appropriate and effectively meet the community's needs (Baum et al., 2006). The main aim of this program was to improve public awareness, abilities, and earnings through organized activities, training workshops, and joint projects that correspond with the intended results outlined. The initiative was conducted over 2025 and included both direct interaction with the community and online sharing of information.

The participants included community members, representatives from local organizations, and chosen partners from pertinent industries. The process for selecting participants relied on purposive sampling to guarantee the involvement of individuals directly engaged in the program's thematic areas, specifically knowledge enhancement, skill acquisition, and income generation. Engagement strategies involved workshops, discussion groups, and live demonstrations, allowing participants to gain both theoretical knowledge and practical experience. The participation of various stakeholders guaranteed that the intervention received cross-sectoral backing, which is crucial for long-term viability and expansion.

Program evaluation data was gathered via observation, structured interviews, and analysis of documents. Observations were conducted to assess participants' involvement and real-world use of the knowledge and skills obtained. Systematic interviews with essential informants, like community leaders and representatives from partner organizations, offered qualitative understanding of the interventions' effectiveness. The analysis of documentation involved examining media publications, SOP documents, and performance indicators associated with enhancements in knowledge, skills, and income. These methods of collecting data from multiple sources enabled a triangulated analysis, enhancing the credibility and dependability of the results.

The execution process went through multiple phases. Initially, a needs evaluation was conducted to determine current deficiencies in community understanding and behaviors. Next came the creation of customized training modules and SOP guidelines that targeted these deficiencies. The third phase involved conducting workshops and practical sessions, held both in-person and online, to cater to varying accessibility needs. The fourth phase included continuous mentoring and oversight to guarantee the enduring use of the acquired knowledge and techniques. The concluding phase involved assessment, which gauged the accomplishment of the intended results and recorded insights for future implementation.

Tools utilized in the program comprised presentation resources, physical SOP manuals, video recordings of activities, and digital publishing platforms. Media coverage was utilized to expand the reach, featuring two electronic mass media articles published in Indonesia and Thailand, in addition to a call for papers and proceedings at an international conference. The program activities were documented on video and uploaded to a public platform to provide

open access to a broader audience. These tools were carefully chosen to enhance the project's results' visibility on both local and international levels.

Ethical factors were emphasized consistently during the program. All participants were made aware of the project's aims, procedures, and possible advantages prior to their engagement. Informed consent was secured, and the identities of participants remained confidential in all publications unless permission was explicitly given. The ethical structure guaranteed that the initiative honored community independence while providing concrete advantages in knowledge growth, skill development, and income enhancement.

Result And Discussion

Executed via a sequence of organized phases designed to enhance organizational capability and advance value-added agricultural methods. The initiative started with a preliminary survey and licensing procedure to pinpoint current conditions and prospects within the cassava production industry. The survey showed that although the village produced plenty of cassava, its commercialization was restricted to selling fresh roots to local buyers, with no processing into more valuable products like tapioca flour, chips, or animal feed. The conclusion is that insufficient processing and marketing tactics are the prevalent obstacles in cassava value chains within rural areas.

The preliminary survey indicated that although Mekaragung Village produces a large quantity of cassava, its economic potential has not been fully utilized because of restricted market access and lack of product variety. The provided training focused on addressing this gap through four essential modules: (1) Management of Organizations, (2) Management of Operations and Supply Chains, (3) Restructuring Organizations and Job Specifications, and (4) Keeping Financial Records. Every module contained pre and post-assessments to quantitatively evaluate the enhancement of participants' knowledge and abilities.

Evaluation Outcomes

Table 1 displays the assessment outcomes concerning participant's comprehension of three essential management indicators: the meaning of management, the significance of effectiveness and efficiency, and the primary management functions. In the pre-test stage, participants exhibited relatively low comprehension levels, with only 15% accurately defining management, 25% acknowledging the significance of effective and efficient management, and merely 10% recognizing fundamental management functions. Following the training session, the post-test results showed significant advancements: 95% of participants accurately grasped the definition and significance of management, while 100% could recognize the fundamental management functions.

Table 1: Evaluation of Training and Mentoring Activities in Management Aspects (Knowledge)

No	Management Aspect	Pre Test	Post Test
1	What is management?	15%	95%
2	Why is effective and efficient management important?	25%	95%
3	The basic functions of management include...	10%	100%

This significant rise showcases the success of the training resources, which were provided through an interactive, case-based method suited to the farmer group's context. The noted increase in understanding also aligns with FAO (2014) (Fajardo Vizcayno et al., n.d.) recommendations on capacity building, which emphasize the necessity of incorporating local instances to guarantee that knowledge transfer is pertinent and useful to participants' practical situations.

Table 2 shows the levels of knowledge among participants concerning the four essential functions of management planning, organizing, implementing, and supervising both prior to and following the training. The results from the pre-test indicate that 15% of participants understood about the benefits of creating a work plan are and 0% were acquainted with the purpose of budgeting. These statistics reveal a significant knowledge disparity, particularly given that these roles are crucial to the foundation of any effectively managed agricultural business. Post-training evaluations show notable enhancement: 100% of attendees knows the benefits of creating a work plan are, 100% know the purpose of budgeting.

Table 2: Evaluation of Training and Mentoring Activities in Management (Skills)

No	Management Aspect	Pre Test	Post Test
1	The benefits of creating a work plan are	15%	100%
2	The purpose of budgeting is	0%	100%

The notable enhancement highlights the effectiveness of the training in elucidating the relationships among these managerial functions. Through practical scenarios like arranging the cassava harvest timeline, coordinating work roles, overseeing quality assessments, and facilitating new product development the training connected theory with real-world application.

Based on the Table 3, the Team evaluated the participants' knowledge of operational aspects before (pre-test) and after (post-test) training and mentoring at the "Surya Tani" Farmer Group in Mekaragung Village. The pre-test results showed that participants' understanding of the five indicators tested was still very low. No participants (0%) understood the indicators 'what is meant by operational management,' 'the importance of task distribution and the presence of a PIC (Person in Charge),' 'supply chain in the context of agriculture means...', or 'one tip for creating an effective distribution channel is....' Only one participant (5%) knew 'how to package products to prevent damage during shipping.' This indicates that before the training, most group members lacked basic knowledge about operational management and supply chain in agricultural product management.

Table 3: Evaluation Table for Training and Assistance Activities Operational Aspects (Knowledge)

No	Operational Aspects	Pre Test	Post Test
1	What is operational management?	0%	85%
2	The importance of task distribution and having a PIC (Person in Charge) is...	0%	65%
3	Supply chain in the context of agriculture means...	0%	65%
4	One tip for creating an effective distribution channel is...	0%	100%
5	The way to package products so that they are not damaged during shipping is...	5%	100%

After the training and mentoring, the post-test results showed a significant improvement. Participants' understanding of the indicator 'what is meant by operational management' increased to 17 people (85%), the indicator 'the importance of task distribution and the presence of a PIC' increased to 13 people (65%), and the indicator 'supply chain in the context of agriculture means...' also increased to 13 people (65%). Meanwhile, the indicators 'one of the tips for creating an effective distribution channel is...' and 'how to package products so they do not get damaged during shipping' are understood by 100% of the attendees. The implementation of the PIC system was particularly significant as it established accountability points, guaranteeing that each phase of operations had a specific leader to oversee advancements and tackle problems proactively.

Table 4. assesses the Team's evaluation of the participants' knowledge of human resources (HR) aspects before (pre-test) and after (post-test) training and mentoring at the 'Surya Tani' Farmer Group in Mekaragung Village. The pre-test results showed that only 2 participants (10%) understood the indicator 'what is meant by organisational structure' and 1 participant (5%) knew 'why organisational structure is important.' Meanwhile, no participants (0%) understood the indicator 'a line organisational structure is suitable for...'. This situation indicates that most group members lacked a basic understanding of the concepts and functions of organisational structure before the training was conducted.

Table 4: Evaluation Table for Training and Mentoring Activities on Human Resource Aspects (Knowledge)

No	Human Resource Aspects	Pre Test (%)	Post Test (%)
1	What is an organisational structure?	10%	100%
2	Why is organisational structure important?	5%	100%
3	A line organisational structure is suitable for...	0%	85%

After receiving training and mentoring, the post-test results showed a significant improvement. Understanding of the indicators 'what is meant by organisational structure' and 'why organisational structure is important' increased to 20 participants (100%). For the indicator 'line organisational structure is suitable for...', the number of participants who understood increased to 17 (85%). The notable enhancement shows that the training successfully tackled both conceptual and procedural knowledge shortcomings. The modules employed actual

instances from other farmer cooperatives like combining harvests to secure better prices, jointly buying fertilizers to cut expenses, writing proposals for government funding, and testing enhanced cassava varieties for increased yields.

Table 5 explores the Team's evaluation of the participants' skills in terms of human resources (HR) before (pre-test) and after (post-test) training and mentoring at the 'Surya Tani' Farmer Group in Mekaragung Village. The pre-test results showed that only 4 participants (20%) understood the indicator 'job description of a treasurer' and the same number, 4 participants (20%), understood the 'main function of the marketing department.' This indicates that most group members had not yet mastered the practical skills related to task distribution and specific functions within the farmers' group's organisational structure.

Table 5: Evaluation for Training and Mentoring Activities on Human Resource Aspects (Skills)

No	Human Resource Aspects	Pre Test (%)	Post Test (%)
1	The job description of a treasurer is...	20%	95%
2	The main function of the marketing department is...	20%	100%

After the training and mentoring were provided, there was a significant improvement. Understanding of the 'job description of a treasurer' increased to 19 participants (95%), while the indicator for the 'primary functions of the marketing department' saw a perfect increase to 20 participants (100%). This enhancement showcases the training's emphasis on clear organization as a key factor in boosting efficiency. Through a participatory workshop model, the program engaged participants in mapping their production and distribution processes, pinpointing major operational bottlenecks, and designating responsibilities according to individual skills (Kim et al., 2018).

Table 6 presents the Team's evaluation of participant's knowledge in financial aspects before (pre-test) and after (post-test) training and mentoring activities. The pre-test results revealed that only 1 participant (5%) could explain 'what financial recording is,' while none of the participants (0%) could answer questions regarding the 'importance of financial recording,' provide 'an example of daily financial recording,' or describe the 'methods of financial recording.' This indicates that the group initially had very limited understanding and awareness of basic financial management practices.

Table 6: Evaluation Table for Financial Aspect Training and Assistance Activities (Knowledge)

No	Financial Aspects	Pre Test (%)	Post Test (%)
1	What is financial recording?	5%	100%
2	Why is financial recording important?	0%	100%
3	An example of daily financial recording is...	0%	100%
4	Financial recording methods can be carried out in...	0%	65%

After the training and mentoring were delivered, there was a substantial improvement in participants' knowledge. Understanding of 'what financial recording is' rose sharply to 20

participants (100%), while comprehension of the ‘importance of financial recording’ and the ability to give ‘an example of daily financial recording’ also increased to 100%. Furthermore, 65% of participants demonstrated knowledge of various ‘financial recording methods.’ These results highlight the effectiveness of the program in strengthening financial literacy and practical skills in record-keeping. By emphasizing the significance of accurate documentation, participants were better equipped to manage resources, monitor income and expenses, and support transparent decision-making processes. This knowledge enhancement contributes to sustainable organizational growth, as effective financial management is a cornerstone of accountability and efficiency in farmer group operations.

Table 7: Evaluation for Financial Aspect Training and Mentoring Activities (Skills)

No	Financial Aspects	Pre Test (%)	Post Test (%)
1	One digital application for financial record-keeping is...	5%	85%

Table 7 emphasizes the assessment of training and mentoring initiatives concerning financial management skills, especially concentrating on the utilization of digital applications for financial documentation. The findings show that merely 5% of participants initially recognized the presence and role of digital tools for managing finances in the pre-test, highlighting a considerable knowledge deficit in this aspect. After the training and mentoring sessions, understanding rose significantly to 85%, showcasing a remarkable enhancement in participants' abilities. This result highlights the success of implementing practical digital tools to improve financial literacy and responsibility among farmer groups. The program enhances participants' capacity to use digital financial recording tools, promoting greater transparency, organization, and sustainability in financial practices, crucial for bolstering institutional credibility and facilitating long-term business development

Summary Related To The Evaluation Of Several Partner Knowledge And Partner Skill Activities

Table 8 provides a summary of the evaluation of partners' knowledge before and after the mentoring and training program, compared against the targeted outcomes. The data show that, prior to training and mentoring activities, the participants' knowledge level was relatively low across all evaluated aspects. For instance, only 17% of participants understood ‘management functions in farmer groups,’ 1% understood ‘operational management and supply chain,’ 5% recognized the ‘organizational structure and job descriptions,’ and 1% had knowledge of ‘financial record keeping.’ On average, the initial knowledge level stood at just 6%, far below the set target of 60%.

Table 8: Summary Related to the Evaluation of Several Partner Knowledge

No	Description	Target	Before	After	Improvement
1	Management Functions in Farmer Groups	60%	17%	97%	80%
2	Operational Management and Supply Chain	60%	1%	83%	82%
3	Organisational Structure and Job Descriptions	60%	5%	95%	90%
4	Financial Record Keeping	60%	1%	93%	92%
Average Increase of Knowledge		60%	6%	92%	86%

Following the implementation of the program, there was a dramatic increase in knowledge across all categories. Understanding of ‘management functions in farmer groups’ improved to 97% (an 80% increase), while knowledge of ‘operational management and supply chain’ rose significantly to 83% (82% increase). Similarly, comprehension of the ‘organizational structure and job descriptions’ reached 95% (90% increase), and knowledge of ‘financial record keeping’ improved to 93% (92% increase). Overall, the average knowledge level after the mentoring and training program reached 92%, resulting in an average improvement of 86%—well above the targeted 60%. These outcomes demonstrate the substantial effectiveness of the training and mentoring activities in bridging knowledge gaps. The program not only met but exceeded its objectives, equipping participants with essential competencies in management, operations, organizational structure, and financial practices.

Table 9 summarizes the evaluation of participants’ skills before and after the mentoring and training program in relation to several key aspects. Prior to program, participants demonstrated only a limited level of skills: 8% had knowledge of ‘management functions in farmer groups,’ 20% understood ‘organizational structure and job descriptions,’ and just 5% possessed skills related to ‘financial record keeping.’ Overall, the average skill level before the intervention was only 11%, which was significantly lower than the expected target of 60%.

Table 9: Summary Related to the Evaluation of Several Partner Skills Activities

No	Description	Target	Before	After	Improvement
1	Management Functions in Farmer Groups	60%	8%	100%	92%
2	Organisational Structure and Job Descriptions	60%	20%	98%	78%
3	Financial Record Keeping	60%	5%	85%	80%
Average Increase of Skills		60%	11%	94%	83%

After the mentoring and training activities were implemented, a remarkable enhancement in skills was observed. Competence in ‘management functions in farmer groups’ rose to a full 100%, marking a 92% increase. Skills in understanding the ‘organizational structure and job

descriptions' also reached 98% (78% improvement), while capability in 'financial record keeping' climbed to 85% (80% improvement). Collectively, these advancements resulted in an average post-program skill level of 94%, reflecting an impressive 83% increase compared to the baseline. These findings highlight the program's strong impact in equipping participants with practical skills essential for managing farmer group activities. By bridging the initial gaps, the program significantly strengthened participants' ability to organize, manage finances, and allocate responsibilities effectively. Such improvements not only surpassed the initial target but also ensure that farmer groups are better prepared to enhance productivity, maintain accountability, and sustain long-term growth.

The evaluation findings demonstrate a significant enhancement in the knowledge and abilities of the Surya Tani farmer group after the training and mentoring program. Knowledge levels rose markedly across multiple domains, with management at 80%, operational skills at 82%, human resources at 90%, and financial literacy at 92%. Skill enhancement was noticeable in crafting work plans, reorganizing the structure, clarifying job roles, and financial record-keeping, achieving improvements between 92%, 78%, and 80%. These developments bolstered the group's internal capability, allowing for more organized and transparent operational methods, which subsequently improved their competitiveness and autonomy as a farming cooperative

With the implementation of training and mentoring, the farmer group began to develop towards achieving sustainable income growth. One tangible outcome of this assistance was the establishment of a partnership between the farmer group and cassava processing MSMEs in Cigundi, Mekaragung. Through this partnership, the group's harvests were no longer dependent on fluctuating market prices but could instead be sold regularly at a more stable price. Table 10 below illustrates the development of the farmer group's income.

Table 10: Development of Income of the Surya Tani Farmer Group

No	Harvest Period	Year	Revenue	Description
1	First Harvest	2024	Rp30.000.000	Cassava price fell to Rp2,000/kg due to oversupply. Out of 20 tons harvested, only 15 tons (15,000 kg) were sold. Income: Rp30,000,000
2	Second Harvest	2024	Rp45.000.000	Cassava price Rp3,000/kg. The group sold 15 tons (15,000 kg), while 5 tons were kept for consumption. Income: Rp45,000,000
3	Third Harvest	2024	Rp20.000.000	Cassava price dropped again to Rp2,000/kg. Only 10 tons (10,000 kg) were sold. Income: Rp20,000,000
4	First Harvest	2025	Rp60.000.000	Cassava price increased to Rp4,000/kg. From 20 tons harvested, 15 tons (15,000

5	Second Harvest (After the Training and Mentoring Program)	2025	Rp120.000.000	kg) were sold. Income: Rp60,000,000 With MSME partnership, 20 tons (20,000 kg) were sold at a stable price of Rp6,000/kg. Income: Rp120,000,000

In addition to enhancing knowledge and skills, the program produced a tangible and quantifiable economic effect. Before mentoring, the group's average revenue in 2024 was roughly Rp31,666,667 per harvest, with variations due to inconsistent cassava market prices. Nevertheless, following the establishment of a partnership with cassava processing SMEs in Cigundi, the group obtained a consistent selling price of Rp6,000/kg. Consequently, the second harvest in 2025 yielded Rp120,000,000, indicating an impressive 279% rise compared to income before mentoring. This change demonstrates that combining capacity development with market collaborations not only stabilized both production and sales but also greatly enhanced the economic well-being of the group, creating a sustainable framework for rural agricultural empowerment

Table 11: Income Improvement Analysis Table

No	Harvest Period	Revenue	Description
1	Average Harvest 2024 (Harvest 1-3)	Rp31.666.667	Before receiving assistance, prices were influenced by market conditions, resulting in fluctuating income.
2	Second Harvest 2025 (After the mentoring and training program)	Rp120.000.000	After establishing a partnership with cassava processing MSMEs, the price became stable at Rp6,000/kg.
Income Increase		Rp88.333.333	
Increase Percentage		279%	

Conclusion

The execution of the participatory role appraisal initiative with the “Surya Tani” Farmer Group in Mekaragung Village has shown that focused capacity-building efforts can greatly improve the managerial, operational, organizational, and financial skills of rural agricultural groups. By utilizing a systematic approach starting with detailed field assessments and licensing processes, then progressing to thorough training workshops and hands-on mentoring the farmer collective shifted from a traditional production-focused model to a more organized, value-enhanced, and market-oriented business. The combination of management function training, operational and supply chain enhancement, organizational redesign, and financial management has allowed members to improve activity coordination, allocate resources effectively, uphold quality standards, and reinforce internal governance. These adjustments have established a basis for sustainable business practices, enabling the group to pursue wider market opportunities and lessen reliance on conventional sales channels.

Moreover, the results of the program emphasize the essential importance of ongoing education, practical experience, and flexible approaches in maintaining progress. Through the promotion of values such as transparency, collaboration, and innovation, the initiative has enabled the “Surya Tani” Farmer Group to function with enhanced resilience and competitiveness in a changing agricultural environment. The knowledge acquired not only aids the existing members but also acts as a transferable example for other rural communities encountering comparable issues. To sustain progress, upcoming initiatives must prioritize enhancing digital literacy in marketing and financial management, building collaborations with agro-industries and government entities, and conducting regular performance assessments to adjust strategies in response to changing market needs. Thus, the program aids not just the economic upliftment of the “Surya Tani” Farmer Group but also aligns with the larger goal of rural economic growth rooted in self-sufficiency and sustainable resource utilization.

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THE ROLE OF AGENCIES WITHIN THE FRAMEWORK OF SPECIAL GUIDELINES FOR HANDLING CASES OF SEXUAL OFFENCES AGAINST CHILDREN IN MALAYSIA: A PROCEDURAL PERSPECTIVE

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Abstract: *Cases of sexual crimes against children show a pattern that is increasing year by year. However, the reported cases are somewhat reduced as many people still use the excuse of shame to come forward and complain. The principle of protecting children must be prioritized for their future as the future generation of the country's leadership. The study is socio-legal in nature, that is, a research method that combines two main fields of research: social science and law. The study used content analysis using inductive and deductive. The Sexual Offences Against Child Act 2017 is an act clearly intended to protect children from sexual offences, in line with the Child Act 2001. The Special Guidelines for Handling Cases of Sexual Offences Against Children in Malaysia are designed to ensure that the aims and objectives of Act 792 can be achieved more effectively. The collective efforts of all agencies are based on the Special Guidelines, which serve as a support measure for the handling of victims of child sexual offences. The public needs to be educated and exposed to the types of sexual criminal behaviour and know effective ways to deal with the issue. Cooperation between Ministries and government agencies such as the Ministry of Women, Family and Community Development, Division of Legal Affairs, Prime Minister's Department, Royal Malaysian Police (PDRM), Ministry of Health, Courts, and Department of Social Welfare (JKM) with one goal, to ensure the protection and welfare of children are guaranteed within the legal and social framework in Malaysia.*

Keywords: *Child Protection, Sexual Crimes, Sexual Offences Against Children Act 2017, Child Act 2001, Special Guidelines for Handling Cases of Sexual Offences against Children in Malaysia*

Introduction

Children are important human capital for the country. This human capital can be developed to an optimal level through the provision of a safe and conducive environment. In this regard, the protection of children from neglect, abuse, violence and exploitation is an important aspect and should be given priority (A.Azhar, et.al., 2017).

According to records from the Ministry of Home Affairs (KDN), statistics on sexual crimes against children in Malaysia continue to show an alarming increase. In a three-year period



(2022-2024), a total of 7,677 cases were reported, with 3,400 cases resulting in convictions (Saifuddin, 2025). In fact, according to the Chairman of the non-governmental organization Children's Protection Society Kuala Lumpur (CPS KL), Tengku Asra Jehan Tengku Azlan, in January 2025 there were 1,000 cases of sexual crimes against children (Astro Awani.com, 2025).

The Sexual Offences against Children Act 2017 (Act 792) which came into effect on 10 July 2017 is an Act to deal with sexual offences committed against Children. The main purpose of the enactment of Act 792 is to provide better protection, safeguard the interests and welfare of Children, and provide effective prevention of sexual offences against Children.

The enforcement of Act 792 is supported by the formulation of Special Guidelines in the handling of cases of sexual offences against Children. The Guidelines define Children as follows:

- (1) For the purposes of these Special Guidelines, reference should be made to section 2 of the Child Act 2001 (Act 611). A child is defined as a person under the age of eighteen (18) years.
- (2) According to the Child Witness Evidence Act 2007 (Act 676), the age of a witness who is given protection under Act 676 is 16 years and below.

Meanwhile, the meaning of sexual abuse of Children according to the Guidelines is: Paragraph 17(2)(c) of Act 611 provides that a person involved in a case of sexual abuse of Children is when he participates either as a participant or observer in any activity of a sexual nature for the purpose of any pornographic material, recording, film, tape, video or performance of a pornographic, obscene or sexually exploitative nature by any person to satisfy the sexual desires of that person or another person.

Protection means a Child who needs protection under section 17 of Act 611 in relation to the Sexual Offences against Children Act 2017 (Act 792), the Penal Code (Act 574) and the Domestic Violence Act 1994 (Act 521).

In this regard, the existing law needs to be detailed not only to look at the aspect of the offense, but also the aspect of the investigation, the admissibility of evidence and the entire criminal justice system itself. The basic principle used in sentencing; it must be commensurate with the offense committed. This means that the punishment does not differentiate between the perpetrators, even including offenders who have a great obligation or responsibility towards the victim are also sentenced based on the principle of commensurate with the offense committed. For a serious offense, the punishment that will be determined will use the same considerations as other laws.

For children or the victims' relatives and families involved, they need support. The guidelines state that support is behavior that helps children's relationships with other individuals and the surrounding community.

Research Methodology

This study is socio-legal, which is a research method that unites two main fields of research, namely social science and law, specifically policy and regulation. Law is formed as a mechanism to manage affairs and conflicts that arise in social society, law has a close and



inseparable relationship with society (Rohani Abdul Rahim, 2002). This study also involved systematic research on new and current legal issues using high originality and creativity through traditional or conventional legal methods involving the process of stating, interpreting and clarifying the existing law in a particular field of law (Mahdi Zahraa, 1998).

The study that was conducted was based on a qualitative approach (Azizah Hamzah, 2010). To examine the legal framework for child protection in Malaysia, the content analysis method was chosen. This method requires the determination of a specific theme so that the analysis process of the text does not deviate. In this study, the theme is related to the role of the agency within the framework of the Special Guidelines for Handling Cases of Sexual Offences against Children in Malaysia. The authors had analysed the document to find out the content and meaning contained in the document (Nazir, 1985; Ratna, 2004; and Muhadjir, 2003). Including online publications on the websites of the relevant agencies.

Content analysis is carried out by selecting appropriate texts based on the objectives of the study. The inductive method is a method of analysing data through the process of drawing conclusions from specific matters to a general statement (Peter A. Angeles, 1981; Henry L. et.al, 1977). Here the authors had presented the specific data and then made general conclusions. The authors had referred specifically to the Special Guidelines for Handling Cases of Sexual Offences against Children in Malaysia.

Next, make conclusions regarding the roles and procedures of agencies involved in handling sexual offences involving children. Next, the authors had analysed the data using the deductive method, which is a way of analysing and conducting research based on a 'thinking pattern' that seeks evidence based on general propositions for specific matters (Abdul Halim, 1987). The authors looked at the general role contained in the Special Guidelines and then made specific conclusions about the related roles and procedures.

The Role of Family/Society Regarding to Child Sexual Offences

All children, whether male or female, from all backgrounds are at risk of becoming victims of sexual abuse. Acts that are considered sexual offences against children include the following (Norazla, 2017),

- 1) groping, raping, molesting and arousing the child's sexual desire by inappropriately asking for, exposing private parts of the body;
- 2) Behavior that does not involve touching, such as stalking, using obscene language or showing obscene materials; and
- 3) exploiting children for pornography purposes, including via the internet, thereby enabling a child to be used by others as a prostitute

Apart from that, among the methods often used by known suspects is through several creative approaches in an effort to approach child victims:

- a. building the victim's trust in the suspect such as giving deep attention, giving gifts, buying food, etc.;
- b. building trust among the victim's family members;
- c. start with normal touching to make the victim feel comfortable, show pornographic pictures to familiarize the victim and then follow with other sexual acts; and
- d. threatening the victim. Meanwhile, the methods often used by unknown suspects are:

- e. looking for victims randomly such as in quiet places, playgrounds and other public places; and
- f. looking for victims on social media sites.

Child grooming is a process where suspects befriend children with the intention of exploiting and abusing them. This process is also carried out online, involving communication between the victim and the predator through chat applications. The process of child grooming that is often carried out (Legal Aid Department, 2025):

- 1- get information about children on social media such as background, school, interests, location, etc.;
- 2- starting a friendship;
- 3- gain trust;
- 4- persuading through loving caresses, praise and gift giving towards creating support;
- 5- starting conversations about sex and pornography;
- 6- commit sexual exploitation; and
- 7- Threatening and using child pornography if the child does not comply.

All parties who know or have information regarding incidents of sexual offences against children are responsible for reporting them. Among the actions that can be taken is to make a report through the following channels:

- 1- Ministry of Women, Family and Community Development (KPWKM) Hotline via 15999 or WhatsApp 019-2615999.
- 2- Social Welfare Office near the reporting person's residence;
- 3- any nearby police station or police hut;
- 4- any member of the child protection team or children's activity centre present in the area where the incident occurred;
- 5- refer to the nearest hospital; and
- 6- Malaysian Communications and Multimedia Commission (MCMC) if it involves sexual offences against children via social media.

The form of assistance provided to victims of sexual offences against children is through two (2) agency channels, namely:

- 1. Social Welfare Department (JKM) (www.jkm.gov.my, 2025).
 - i. refer to counseling services if needed such as psychotherapy, art therapy and others as appropriate;
 - ii. Child witness services for children involved in the criminal justice process in the following matters:
 - a. information on trial cases and the criminal justice system proceedings;
 - b. counseling;
 - c. emotional support to help victims prepare for court; and
 - d. accompany; prepare children for a court decision.
 - iii. provide shelter for children in need of protection and provide appropriate care/upkeep; and
 - iv. assistance to parents/guardians of victims such as support/counseling.
- 2. Non-Governmental Organizations (NGOs) also provide assistance such as (Department of Social Welfare, 2025):-
 - i. protect child victims of sexual offences by supporting them and their families,

- ii. guiding them throughout the reporting process up to the court proceedings, and;
- iii. find a safe place to live for them.

In this regard, the role of the family or general individuals is to respond when a child victim complains about sexual offenses. Most importantly, a positive response is important to help the emotional stability of the victim. Forms of positive response include (Legal Aid Department, 2025):

- 1- always calm;
- 2- believe the complaint;
- 3- ensuring the safety of victims;
- 4- convince the victim not to blame themselves; and
- 5- get appropriate help.

Screening of child handlers can be done by referring to Part XIV, Miscellaneous, Sections 118 to 122, the Child Act 2001 has expanded the function of the “Register of Children in Need of Protection” or known as the “Register of Children” which contains information on offenders for crimes under any written law of which children are victims. This information includes individuals convicted of crimes of a sexual nature. The purpose of expanding the function of the Register of Children is to enable any person to be screened when they are involved in handling children such as babysitters, school bus drivers, school and hostel security guards, teachers and others. Inspection can be done through Registry System for Sexual Offenders against Children (e-DKK) System inspection at any District Social Welfare Office (PKMD) or State Department Social Welfare (JKMN) (www.jkm.gov.my, 2025). An application to examine an employee or prospective employee if there is a record of criminal offences against children.

Special Guidelines for Handling Cases of Sexual Offences against Children in Malaysia

A strategic initiative of the Legal Affairs Division (BHEUU), Prime Minister's Department by implementing efforts to refine the content of the Special Guidelines for Handling Cases of Sexual Offences Against Children. The following is the full chronology of the BHEUU initiative (petari.bheuu.gov.my, 2025):

- 1- The meeting on 27 January 2025 was chaired by Mr. Thiyagu Ganesan to discuss guidelines following the amendments to the Child Witness Evidence Act 2007 and the Sexual Offences Against Children Act 2017.
- 2- Meeting of the Technical Committee for the Evaluation of Special Guidelines for the Handling of Cases of Sexual Offences Against Children in Malaysia on 7 February 2025.
- 3- Amendments to Act 676 and Act 792 come into effect on 3 March 2025. Implementation involves collaboration between National Legal Academy (ILKAP), the Attorney General's Chambers (Prosecution Division), and Office of the Chief Registrar's Federal Court of Malaysia (PKPMP) for training programs.
- 4- Discussion session with the Ministry of Home Affairs on the preparation of special guidelines to deal with sexual offences against children on 25 March 2025.
- 5- The Special Guidelines Evaluation Technical Committee Meeting No. 2/2025 on 14 April 2025 was held to evaluate the draft guidelines prepared by UNICEF.

- 6- Workshop on Refining Special Guidelines for Handling Cases of Sexual Offences Against Children in Malaysia 19 May 2025.
- 7- The ASEAN Conference on Legal Aid Services for Children will be held in Penang on 8 September 2025. The Special Guidelines for the Handling of Cases of Sexual Offences Against Children are proposed to be officially launched during this prestigious conference, as a manifestation of regional commitment in protecting and strengthening children's rights.

These Special Guidelines are divided into the following 4 main headings:

Title 1: Receiving Reports and Investigations This heading explains and provides guidance to agencies involved in cases of sexual offences against children at the initial stage, namely making and receiving reports and conducting investigations.

Title 2: Trial This title is about the procedure for handling cases in the Court for Sexual Crimes Against Children which covers the entire process from the case being registered in Court until the case is completed including special features in the handling of Child witnesses for sexual offense cases in Court during the trial.

Title 3: Handling Child Victims/Witnesses This topic discusses the handling of Child victims/witnesses in Court. Since Child victims/witnesses will face various parties such as the Court, Royal Malaysian Police (PDRM), Deputy Public Prosecutors, Lawyers, Legal Aid Department, Social Welfare Department, Non-Governmental Bodies and so on in addition to the perpetrators themselves, this topic will discuss in detail how these parties handle Child victims/witnesses from the pre-trial stage until the trial day according to their respective roles/responsibilities.

Title 4: Protection and Support Services This section discusses the protection and support services that can be provided by agencies involved in assisting child victims/witnesses. These services will be provided immediately after the complaint is received until the completion of the trial.

Guidelines for Receiving Reports and Investigations

These Guidelines for Receiving Reports and Investigations are to provide guidance to agencies involved in reporting and investigating cases of sexual offences against Children.

a. Receipt of Report

(1) Police Report

- (a) A police report on a case of sexual offences against Children can be made at any police station/police station/hospital. (b) The police report can be written by the complainant himself on the form or written by the police. (c) The police report must be read back to the complainant by the police officer who receives the complaint and confirmed as correct by the complainant before being signed by the complainant. The complainant must be informed regarding the complaint number. (d) The Investigating Officer (IO) or Assistant Investigating Officer (AIO) will be informed by the police officer who receives the complaint.

(2) Interviewing the Complainant

- (a) The Investigating Officer or Assistant Investigating Officer interviews the complainant to obtain additional information other than that stated in the police report. (b) PDRM informs the Social Welfare Department (JKM) if the complainant and/or victim requires

protection. (c) JKM must take action to apply for an interim protection order (IPO) in Court (if necessary). (d) PDRM also provides counselling services to the complainant/victim/witness before the interview session and during the investigation process (if necessary). Victim Support Services and counselling are provided by a psychological officer and an assistant psychological officer or a registered counsellor from the Victim Support Unit, Sexual, Women and Children Investigation Division (D11). (e) PDRM informs the complainant/victim about the Legal Companion service. Legal Companion services are provided by the JBG to victims who are under 18 years of age at the time of trial.

(3) Classification of Offenses

The classification of police reports is according to the offence sections provided under the laws currently in force in Malaysia.

(4) Recording of Complainant/Victim/Witness Conversations via Video at the Child Interview Centre (CIC)

(a) The complainant/victim/witness must be interviewed and their conversation recorded to obtain the facts about the incident. (b) The conversation of the complainant/victim/witness will be recorded in accordance with the provisions of the law. If necessary, PDRM will obtain the services of an interpreter or sign language interpreter. (c) The recorded statement of the complainant/victim/witness must be read again before being confirmed and signed by the complainant/victim/witness. The fingerprints of the complainant/victim/witness may also be taken if they are unable to sign. (d) If the complainant/victim/witness is 16 years of age and below, their interview statement will be recorded via video recording at the CIC (if necessary).

b. Health Checkup

- (1) PDRM will take the victim to a government hospital for examination and treatment by medical officers (if necessary).
- (2) In certain circumstances, the victim will continue to attend the hospital together with the parent/guardian/teacher/member of the public.
- (3) Screening at the Hospital Emergency Department
 - (a) Medical officers/staff handling cases of child sexual abuse must attend a course/seminar or have been given exposure to the handling and management of Suspected Child Abuse and Neglect (SCAN). (i) Non-critical the child is placed at the One Stop Crisis Centre (OSCC) for an interview and examination by the SCAN Team. Medical officers/staff must make a report to JKM and the police (if a police report has not been made). (ii) Critical/semi-critical the victim is admitted to the critical zone for emergency treatment. The victim is also referred to the SCAN Team. (b) The victim will be admitted to the ward. Follow-up treatment by the SCAN Team and a case conference will be conducted. After discharge, the victim is given a follow-up appointment.
- (4) Preparation of Medical Reports
 - (a) The Investigating Officer or Assistant Investigating Officer requests an initial medical report from the government hospital on the same day the victim is referred to the hospital.

(b) The hospital must provide an initial medical report of the health examination on the same day the victim is referred after completing the examination of the victim.

(c) The Investigating Officer or Assistant Investigating Officer shall request in writing a full (complete) medical report as soon as possible. (d) The hospital shall provide a full (complete) medical report as soon as possible. (e) The Investigating Officer or Assistant Investigating Officer shall promptly obtain a full (complete) medical report from the hospital. (f) For certain cases, PDRM will request in writing an extended medical report. For example, a psychological report and a psychiatric report.

c. Investigation

(1) On-Scene Investigation

(a) The Investigating Officer or Assistant Investigating Officer shall attend the scene of the incident to take photographs of the scene and collect evidence. (b) The Investigating Officer or Assistant Investigating Officer shall send the samples/evidence found to the Malaysian Chemistry Department for analysis. (c) The Investigating Officer or Assistant Investigating Officer shall apply in writing for a chemical report as soon as possible after the samples/evidence have been sent to the Malaysian Chemistry Department. (d) The Malaysian Chemistry Department shall prepare a chemical report as soon as possible after the samples/evidence have been received from the Investigating Officer or Assistant Investigating Officer.

(2) Arrest of Suspect (OYDS)

(a) PDRM identifies the profile of OYDS and makes an arrest. The reasons for the arrest will be explained to OYDS as per the procedure under the Criminal Procedure Code (Act 593) and a search of OYDS's body will be made. If the arrest is made on premises, the search must also be carried out on the premises in question. (b) PDRM must make a police report on the arrest made.

(3) Recording the statement of a suspect under section 112 of the Criminal Procedure Code PDRM must record the statement of the OYDS. The recording of the statement must comply with the procedure under the Criminal Procedure Code (Act 593).

(4) Remand application under section 117 of the Criminal Procedure Code (Act 593)

(a) A remand application must be made if the investigation cannot be completed within 24 hours. (b) If the remand application is granted, OYDS will be detained for further investigation by the police. (c) If the remand application is rejected, OYDS will be released on police bail.

(5) Identity parade (a) identity parade is conducted if necessary. The victim will be taken to the Police Station for ID parade. (b) Further conversation recordings will be taken after the ID parade.

d. Evaluation of Evidence and Referral to Deputy Public Prosecutor to Evaluate Evidence

- (1) The Investigating Officer or Assistant Investigating Officer collects and evaluates all evidence before referring the Investigation Paper (IP) to the Deputy Public Prosecutor.
- (2) The completed IP is referred to the Deputy Public Prosecutor for advice and opinion on whether charges can be laid.
- (3) If the Deputy Public Prosecutor orders further investigation, the Investigating Officer or Assistant Investigating Officer shall continue the investigation. After that, the IP shall be referred back to the Deputy Public Prosecutor.
- (4) If there is sufficient evidence, charges will be laid in the relevant Court by the Deputy Public Prosecutor.

e. Procedures in the Special Sessions Court Trying Sexual Offences Against Children

1. Case Registration
 - 1.1 The court accepted the Charge Sheet and filed the case.
2. Case Hearing
 - 2.1 The charge was read to the Accused (OKT) in a language he understood.
 - 2.2 The court recorded OKT's confession, whether he pleaded guilty/requested a trial.
3. If OKT admits fault:
 - 3.1 The court will ensure that OKT understands the nature and consequences of his confession.
 - 3.2 The facts of the case are read and explained to the OKT and case items are presented and marked as exhibits.
 - 3.3 The court will receive the Young Offender Social Report (if the OKT is under 21 years of age), the Victim Impact Statement, hear the mitigation of the OKT, hear the sentencing aggravation argument from the prosecution and receive records of past convictions (if any).
 - 3.4 The court shall sentence the OKT in accordance with the relevant Law and make any appropriate orders on the exhibits and case materials.
4. If OKT does not admit fault:
 - 4.1 The court will either grant or deny bail to OKT depending on the type of offence. If bail is not granted, then OKT will be remanded in prison until the case is resolved, while if bail is granted, OKT will be released on bail.
5. Full Trial
 - 5.1 Other prosecution witnesses: Witnesses are brought into Open Court to give evidence in the witness box.
 - 5.2 Child prosecution witnesses: Child witness testimony may be given in any one or a combination of the following ways:-
 - i. establish a barrier between the child and the OKT (Screen Barrier);
 - ii. live network (Video Link Network); and or video recording
6. Results
 - 6.1 If the Court finds OKT not guilty, the Court will release and acquit OKT.
 - 6.2 If the Court finds OKT guilty, the Court will sentence OKT in accordance with the relevant law and make any appropriate orders on the exhibits and case materials.

Guidelines for Handling Victims/Witnesses and Protection and Support Services

Agencies responsible for children who are victims of sexual offences. Procedures for handling Victims/Witnesses and Protection and Support Services involve the collaboration of the following three agencies;

Royal Malaysian Police (PDRM)

PDRM will apply to the court to issue an Interim Protection Order (IPO) meaning an order issued by the Court while waiting for the police to complete their investigation into domestic violence cases. If anyone needs an IPO and other services at the Social Welfare Department (JKM), they can also refer the victim to a JKM officer by attaching documents such as a copy

of the police report, a letter confirming the case under investigation and a medical officer's report (if any).

The PDRM also provides a Child Interview Centre (CIC) to assist Investigating Officers in obtaining clear and quality evidence from children and children with disabilities. The evidence taken is in the form of video recordings.

Among other assistance provided by the PDRM during the investigation process is providing emotional support and counseling sessions to the victim and family or referring to other Departments/Agencies that can provide support services to the victim and family. The PDRM will conduct the investigation, track down and arrest the suspect and charge the suspect in Court if they have strong evidence after receiving advice and instructions from the Attorney General's Chambers.

Court for Children (MBKK)

MBKK is a Court established under Section 11 of the Child Act 2001 [Act 611] consisting of a magistrate and assisted by two advisors appointed by the Minister (selangor.kehakiman.gov.my, 2025). Temporary Order refers to the temporary placement of a child sexual abuse victim for a period of one month and placed in a safe place or under the care of a qualified person.

MBKK Order (Standing Orders) relating to a child who needs care and protection through the four (4) provisions of the powers of the Court for Children as follows (Children Act, 2001):

1. Section 30(1)(a) The parent or guardian of the child executes a bond to carry out proper care and custody for a period specified by the MBKK;
2. Section 30(8) Interactive workshops is a provision in the Child Act 2001 which requires parents/guardians and children to undergo prescribed intervention programs such as counseling, parenting workshops and so on;
3. Section 30(1)(b) Makes an order placing a child in the care of a fit and Suitable Person Custody Order (OYLS) for a period specified by the MBKK;
4. Section 30(1)(c) Making an order placing a child under supervision-
 - (i) A Protector; or
 - (ii) Another person appointed for that purpose by the Court for Children, For a period specified by the Court for Children;
5. Section 30(1)(d) The child is placed in a Centre for a period of three (3) years from the date of the order or until the child reaches the age of 18 years, whichever is shorter; or
6. Section 30(1)(e)

For children without parents, the child is placed in the care, custody and control of a foster parent or guardian found suitable by the Director General of the Social Welfare Department (JKM) for a period of two (2) years from the date of placement or until the child reaches the age of 18, whichever is shorter. While a suitable foster parent or guardian is being sought, the child will be placed in a safe place.



Ministry of Health Malaysia

The role of the Ministry of Health is that any victims sent to hospital will be referred to the One Stop Crisis Centre (OSCC) and further examinations will be carried out by medical officers.

The One Stop Crisis Centre (OSCC) is a special unit in the Emergency Department of a hospital that provides comprehensive services to victims of child abuse. It is also specifically set up to provide privacy for victims during the interview and physical examination process.

The Suspected Child Abuse & Neglect (SCAN) Team is a professional team consisting of doctors and experts from various disciplines who function to conduct examinations and assessments on child victims of abuse.

The SCAN Team is also responsible for ensuring coordination between hospitals and other government and non-government agencies to ensure that child victims receive protection and justice. The SCAN Team is led by a Child Specialist (Pediatrician) and other members consist of specialists and doctors from the Emergency Department, Pediatrics Department, Obstetrics and Gynecology Department, Surgery Department, Psychiatry Department and Forensic Department. Other SCAN team members also consist of counseling officers, psychologists and officers from the Medical Social Work Department, child protection officers and police officers.

Conclusion

Malaysia has created a conducive environment in the realization of child protection efforts. Collaborative efforts between government agencies, non-governmental organizations and public institutions to raise public awareness on various issues. Children's awareness and understanding of any behavior that leads to sexual crimes is very important to ensure that they do not become victims of such indecent behavior. Various efforts have been and will be implemented to educate and make children aware of behavior that can be defined as sexual crimes, since they are not only vulnerable to becoming victims but also do not know what the immoral behavior or action is.

The Special Guidelines were formulated to ensure that the goals and objectives of Act 792 can be achieved more effectively. It is hoped that these Special Guidelines will assist Child victims/witnesses and their families in particular as well as the public in general, starting from the complaint stage until the case is heard. These Special Guidelines also discuss the forms of protection and support that can be obtained from the various agencies involved.

The problem of convictions that cannot be imposed on child sexual offenders. The lack of conviction aspects actually depends on several factors including insufficient evidence. Therefore, the results of the investigation carried out cannot satisfy the court to convict the accused. In general, the problem of the procedure for convicting the accused does not actually depend on the law alone but on the entire criminal justice administration system.

Child protection efforts are urgently needed at this time to encourage every agency, organization and member of society to prioritize child protection as a collective responsibility. The role of agencies such as the Royal Malaysian Police (PDRM), the Court, the



Ministry of Health (hospitals), the Ministry of Women, Family and Community Development and Department of Social Welfare (JKM) also work together to play an active role in ensuring the protection and well-being of children based on specific, systematic procedures.

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ADOLESCENTS AT RISK ONLINE: CONSOLIDATING GLOBAL EVIDENCE AND CALIBRATING MALAYSIAN POLICY (2013–2025)

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Abstract: *This semi-systematic review (2013–2025), guided by PRISMA and a systems lens, maps global and Malaysian scholarship on cyberbullying in social media and evaluates alignment with Malaysia's policy environment. Internationally, evidence centres on adolescent mental health, gendered vulnerabilities, and cultural variation, with growth in longitudinal and mixed-methods designs. Malaysian studies have expanded but remain largely descriptive and cross-sectional, with limited theoretical integration and weak translation into interventions. Policy analysis indicates partial alignment: national initiatives acknowledge risk while underusing empirical insights on digital harms and resilience. The paper contributes by: (1) diagnosing methodological and thematic gaps that constrain evidence-informed strategies; (2) positioning cyberbullying as an education–public-health priority linked to adolescent mental health; and (3) proposing context-sensitive pathways to integrate international best practices in Malaysia. Originality lies in bridging systematic evidence and policy routes, situating Malaysian scholarship within global debates and outlining a roadmap for responsive, culturally grounded action.*

Keywords: *Cyberbullying, Social Media, Adolescent Mental Health, Gender Dynamics, Malaysian Policy Pathways*

Introduction

Cyberbullying in social media has become a multidimensional challenge spanning public health, education, and digital governance. It is strongly associated with depression, anxiety, social withdrawal, suicidal ideation, and declining academic performance among adolescents (Kowalski, Giumetti, Schroeder & Lattanner, 2014; Hamm et al., 2015; Selkie, Fales & Moreno, 2020). UNICEF (2022) estimates that one in three adolescents worldwide has experienced online bullying and one in five has missed school as a result, underscoring the severity of its impact. The expansion of algorithm-driven platforms such as TikTok, Instagram, and WhatsApp has embedded harassment within everyday digital routines, complicating timely detection and response. Cyberbullying in Malaysia is deeply entangled with the communication logics of social media, where platforms originally designed for connection—Facebook, TikTok, WhatsApp, Instagram—now serve as venues for harassment, body shaming, doxing, and coordinated troll attacks (Bernama, 2025). The affordances of speed, anonymity, and algorithmic amplification allow a single humiliating post to circulate indefinitely, leaving lasting digital scars (The Star, 2025; MalaysiaGazette, 2025). Unlike traditional bullying, cyberbullying penetrates victims' digital spaces continuously, creating mediated aggression that is both invasive and enduring.

Malaysia reflects these global dynamics in sharp ways. Reported cases surged from 3,199 in 2023 to 8,399 by November 2024, making cyberbullying the nation's most prevalent cybercrime (MCMC, 2024). Adolescents in urban and semi-urban areas appear especially exposed, while national responses remain fragmented. Although local scholarship has grown, research continues to be dominated by descriptive and cross-sectional designs with limited engagement with global theoretical models (Balakrishnan, 2018; Samsudin et al., 2023). Critical factors such as gender, cultural norms, and socio-economic conditions are often insufficiently analysed, even though international studies increasingly employ longitudinal and intersectional approaches that demonstrate how cultural values and power structures heighten vulnerability (Souza et al., 2022; Wright, 2016). This divergence generates a knowledge–practice gap that constrains the development of interventions rooted in Malaysian realities.

Existing syntheses also provide limitations. Malaysian reviews (Lian, Tang & Omar, 2023) tend to catalogue prevalence without situating findings in wider theoretical debates, while global bibliometric mappings (Hamm et al., 2015; Selkie et al., 2020) rarely extend their implications to national policy alignment. To date, no integrated assessment has combined systematic mapping with conceptual synthesis across global and Malaysian contexts to evaluate whether empirical evidence informs the country's evolving policy frameworks.

This study addresses that gap with two objectives: first, to review global and Malaysian research on cyberbullying in social media (2013–2025), with particular focus on adolescent mental health and gender; and second, to evaluate the extent to which Malaysian policy responses reflect empirical insights and to propose pathways for alignment with international best practices. Guided by a structured literature review using Cabrera's systems lens and PRISMA procedures, the study synthesises a decade of Scopus-indexed evidence. Its contribution is threefold: it consolidates thematic and methodological patterns across global and Malaysian contexts, positions Malaysian scholarship within theoretical debates on culture, gender, and mental health, and advances policy relevance by aligning research insights with national legal and institutional frameworks. In doing so, the paper offers a roadmap for interventions that are both responsive and culturally grounded.

Literature Review

Global Research on Cyberbullying (2013–2025)

Over the past decade, international scholarship has shifted from mapping prevalence to investigating persistence, mediating factors, and cultural contexts through longitudinal and mixed-methods designs (Wright, 2016; Souza, Ferreira, & Silva, 2022). More recently, scholars highlight how platform design and algorithmic amplification sustain harassment, embedding it within digital ecosystems rather than isolated interactions (Lim et al., 2024).

Gender and culture have become central explanatory axes. Research consistently indicates that girls face heightened relational victimisation and psychological distress, while boys are more often identified as perpetrators (Souza et al., 2022; Baltzidis, 2024; Connell et al., 2014). Intersectional and social-ecological frameworks explain these vulnerabilities as socially constructed and amplified within digital environments (Wright, 2016). Global syntheses increasingly frame cyberbullying as a structural phenomenon that interacts with platform affordances, social hierarchies, and cultural logics (Kowalski, Giumetti, Schroeder, &

Lattanner, 2014; Selkie, Fales, & Moreno, 2020; Zsila et al., 2019; Kapitány-Fövény et al., 2022).

Malaysian Research on Cyberbullying

Local scholarship reflects these concerns but remains methodologically limited. Early studies documented behaviours of bullies, victims, and bystanders without theoretical anchoring (Balakrishnan, 2018). More recent surveys report high victimisation rates and associations with family dysfunction, risky health behaviours, and psychological distress (Samsudin, Yaacob, Xin Wee, & Mohamad, 2023). Systematic reviews such as Lian, Tang, and Omar (2023) draw attention to lived experiences but seldom situate them within comparative or policy contexts.

Three weaknesses persist. First, the interaction of gender and culture is rarely analysed, despite global evidence that these strongly mediate both risk and resilience (Souza et al., 2022; Wright, 2016). Second, theoretical frameworks remain marginal: prevalence surveys dominate, while social-ecological perspectives and intersectional analyses are rarely employed. Third, policy translation is weak, with research seldom informing initiatives such as the Malaysia Education Blueprint or MCMC's cyber safety programmes. Collectively, these limitations render Malaysian research descriptive rather than explanatory, reducing its capacity to inform targeted interventions or contribute to global theoretical debates.

Comparative Gaps and Theoretical Positioning

Cross-context comparisons reveal a persistent divergence. International research increasingly embeds cyberbullying within social-ecological and intersectional frameworks that account for peer dynamics, cultural expectations, and digital affordances (Wright, 2016; Souza, Ferreira, & Silva, 2022; Liang, Zheng, & Xu, 2022; Wong, Chan, & Cheng, 2018). Longitudinal and mixed-methods designs extend this by tracing developmental trajectories and identifying protective factors such as parental monitoring and peer support (Kowalski et al., 2014; Selkie et al., 2020). Bibliometric analyses also highlight theoretical fragmentation, calling for stronger consolidation across frameworks (Ding, Li, & Chen, 2025).

Malaysian work, however, remains anchored in cross-sectional surveys with limited theoretical integration. Gendered vulnerabilities, well-documented globally, are rarely analysed locally, even though Malaysia's socio-cultural diversity almost certainly shapes adolescent experiences of online harm (Balakrishnan, 2018; Samsudin et al., 2023). Local reviews (Lian et al., 2023) also remain inward-looking and disconnected from global syntheses, weakening scholarly visibility and theoretical refinement.

This asymmetry produces two consequences: Malaysian research risks remaining siloed and globally peripheral, while policy-makers are left without conceptual tools to anticipate cultural, gendered, and developmental complexities. Advancing beyond this requires methodological diversification and theoretical adoption that embed Malaysian findings within international debates on adolescent wellbeing and digital governance.

Policy Alignment and Research–Practice Gap

The misalignment between empirical evidence and national policy represents a structural weakness. Globally, agencies such as UNICEF (2022) and WHO frame cyberbullying as a joint education–public health priority, recommending school-based prevention, platform accountability, and expanded mental-health support. Malaysia’s initiatives, including the Education Blueprint, Child Act, and MCMC campaigns, reflect rising awareness, and reports confirm that cyberbullying has overtaken scams as the country’s leading cybercrime (MCMC, 2024). However, links between empirical findings and policy remain tenuous: evidence on psychological distress (Samsudin, Yaacob, Xin Wee, & Mohamad, 2023) and gendered experiences (Balakrishnan, 2018) are largely absent from school counselling frameworks and awareness campaigns, leaving responses fragmented (Mohamad, Ismail, & Ahmad, 2022; Nasruddin, Jamaludin, & Hassan, 2023).

Weak theoretical grounding further exacerbates this gap. Policies not informed by evidence risk becoming generic and reactive, while legal provisions remain fragmented and insufficiently attuned to adolescent digital harms (Rajamanickam, Ali, & Karim, 2019; Putra, 2024). Comparative studies report stronger outcomes when cybercrime laws are integrated into child protection frameworks (Stylios, Papaioannou, & Karyda, 2016; Ghandour, El Sayed, & El Sayed, 2021). In contrast, Malaysian strategies rarely combine cultural responsiveness with platform accountability, a gap that global research identifies as critical (Wright, 2016; Souza, Ferreira, & Silva, 2022).

To move beyond piecemeal initiatives, Malaysian scholarship requires greater theoretical and methodological sophistication, while national strategies must embed empirical insights to ensure interventions are evidence-based, culturally grounded, and internationally aligned. This review highlights that while global scholarship has advanced through longitudinal, intersectional, and theoretically anchored approaches, Malaysian studies remain largely descriptive, under-theorised, and weakly connected to policy debates. To make this divergence visible, Table 1 consolidates the comparative analysis across five critical dimensions—mental health, gender, theoretical positioning, methodological development, and policy integration—illustrating not only the empirical gaps but also the implications these weaknesses create for evidence-based interventions and national strategies.

Table 1: Comparative Synthesis of Global and Malaysian Cyberbullying Research (2013–2025): Evidence, Gaps, and Policy Implications

Dimension	Global Scholarship	Malaysian Scholarship	Analytical Gap	Policy Implication	Exemplar Studies
Adolescent Mental Health	Longitudinal and mixed-method designs demonstrate strong links to depression, anxiety, suicidal ideation, and school disengagement	Cross-sectional surveys report psychological distress but lack causal or developmental depth	Causality unexplored; fragmented evidence	Need for evidence-informed counselling and adolescent mental health integration	Kowalski et al. (2014); Hamm et al. (2015); Selkie et al. (2020); Zsila et al. (2019); Kapitány-Fövény et al. (2022); Samsudin et al. (2023)
Gender and Identity	Intersectional analyses confirm girls face higher victimisation and boys are more often perpetrators; cultural norms mediate risk	Gender seldom analysed; framing remains descriptive	Identity-sensitive data absent	Campaigns remain gender-neutral, not culturally adapted	Connell et al. (2014); Wright (2016); Souza et al. (2022); Balakrishnan (2018); Baltzidis (2024)
Theoretical Positioning	Social-ecological and intersectional models increasingly guide research	Local work prevalence-focused with minimal theory-building	Weak conceptual grounding	Policymakers lack theoretical tools for designing interventions	Kowalski et al. (2014); Wright (2016); Selkie et al. (2020); Wong et al. (2018); Liang et al. (2022); Lian et al. (2023); Ding et al. (2025)
Methodological Development	Expansion of longitudinal, mixed-method, and bibliometric studies	Reliance on cross-sectional surveys and descriptive reviews	Limited methodological diversity	Policymakers operate with partial and non-generalizable findings	Kowalski et al. (2014); Hamm et al. (2015); Selkie et al. (2020); Lian et al. (2023); Samsudin et al. (2023)

Digital Platforms & Algorithmic Risks	Research highlights TikTok, Instagram, gaming platforms, anonymity, and algorithmic amplification	Focus largely on Facebook/WhatsApp; little attention to platform design	Platform-level risks under-analysed	Policy lacks accountability frameworks for platforms	Kowalski et al. (2014); Hamm et al. (2015); UNICEF (2022); Lim et al. (2024); MCMC (2024)
Policy Integration	UNICEF and WHO frame cyberbullying as a multi-sectoral public health and education priority	Malaysia acknowledges the issue in the Education Blueprint, Child Act, and MCMC reports, but the link to evidence is weak	Fragmented, reactive interventions	Urgent need for an integrated national strategy grounded in research	UNICEF (2022); MCMC (2024); Balakrishnan (2018); Samsudin et al. (2023); Mohamad et al. (2022); Nasruddin et al. (2023)
Legal and Regulatory Gaps	Comparative legal reviews stress alignment between cybercrime law and child protection	Malaysian provisions are fragmented, with limited recognition of adolescent digital harms	Regulatory lag; weak enforcement	Need for integrated cybercrime–child protection legislation	Stylios et al. (2016); Ghandour et al. (2021); Rajamanickam et al. (2019); Putra (2024)

Methodology

This study adopted a semi-systematic literature review (SLR) to consolidate interdisciplinary evidence on cyberbullying in social media, focusing on adolescent mental health outcomes and gender dynamics. A semi-systematic design was chosen because the topic spans multiple disciplines and theoretical perspectives, where conceptual integration is as important as comprehensive coverage (Snyder, 2019). The review followed the PRISMA 2020 guidelines to ensure transparency and replicability (Page et al., 2021).

Scopus was selected as the sole database because of its broad multidisciplinary coverage and high quality of indexed material, which surpasses Web of Science in journal representation across social sciences, psychology, computing, and health (Mongeon & Paul-Hus, 2016; Martín-Martín et al., 2018). Google Scholar was excluded due to quality control issues, duplication, and inconsistent metadata (Haddaway et al., 2015; Harzing & Alakangas, 2016). Searches were restricted to 2013–2025, reflecting a decade of rapid platform evolution (e.g., Instagram, TikTok) and shifts in research on adolescent mental health. Boolean search strings combined four clusters: cyberbullying terms (“cyberbullying” OR “online harassment”), social media terms (“social media” OR platform names), gender terms (“gender” OR “sex differences”), and psychological distress terms (“mental health” OR “depression” OR “anxiety”). Only English-language, peer-reviewed articles in Scopus subject areas relevant to social sciences, psychology, computer science, health, and humanities were included.

The initial search yielded 220 records, which were reduced to 88 after subject-area filtering and then 82 unique records after duplicate removal. Title and abstract screening removed studies outside the adolescent or social media context, producing 65 final studies for full-text analysis. A PRISMA 2020 flow diagram (Figure 1) documents this process. Data extraction captured bibliographic details, research design, social media platform, participant role, gender-related variables, psychological outcomes, and theoretical frameworks.

Analysis combined bibliometric mapping and thematic synthesis. Bibliometric techniques were used to identify publication trends, geographic distributions, and keyword co-occurrences, providing a structural overview of the research landscape (Donthu, Kumar, Mukherjee, Pandey, & Lim, 2021). Thematic synthesis was then applied to interpret how gender shapes the link between cyberbullying and psychological distress, emphasising cultural and platform-specific contexts. This dual approach enabled integration of macro-level patterns with micro-level conceptual insights, directly addressing the study’s objectives of mapping global and Malaysian research and evaluating policy alignment.

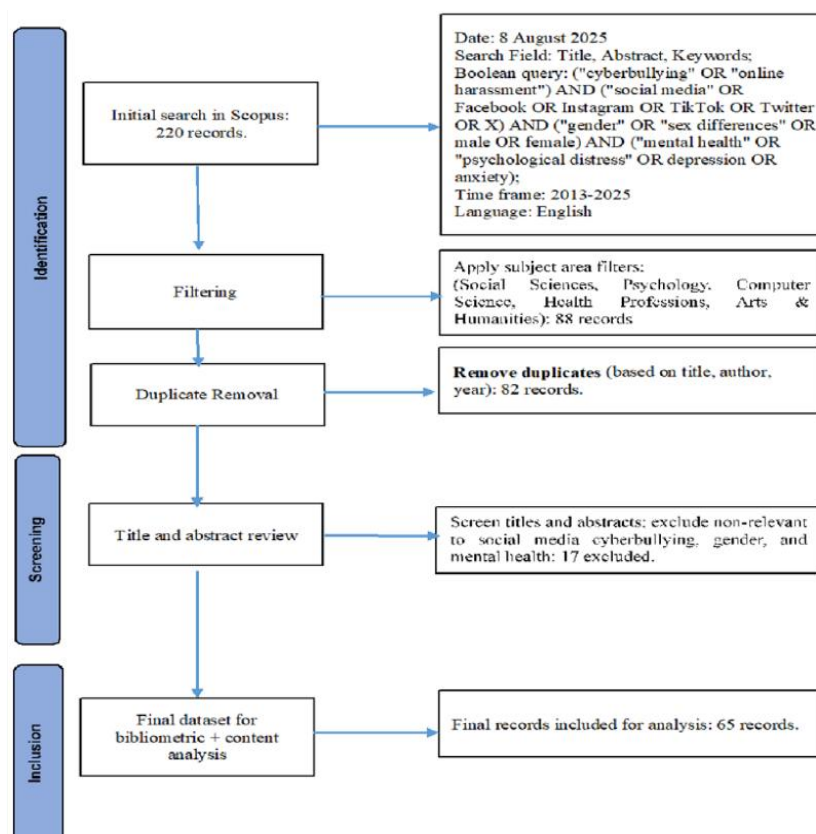


Figure 1: PRISMA 2020 Flow Diagram for the Semi-Systematic Review on Cyberbullying, Gender, and Adolescent Mental Health (2013–2025)

Findings and Discussions

Adolescent Mental Health

Global research over the past decade has established cyberbullying as a sustained determinant of adolescent well-being. Longitudinal and mixed-method studies consistently identify strong associations with depression, anxiety, suicidal ideation, and reduced academic performance, extending analysis beyond prevalence counts to the developmental course of harm across adolescence (Hamm et al., 2015; Selkie, Fales, & Moreno, 2020; Zsila et al., 2019; Kapitány-Fövény, Urbán, & Griffiths, 2022). By moving beyond short-term correlational designs, this scholarship reveals how victimisation gradually undermines coping resources and interacts with peer relationships, family support, and cultural context, producing accumulated distress that weakens both educational attainment and long-term health. Mental health has therefore become the central frame through which cyberbullying is conceptualised internationally.

In Malaysia, research has confirmed the seriousness of these harms, but with a narrower scope and design. Cross-sectional surveys highlight significant associations between victimisation, depressive symptoms, risky behaviours, and family dysfunction, particularly among adolescents and young adults in urban contexts (Samsudin, Yaacob, Xin Wee, & Mohamad, 2023). Early descriptive studies also noted emotional and behavioural consequences among both victims and perpetrators, even in the absence of clinical assessment (Balakrishnan, 2018). While these findings make the burden of cyberbullying visible, the reliance on single-timepoint

surveys restricts explanatory depth and prevents assessment of causal pathways across developmental stages.

The divergence between global and Malaysian evidence leaves a structural knowledge gap. International work has begun to map mediating influences such as peer support and cultural norms that shape resilience (Selkie et al., 2020; Zsila et al., 2019), but Malaysian studies have not tested these mechanisms. Without longitudinal approaches or culturally grounded frameworks, national policies risk being guided by surface-level prevalence rather than nuanced insights. The result is an orientation towards crisis response rather than preventive strategies that anticipate how cyberbullying interacts with adolescent development and mental health.

Gender and Identity

Global research increasingly positions gender and identity at the centre of cyberbullying analysis. Studies no longer treat boys and girls as homogenous categories, but examine how relational aggression, cultural expectations, and online affordances interact to produce differentiated vulnerabilities. Large-scale reviews confirm that adolescent girls are more likely to experience relational victimisation with stronger links to internalised distress such as anxiety and depression, while boys are more frequently involved as perpetrators or targets of direct aggression (Souza, Ferreira, & Silva, 2022; Wright, 2016; Connell, Schell-Busey, Pearce, & Negro, 2014). Recent work extends this binary by embedding gender within broader identity frameworks, highlighting how peer reputation, digital self-presentation, and cultural scripts magnify risks for girls navigating visible social media spaces (Baltzidis, 2024). By integrating gender into intersectional perspectives, international scholarship provides both explanatory depth and conceptual tools to understand how identity-based vulnerabilities are socially constructed and amplified within digital environments.

In Malaysia, however, gender and identity remain marginal in cyberbullying studies. Descriptive surveys document emotional consequences of victimisation (Balakrishnan, 2018), and more recent work demonstrates associations with distress and behavioural problems (Samsudin, Yaacob, Xin Wee, & Mohamad, 2023). Neither line of research systematically interrogates how harms are differentiated by gender or mediated by Malaysia's diverse socio-cultural and religious contexts. The silence is significant given that expectations around gender roles, respectability, and communal reputation remain powerful influences in adolescent life, shaping whether harassment is reported, concealed, or normalised.

The absence of identity-sensitive analysis constitutes a conceptual fault line. International evidence confirms that gendered and cultural norms interact with platform design to sustain cycles of harm (Souza et al., 2022; Wright, 2016; Baltzidis, 2024). By contrast, Malaysian scholarship has remained descriptive, providing little empirical foundation for gender-responsive or culturally attuned interventions. This disjuncture has direct policy consequences: national campaigns continue to promote universalised messages of "cyber safety," overlooking that adolescent girls and boys experience different forms of aggression, respond in distinct ways, and shoulder unequal burdens of stigma. Without integration of gender and identity, strategies risk overlooking the most vulnerable groups and failing to address the cultural realities that shape adolescent digital experiences.

Theoretical Positioning

Global scholarship demonstrates that explanatory strength in cyberbullying research lies not in prevalence surveys alone but in the frameworks that situate online aggression within wider social, cultural, and institutional contexts. Social-ecological and intersectional models increasingly guide analysis, enabling scholars to explain how peer dynamics, cultural expectations, and digital affordances sustain cycles of harm (Wright, 2016; Souza, Ferreira, & Silva, 2022; Liang, Zheng, & Xu, 2022; Wong, Chan, & Cheng, 2018). By embedding cyberbullying within these perspectives, researchers have been able to move beyond identifying who is at risk to explaining why vulnerabilities persist, how they are reproduced, and what protective mechanisms mitigate their effects. Bibliometric reviews further confirm this trend, mapping an emerging consolidation around multidisciplinary theories that connect psychology, sociology, and media studies into a coherent conceptual foundation (Ding, Li, & Chen, 2025).

In Malaysia, theoretical development has lagged. Local studies have generated valuable descriptive insights into prevalence, correlates, and emotional consequences (Balakrishnan, 2018; Samsudin, Yaacob, Xin Wee, & Mohamad, 2023), and qualitative syntheses have captured elements of lived experience (Lian, Tang, & Omar, 2023). However, most of this work is not anchored in established theoretical models, resulting in evidence that informs but seldom explains. This absence reduces both the depth of local scholarship and its capacity to connect with global debates.

The implications are twofold. Without theoretical anchoring, Malaysian studies struggle to identify mechanisms and mediators of harm, limiting their relevance for policy design. At the same time, the absence of conceptual engagement weakens international visibility, as descriptive findings are less likely to shape comparative debates or inform the consolidation of global frameworks. Global research is converging on theories that account for culture, identity, and systemic influence, while Malaysian scholarship risks remaining siloed, generating evidence that is locally descriptive but internationally peripheral. To contribute more meaningfully, Malaysian research must adopt and adapt theoretical models that translate empirical findings into conceptual and policy relevance.

Methodological Development

Global research on cyberbullying has advanced methodologically from single-time-point prevalence surveys to more sophisticated designs that capture the evolving nature of digital harm. Longitudinal cohorts and mixed-method approaches are increasingly used to analyse persistence, mediating influences, and protective factors across adolescence (Hamm et al., 2015; Selkie, Fales, & Moreno, 2020). These methods illuminate how parental mediation, peer support, and cultural norms interact with digital practices to shape both vulnerability and resilience. At a macro level, bibliometric analyses have mapped thematic interconnections across a decade of work, highlighting how conceptual and methodological developments converge to provide a more coherent understanding of adolescent online risk (Ding, Li, & Chen, 2025; Donthu, Kumar, Mukherjee, Pandey, & Lim, 2021).

In Malaysia, methodological approaches remain constrained. Most studies rely on cross-sectional survey designs that measure prevalence and correlate experiences of cyberbullying



with psychological distress (Balakrishnan, 2018; Samsudin, Yaacob, Xin Wee, & Mohamad, 2023). While these surveys offer valuable baseline data, they cannot establish causal directionality or capture developmental change. More recent attempts to diversify the evidence base include phenomenological syntheses of lived experiences (Lian, Tang, & Omar, 2023) and analyses acknowledging victim–perpetrator dual roles (Ayub, Ismail, Abdul Rahman, & Anuar, 2023; Rina, Kadir, & Omar, 2022). These contributions enrich understanding but still fall short of the multi-layered approaches that characterise global scholarship.

The imbalance is not a minor limitation but a structural constraint. Evidence generated from narrow designs reduces the ability of policymakers to anticipate long-term consequences or design preventive strategies grounded in causal inference. Without longitudinal or mixed-method approaches, Malaysian scholarship remains descriptive, documenting the existence of harm without explaining how it evolves or how interventions might disrupt it. Addressing this requires methodological diversification that can capture the complexity of adolescent online experiences and align research evidence with the systemic needs of national policy.

Digital Platforms and Algorithmic Risks

Digital platforms are not passive environments but active mediators of risk, shaping both the intensity and visibility of cyberbullying. Global scholarship increasingly recognises that design features and algorithmic amplification embed harassment within digital ecosystems. Studies of platforms such as TikTok and Instagram highlight how recommendation systems promote sensational or conflict-driven content, reinforcing cycles of aggression and expanding the audience of harassment (Lim, Lee, & Tan, 2024; UNICEF, 2022). Research on gaming environments and ephemeral messaging applications has also revealed how anonymity and reduced accountability enable sustained patterns of covert bullying (Kowalski, Giumetti, Schroeder, & Lattanner, 2014; Hamm et al., 2015). By directing attention to platform-level affordances, these studies shift the field from analysing individual behaviours to interrogating the technological architectures that produce conditions of digital harm.

In Malaysia, however, research continues to concentrate on older platforms such as Facebook and WhatsApp (Balakrishnan, 2018; Samsudin, Yaacob, Xin Wee, & Mohamad, 2023). Little empirical work has examined TikTok, Instagram, or online gaming spaces, even though these dominate adolescent digital life. This narrow focus obscures how platform design intensifies risk, leaving critical blind spots in both scholarship and policy. The absence is particularly notable given Malaysia's high rates of adolescent engagement with emerging platforms, where algorithmic systems and visual cultures are integral to daily interactions.

The lack of attention to platform dynamics carries direct policy implications. Interventions remain centred on individual responsibility and awareness campaigns, while systemic risks created by platform governance are overlooked. Global evidence emphasises that algorithmic accountability and platform regulation must be central to strategies for adolescent wellbeing (UNICEF, 2022; Lim et al., 2024). For Malaysia, advancing in this direction requires stronger collaboration between regulators, researchers, and technology companies so that empirical insights into platform design inform both preventive measures and regulatory frameworks.

Policy Integration and Legal Gaps

The alignment between research and policy remains a structural weakness in addressing cyberbullying. International agencies such as UNICEF and WHO position the phenomenon as a joint education and public health priority, calling for integrated prevention, platform accountability, and expanded mental health services (UNICEF, 2022). Malaysia has acknowledged the issue through frameworks such as the Education Blueprint 2013–2025, the Child Act 2001, and MCMC initiatives, and recent reports confirm that cyberbullying has surpassed scams as the most reported cybercrime (MCMC, 2024). Despite this recognition, empirical insights—particularly evidence on psychological distress (Samsudin, Yaacob, Xin Wee, & Mohamad, 2023) and gendered vulnerabilities (Balakrishnan, 2018)—remain absent from national counselling programmes and cyber safety campaigns. Evaluations of policy responses highlight a pattern of disjointed initiatives developed in isolation from the research base, leading to reactive rather than preventive strategies (Mohamad, Ismail, & Ahmad, 2022; Nasruddin, Jamaludin, & Hassan, 2023).

Legal frameworks further accentuate this gap. Malaysian provisions remain piecemeal and insufficiently responsive to adolescent digital harms (Rajamanickam, Ali, & Karim, 2019; Putra, 2024). Comparative studies demonstrate that outcomes are strengthened when cybercrime laws are explicitly integrated into child protection frameworks, creating systems that are preventive, enforceable, and sensitive to adolescent needs (Stylios, Papaioannou, & Karyda, 2016; Ghandour, El Sayed, & El Sayed, 2021). Without similar reforms, Malaysia risks leaving adolescents exposed to systemic vulnerabilities and remaining out of step with global standards of digital governance.

Addressing these gaps requires both scholarly and policy innovation. Malaysian research must progress towards theoretically anchored and methodologically diverse designs that can generate evidence for policy, while national strategies must embed this evidence into integrated education, mental health, and child protection frameworks. Only through this alignment can interventions become preventive, culturally grounded, and internationally coherent, positioning Malaysia to protect adolescents effectively in an increasingly complex digital ecosystem.

Conclusion and Implications

Over the past decade, cyberbullying on social media has been reframed internationally as a structural challenge situated at the nexus of adolescent mental health, educational outcomes, and digital governance, with longitudinal and mixed-method designs, intersectional perspectives, and theoretical consolidation establishing it as both a developmental and systemic risk. Within Malaysia, however, scholarship has expanded without achieving comparable methodological or conceptual depth, remaining dominated by descriptive surveys, limited theoretical engagement, and weak connections to national strategies.

This divergence is not a matter of academic style but of consequence, for evidence that catalogues prevalence without explaining mechanisms leaves policymakers with little capacity to design preventive or culturally responsive interventions. The absence of gender-sensitive and platform-level analyses further diminishes the ability of national frameworks to anticipate

how adolescent vulnerabilities are shaped by socio-cultural norms and algorithmic environments that define everyday digital life.

As with all semi-systematic reviews, the scope of this study is bounded by its reliance on Scopus-indexed literature between 2013 and 2025, thereby excluding grey sources and regional publications that may capture additional insights. These boundaries point directly to the need for Malaysian scholarship to invest in longitudinal and mixed-method designs that test mechanisms of resilience and to align more closely with global debates on gender, culture, and platform governance. For policy, the priority is embedding research evidence into education, child protection, and digital safety frameworks so that interventions become preventive, culturally grounded, and internationally coherent. Closing this gap would not only strengthen Malaysia's protection of adolescents but also reposition its scholarship from a descriptive base to a contributor shaping international agendas on adolescent wellbeing and digital governance.

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A COMPARATIVE ANALYSIS OF HALAL AND FOOD SAFETY AUDITING PRACTICES IN MALAYSIA, INDONESIA, SINGAPORE AND BRUNEI DARUSSALAM

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Abstract: *Halal quality assurance ensures food is not only permissible but also safe, hygienic, and of high quality. Auditing is essential to establish this assurance, however different countries have different methods for conducting halal and food safety audits. This study compares the auditing practices in Malaysia, Singapore, Indonesia, and Brunei Darussalam to assist in the development of a standardised internal audit checklist for Brunei's food manufacturing companies. A qualitative approach was adopted through the review of national halal standards, food safety regulations, and relevant academic literature. The comparative analysis reveals that all four countries share several core halal and food safety auditing practices. At the same time, differences exist in the comprehensiveness of their auditing practices and the degrees of food safety integration. Based on these findings, this paper recommends that Brunei implement a risk-based internal auditor checklist that integrates both halal and food safety requirements. This tool further strengthens halal governance, improves audit consistency, and enhances national recognition of Brunei's halal certification system.*

Keywords: *halal, food safety, auditing practices, internal audit checklist, Brunei*

Introduction

Halal food is projected to exceed USD 6.0 trillion by 2024, indicating halal is not only about religious obligatory but also a global symbol of a high-quality products adhere to strict quality assurance and a lifestyle choice (Azam & Abdullah, 2020; Azalie & Samad, 2022). Halal food consumption is essential in Islam encompass of halal (permissible) and *thayyib* (good or wholesome). This has been emphasised in the Quranic verses including Surah al-Baqarah (2:168, 2:172) and Surah Al-Ma'idah (5:5, 5:88). The demand of safe and halal food is increasing especially with halal developing into global presentation of quality assurance (Sulaiman et al., 2023).

Other than halal, food safety is another critical component in halal quality assurance representing *Thayyib* that guarantees that food will not harm consumers when it is prepared or consumed as intended (Hassan et al., 2015). Nowadays, people are more concern on the widespread issues regarding food safety such as threat of diseases. Although, the visible aspects of food quality can be verified but contamination or non-compliance towards halal and food safety standards may not be noticeable through sensory inspection only (A.Hanni & Hashim, 2025). Hence, a comprehensive internal audit processes are important in assisting to assure both halal integrity and food safety of the products complementing the role of external audits.

The function of audit is to ensure members of the organization perform their responsibilities effectively, and also crucial for evaluating activities such as certification, registration and supervision (Aziz & Hussin, 2024; Amrizal et al., 2025). Meanwhile, internal audit is an independent mechanism that ensures compliance with regulations, effectiveness of risk management, and operational efficiency (Zunaedi et al., 2022; Amrizal et al., 2025). In halal certification process, halal audit is a critical component to confirm compliance on halal standards and procedures (A.Hanni & Hashim, 2025). Whereas, food safety audit is a health protection employed by many food safety regulators in preventing foodborne illnesses by analysing food samples, assessing food handling practices, and evaluating condition to food production environment in ensuring the food safety standards are being met (Barnes et al., 2022). Hence, integrating both halal and food safety elements is important to fulfill the principle of *halalan thayyiban*.

Different countries adopt different approaches towards halal and food safety auditing practices. Malaysia, Singapore and Indonesia have developed globally for their halal standards and are widely referenced from accredited Halal Certifying Bodies (HCBs) across different countries worldwide (Azam & Abdullah, 2021). Additionally, Brunei Darussalam is also known for its stringent halal certification process, but there is still ambiguity on the audit scope and uncertainty regarding whether food safety have been incorporated in the current halal auditing practices (A.Hanni & Hashim, 2025). There is also lack of standardised internal audit checklist to enhance halal quality assurance and streamlining auditing processes among the food manufacturing companies. As a result, this can create inconsistencies in interpretation among internal auditors and potential gaps in fulfilling the principle of *halalan thayyibban*.

Furthermore, majority of the existing studies mainly focused on halal certification, policy, branding, and governance (Asa, 2019; Deuraseh, 2020; Ibrahim, 2020; Hosen & Lathifah, 2020; Rahim & Sulaiman, 2024; Kamil et al., 2025). There is limited research on the practical auditing practices in Malaysia, Singapore, Indonesia and Brunei Darussalam. Therefore, this preliminary study aims to identify commonalities and differences in auditing practices in Malaysia, Singapore, Indonesia and Brunei. Hence, assisting in proposing recommendations in developing of a standardised checklist for internal auditor in Brunei's food manufacturing companies.

Literature Review

Concept of Halalan Thayyiban

The concept of *halalan thayyiban* (HT) extends beyond the Muslim's belief and adherence to Islam. It has been applied as standards to all parties regardless the religion. The terminology of *halalan thayyiban* comes from the Arabic term Halal which means lawful or permissible, and also *Thayyib* which is defined as safe, clean, healthy, and unharmed for consumption (Awang, 2021). Allah has mentioned in the Quran in Surah Al-Ma'idah (5:88), Surah Al-Baqarah (2:168), and Surah Al-A'raf (7:157) highlighting that the product consumed should not only be halal but also *thayyib*.

Demirci et al. (2016), Raheem and Demirci (2018), Hamdan et al. (2024) and Matnor et al. (2024) further highlights that halal food must not only meet permissibility criteria, but also adhere to the principles of *Thayyib* which prioritises wholesomeness, quality, ethical considerations and free from hazards to health.

From the *Halalan Thayyiban* explanation above, it is assured that food safety in halal is also important which can be further strengthened in Surah al-Baqarah, ayat 195 as translated below: “*Spend in the cause of Allah and do not let your own hands throw you into destruction by withholding. And do good, for Allah certainly love the good-doers.*” (2:195)

This verse states that individuals should distance themselves from any form of destruction including harm from food. In food sector, this verse can be translated as preventing or avoiding hazards which are essential in food handling (Raheem & Demirci, 2018). Therefore, Mustaffa (2019) highlights that food that lacks guaranteed quality or clarity cannot be considered *Thayyib* despite its being nutritious.

Furthermore, Alzeer et al. (2018) emphasises halal food is not only free of alcohol and pork, but also requires extensive evaluation to verify all ingredients are both halal and non-toxic. Food quality encompasses more than only health benefits, including product purity and production process integrity (Arif & Sidek, 2015; Dahlal & Ahmad, 2018). *Halalan Thayyiban* principles relate to the entire food processes from farm to fork, including manufacturing, preparing, processing, storage, and serving (Arif & Sidek, 2015; Yahaya & Ruzulan, 2020).

Guidelines for Halal Audit

A halal audit is a regular, independent, and documented process to assess compliance with audit criteria involving evaluating businesses in ensuring it meet the requirements for halal certifications. It serves as a crucial step in verifying halal compliance which are conducted by qualified personnel (Hamdan & Jamaian, 2024). This section explains guidelines and standards used in halal auditing for Brunei Darussalam, Malaysia, Singapore and Indonesia.

Brunei Darussalam

Halal certification is administered by BKMh, covering halal-related matters in terms of preparation, food handling and site audit (Kifli, 2023). Company must comply to halal procedures and requirements indicated in the Halal Certificate and Halal Label Order 2005 (HCHLO), Brunei Darussalam Standard for Halal Food PBD 24:2007, and BCG Halal (Hosen & Lathifah, 2020). HCHLO is a regulation to control halal certification related matters for businesses dealing with products consumption food premises, products and services (Kifli, 2019; Ibrahim, 2022). PBD 24:2007 is a national standard providing comprehensive guidelines on production, preparation, handling, distribution and storage of halal food in accordance to what is allowed under the authority of Religious Council Negara Brunei Darussalam or *Majlis Ugama Islam Brunei (MUIB)* (Kifli, 2019). BCG Halal 1 Guideline for Halal Certification aim to clarify compliance requirements to obtain Halal Certificate or Halal Permit. BCG Halal 2 Guideline for Halal Compliance Audit provides third party verification that Halal elements have been implemented. BCG Halal 3 Guideline for Certification Halal Compliance Auditor aims to provide numbers of qualified auditors with relevant qualifications, skills and experience to perform Halal audits. Lastly, BCG Halal 4 Guidelines for Halal Surveillance Audit verify the Halal procedures and requirements are effectively maintained involving on-site observations and record review which carried out by one or two appointed auditors by MUIB (MUIB, 2007).

Malaysia

The enforcement of halal law including overseeing Islamic affairs, creating halal-awareness programs for those involved in food businesses, and supervising food factories are managed by The Malaysian Department of Islamic Development, *Jabatan Kemajuan Islam Malaysia* (JAKIM) (Akbar et al., 2023). Malaysia's Halal Standard are documented under MS 1500:2019, Halal food – General requirements that outline the general requirements in the manufacturing and handling of halal food (Department of Standards Malaysia, 2019). Besides that, Malaysia Halal Standard also adopt other regulation known as Malaysia Halal Management System Manual (MHMS) 2020, encompassing of Halal Assurance System (HAS) for large and medium industries. Its main objective is to elaborate in detail the requirement in developing, implementing, and maintaining halal assurance to comply with Malaysian Halal Certification procedures. The development of HAS focuses on minimizing and eliminating non-conformance of halal requirements (Shafii & Zain, 2015).

Singapore

Majlis Ugama Islam Singapore (MUIS) is in charge of overseeing halal certification in Singapore in order to facilitate trade and business opportunities, ensuring constant adherence to halal certification conditions (HCC), and offering religious and technical guidance for halal certification. There are two standards used for halal that includes MUIS-HC-S001 General Guidelines for the Handling and Processing of Halal Food, assisting in preparing and providing halal food. Secondly, MUIS-HC-S002 General Guidelines for the Development, Implementation and Management of a Halal System for adherence and development of halal quality management system (Akbar et al., 2023). HCC consists of different types of halal certification schemes including Product (PRO) Scheme, issued for partly manufactured/processed or manufactured products in Singapore. Meanwhile, Whole Plant (WP) Scheme is for manufacturing facilities and all products manufactured with it (MUIS, 2025).

Indonesia

Halal-related matters for food is overseen by *Majelis Ulama Indonesia* (MUI), serving as a national and international halal certification body to ensure it complies with the halal standards (Akbar et al., 2023). HAS 23000-1 Halal Certification Requirements for Processing Industry is the standard used in halal that includes criteria for the Halal Assurance System (HAS), policies and procedures for certification (LPPOM MUI, 2021; Akbar et al., 2023).

Guidelines for Food Safety Audit

Food safety audit is conducted to assess the safety and quality of food including manufacturing procedures, sanitation and hygiene. It also serves to verify if the food manufacturer complies to specific guidelines, requirements or rules of food safety (Powell et., 2013). Food Safety Management System (FSMS) is a globally recognised system designed to control and where possible, eliminate any potential food safety hazards that can be biological (e.g. microorganisms like bacteria, viruses or parasites), physical (e.g. presence of foreign elements in food like metal) or chemical (e.g. residues of cleaning and sanitising agents) in food product and production processes to ensure adherence with food safety regulation, retailer requirements

and/or private third-party certification standards (Manning & Grant, 2025). Two types of assessments in determining a safe food, encompassing of the presence or absence of food safety hazards which can be assessed using Hazard Analysis Critical Control Point (HACCP). Secondly, evaluating the likelihood and severity of an adverse effect which are determined using a risk assessment method (Manning & Grant, 2025). This section describes the guidelines and standards used in food safety auditing in Brunei Darussalam, Malaysia, Singapore and Indonesia.

Brunei Darussalam

Brunei Darussalam Food Authority (BDFA) is responsible in ensuring food safety and quality for all food related businesses through monitoring and inspect, test and certifying food manufacturing (BDFA, 2022). BDFA mission and vision in ensuring safe, clean and high-quality of food are outlined in Brunei Darussalam Food Order, 2020. Whereas, Public Health (Food) Act (Chapter 182) is the standard used on labelling, hygiene practices and food safety. Its main objective is to protect public from any element that may cause harm to human health, and fraud during the preparation, sales and consumption of food (Ibrahim, 2022).

Malaysia

Bahagian Keselamatan dan Kualiti Makanan (BKKM), Ministry of Health are the leader of national food safety and quality control, aiming to protect public from health hazards and fraud whilst the preparation, sale and consumption of food (BKKM, 2023). The Act and Regulations involved in achieving the purpose of BKKM are Food Act 1983, Food Regulations 1985, and Food Hygiene Regulations 2009. Meanwhile, Guideline on the Appointment and Competency Assessment of Personnel for the Food Safety Assurance Programme Certification Scheme and Other Certifications provides comprehensive guidance on the prerequisites for recruiting and assessing employees under the Food Safety Assurance Program (FSAP) and other certifications run by Food Safety Quality Programme (FSQP). FSAP is mandatory for food industry as stated in Food Hygiene Regulations 2009. This guideline comprises of different certification schemes including *Skim Pensijilan Makanan Selamat Tanggungjawab Industri* (MeSTI), Good Manufacturing Practices (GMP), and Hazard Analysis Critical Control Point (HACCP) (Ministry of Health Malaysia, 2025). Moreover, Guideline for Malaysian Certification Scheme for HACCP and GMP explains the requirements for HACCP and GMP, followed by certifications.

Indonesia

National Agency for Drug and Food Control (NAFDAC) ensure food safety in Indonesia with a special division, Deputy for Food Safety and Hazardous Substance Control to control food safety issues (Putri, 2018). Act 18/2012 on Food regulates the requirements to produce food that is safe, nutritious, qualified and affordable. Whereas, Government Regulation 86/2019 on Food Safety elaborates the implementation of food safety that is conducted by food sanitation, control of food additives, control of Genetically Engineered Food Products, control of Food Irradiations, establishment of Food Packaging standard, issuance of Food Quality and Food Safety assurance and halal product assurance (NADFC, 2019). Government Regulation 28/2004 on Food Safety, Quality and Nutrition ensures a system of effective development and supervision for the security, quality and nutrition of food is implemented (Food and Agriculture

Organisation of the United Nations, 2004). Lastly, Minister of Health Regulation 33/2012 on Food Additives is a regulation concerning the usage of food additives (Ministry of Health Indonesia, 2012).

Singapore

Singapore Food Agency (SFA) ensure and secure supply of safe food (SFA, 2025). Food Safety and Security Act 2025 is a regulation relating to food safety inclusive of production of primary produce, supply of food, and the provision of drinking water. Whereas, Conditions of Licensing for Food Establishment aims to assist in setting up food establishment with appropriate structures and features including HACCP to be incorporated during the design of premises in ensuring food safety (SFA, 2024). In addition, food manufacturing companies are also advised to align with Good Warehousing Practices. It encompasses of procedures and principles to ensure food and raw materials are stored under hygienic, safe and controlled conditions (SFA, 2011).

Methodology

This study focuses primarily on qualitative research design to conduct a comparative analysis of halal and food safety auditing practices across Malaysia, Singapore, Indonesia and Brunei Darussalam. It incorporates secondary sources comprising of government regulations, official guidelines and websites from national halal and food safety certification authorities covering auditing practices as illustrated in Table 1.

Table 1: Standards and guidelines governing halal and food safety audit in Brunei Darussalam, Malaysia, Singapore and Indonesia.

Country	Standards and guidelines
Brunei Darussalam	-BCG Halal 1 Guideline for Halal Certification -BCG Halal 2 Guideline for Halal Compliance Audit -BCG Halal 3 Brunei Guidelines for Halal Auditors -BCG Halal 4 Brunei Guidelines for Halal Monitoring Audit -Public Health Act, Chapter 182.
Malaysia	-Malaysia Halal Management System 2020 (MHMS 2020) - Food Act 1983 -Guideline on the Appointment and Competency Assessment of Personnel for the Food Safety Assurance Programme Certification Scheme and Other Certifications -Guideline for Malaysian Certification Scheme for HACCP and GMP -Food Safety is Responsibility of the Industry (MeSTI)
Singapore	-General Guidelines for the Handling and Processing of Halal Food (MUIS-HC-S001) -General Guidelines for the Development, Implementation and Management of a Halal System (MUIS-HC-S002) -MUIS Halal Certification Conditions (MUIS HCC) for Product / Whole Plant Scheme -MUIS Halal Competency Assessment Modules (Halal Certifications Conditions)

Indonesia

- Food Safety and Security Act 2025 (No.7 of 2025)
- Halal Certification Requirements for Processing Industry (HAS 23000-1)
- Act 18/2012 on Food
- Government Regulation 86/2019 on Food Safety

The other main source is academic literature from online source such as Google Scholar. The data collected were then analysed by categorising manually themes related to food safety and halal auditing practices for comparison to identify commonalities and differences among the four countries.

Results and Discussion

Comparative analysis was conducted on both halal and food safety auditing practices in Malaysia, Singapore, Indonesia and Brunei Darussalam focusing on audit process, criteria, scope, food safety aspects (where relevant to halal audit), checklist, auditor requirements, evaluation measurement and frequency. Table 2 shows the comparison of the halal auditing practices between these four countries.

Table 2: Comparative analysis of halal auditing practices in Brunei Darussalam, Malaysia, Singapore and Indonesia.

Criteria	Brunei	Malaysia	Indonesia	Singapore
Audit process	√	√	√	√
Audit Criteria	√	√	√	√
Food safety aspects	√ (partial)	√ (partial)	√ (partial)	√ (fully)
Audit scope	Process flow, site inspection, sampling, documents, raw materials, processing, equipment, segregation, hygiene, packaging, labelling, records review, CCPs, training, management review	Documentation, company profile, halal assurance system, raw materials & additives, tools/equipment, packaging & labelling, storage, processing, transport, workers, sanitation & cleanliness, waste, premises, HCPs, halal risk management, traceability, halal committee, halal training, lab analysis, sertu, certification mark	Halal inspection board, documentation, halal label, forbidden information, segregation waste, halal supervisor, production site checks, HAS manual, management team, training, materials, production facility, product verification, critical procedures, traceability, non-conformance product handling, internal auditor, management review, evidence verification, facility & storage observation, material and product sampling	ingredients, menu and marketing, transportation, receiving, storage and handling of ingredients and processing aid; Production, packing, labelling, storage of finished products; Washing and handling of equipment(s).
Audit Checklist	List down contents of checklist in general encompassing halal	Checklist in the form of tables comprises of Malaysia Halal	No official checklist but audit verifies the compliance with HAS 23000-1.	No official checklist but need to refer HCC for list of

Auditor requirements	procedures and pre-requisite programs. Must have a science/technical background with a few years' experience, complete several supervised audits, and be officially approved. Listed down the attributes, code of ethics, and terms to be auditor.	Certification procedures and Halal Control Point. Must hold a recognized Halal Auditing or Halal Executive Certificate from an approved training provider and be formally appointed by the Internal Halal Committee (IHC). Third-party auditors, if used, must also hold a certified qualification from a registered training centre under JAKIM.	Competence in planning, implementing, evaluating, and improving HAS following HAS23000-1 halal certification requirements and their responsibilities in internal auditor	requirements for audit.	Not stated
Evaluation measurement	Not stated	Percentages comprises of very good, good, satisfactory, and unsatisfactory.	Using HAS grading simulation for Halal Assurance System implementation by identifying type of weakness.	Not stated	
Frequency	At least 6 months. It will vary according to needs.	At least once a year. It can be done more than once a year for companies operating in high risk level sectors.	Once a year.	Repeat conducted necessary.	audit when

Sources: MUIB, 2007; Hosen & Lathifah, 2020; Working Committee for MHMS, 2020; LPPOM-MUI, 2021; Aziz & Hussin, 2024; MUIS, 2025.

Audit Process

Brunei applies adequacy, compliance, follow-up, on-site, and surveillance audits, highlighting its focus on verifying both documentation and implementation (MUIB, 2007). Whereas, Malaysia emphasizing on-site, surveillance audit, supplier audit, if necessary, alongside internal audit which is implemented by the company internally (Working Committee for MHMS, 2020). This is similar to Indonesia by adopting pre-audits, on desk audits, surveillance audits, and also internal audit reflecting comprehensive verification (LPPOM-MUI, 2021). It has been found that 66.3% of internal audit positively affects good governance and performance of the organization (Gollopeni et al., 2022). Internal audit further adds value in improving the control within organization to detect fraud (Coram et al., 2006). Therefore, indicating the importance of internal audit. Meanwhile, Singapore demonstrates broad coverage involving forensic audits if needed together with desktop, site inspections, surprise audit and repeat audit highlighting investigative orientation (MUIS, 2025).

Audit Criteria and Food Safety Aspects

Brunei's audit criteria are set out in multiple standards and guidelines indicating strong regulations. It also emphasizes hygiene, sanitation and food safety by ensuring compliance with Good Manufacturing Practices (GMP), and employees attended both trainings in HACCP and GMP (MUIB, 2007). Malaysia's employ compliance towards its halal standards alongside GMP, Good Hygienic Practices (GHP), and Veterinary Hygiene Practices (VHP) (Working Committee for MHMS, 2020). This is also similar to Indonesia halal auditing criteria, focusing on halal standards, clean facilities and adherence to GMP and GHP (LPPOM-MUI, 2021).



Whereas, Singapore's halal audit criteria encompassing integration of halal and food safety which has been highlighted under Basic Principles about Hygiene and Sanitation that "All foods shall be prepared, processed, packaged, transported and stored in such a manner that they are in compliance to hygiene and sanitary requirements of the relevant authorities," emphasizing operational compliance that food handling processes meet safety and sanitation standards (MUIS, 2025). Furthermore, the business also needs to be recognised by relevant authority in meeting both food safety and workplace safety regulations (MUIS, 2025).

Audit Scope

Brunei's scope emphasizes process flow, site inspections, segregation, hygiene, packaging, labeling, and training (MUIB, 2007). Malaysia expands this to sanitation, risk management, traceability, and laboratory analysis (Hosen & Lathifah, 2020; Working Committee for MHMS, 2020; Aziz & Hussin, 2024). Indonesia's scope is the most detailed, encompassing product verification, traceability, certification, and sampling, alongside internal auditor evaluation (Hosen & Lathifah, 2020; LPPOM-MUI, 2021). Singapore focuses more heavily on operational aspects such as handling, transport, production, packing, storage, and washing of equipment (MUIS, 2025).

Audit Checklist

Brunei provides general contents of the auditing checklist in BCG Halal 2 Halal Compliance Audit inclusive of halal procedures and prerequisite programs aimed at not only maintaining the halal integrity but also food safety and quality during production (MUIB, 2007). However, it was found that there is still ambiguity about how food safety is also integrated in halal assurance processes as stated in the literature review before (A.Hanni & Hashim, 2025). A.Hanni and Hashim (2025) emphasized that the existing audit focuses on religious compliance while holding a passive role of food safety in halal certification, indicating minimal emphasis on food safety. Raheem and Demirci (2018) also supported this statement in which currently practical integration of food safety elements in halal certification remains vague leading to passive approach towards *Thayyib* assurance. Malaysia provides structured checklists covering certification procedures and control points (Working Committee for MHMS, 2020). Indonesia does not employ a formal checklist but evaluates compliance directly against HAS 23000-1 (LPPOM-MUI, 2021). Singapore also lacks a specific checklist but requires reference to MUIS standards (MUIS, 2025).

Auditor requirements

In Brunei, auditors must have a technical or scientific background, experience, and formal approval, with attributes and ethical codes outlined (MUIB, 2007). Malaysia requires recognized halal auditing or executive certification from an approved provider, with appointment by the Internal Halal Committee (Aziz & Hussin, 2024; Working Committee for MHMS, 2020). Indonesia emphasizes competence in implementing HAS requirements, focusing on technical capability and responsibility (LPPOM-MUI, 2021). Singapore does not publicly state requirements, possibly reflecting reliance on MUIS control rather than on individual qualifications or due to confidentiality concerns.

Evaluation Measurements

The evaluation measurements vary in each country. Brunei and Singapore do not explicitly state on how evaluation is measured in their standards and guidelines, possibly due to confidentiality concerns. Meanwhile, Malaysia uses grading by percentages (very good, good, satisfactory, unsatisfactory), offering an organized scoring system (Working Committee for MHMS, 2020). Indonesia applies a HAS grading simulation, identifying weaknesses in halal assurance implementation, thus supporting continuous improvement (LPPOM-MUI, 2021).

Frequency

Audit frequency varies considerably. Brunei mandates surveillance audits in at least six months depending on necessity. More frequent audit will be conducted based on the recommendation of compliance report and cases (MUIB, 2007; Hosen & Lathifah, 2020). Malaysia requires at least annual audits, with additional audits for high-risk sectors. Furthermore, its halal audit effectiveness and frequency must be assessed by Internal Halal Committee in ensuring non-compliance towards the halal certification is not repeated (Hosen & Lathifah, 2020; Working Committee for MHMS, 2020; Aziz & Hussin, 2024). Indonesia applies an annual cycle (LPPOM-MUI, 2021), while Singapore conducts repeat audits only when necessary and the halal system shall be reviewed at least once every year. However, immediate review is required for Singapore if controls are ineffective, change in halal team, changes are made to the monitoring schedules, and change in operations (MUIS, 2025). This shows that countries like Brunei, Singapore and Malaysia demonstrate a proactive approach to handle potential non-compliance, whereas Indonesia rely more on routine schedules.

Comparative Insights

Across all systems, similarities include reliance on adequacy, on-site and surveillance audits, and alignment with national halal standards. Key differences lie in the comprehensiveness of auditing practices in terms of scope, checklist, auditor requirement, evaluation, and frequency of audit. These differences indicate Brunei's system is compliance-driven, Malaysia and Indonesia integrate more technical and risk-oriented features, and Singapore stresses on operational and customer assurance. Moreover, there is variation in the degree of food safety integration within halal auditing comprises of partial and fully integration. As highlighted in the literature review, food safety audit is adhering to food safety standards and guidelines including assessing food safety hazards (biological, chemical and physical), and evaluating the severity and likelihood of an adverse effect (Manning & Grant, 2025). This principle has been implemented in Singapore where their halal auditing practices fully integrate food safety as stated under Basic Principles about Hygiene and Sanitation for halal and Halal Certification Condition for Product / Whole Plant Scheme such that food safety is not entirely about certificate compliance or general principle of cleanliness but also ensuring the procedures from farm to fork adhere to the food safety standards and regulations of relevant authorities (MUIS, 2025). In contrast, Brunei Darussalam, Malaysia and Indonesia focuses primarily on compliance with GMP, and GHP among factory and employees, indicating partial integration of food safety. As shown in Table 3, food safety auditing practices from these countries are not incorporated in their halal audit, and is treated as two separate entities. Raheem and Demirci (2018) further argues that halal certificate itself does not reflect *Thayyib* part if food safety

holds a passive role during halal audit because incorporating food safety assessment into halal certification process would have an active approach towards *Thayyib* assurance.

Table 3: Comparative analysis of food safety auditing practices in Brunei Darussalam, Malaysia, Singapore and Indonesia.

Criteria	Brunei	Malaysia	Indonesia	Singapore
Audit process	Enter premises, production site, storage and also transport vehicles to examine food, packaging and documents; verify relevant documents, records, identity, and business license; ensure proper weighing, and measurement of food items; take samples for food analysis; stop and detain vehicle transport with food suspected non-compliance, conduct inspection, surveillance and lab test.	Regulatory audit: similar to Brunei and Indonesia with additional information in allowing transport vehicles not to be detained for those making an international voyage in which International Health Regulations apply MeSTI: field and follow-up audit HACCP and GMP: compliance, adequacy, renewal, surveillance and follow-up audits	Enter premises, production site, storage and also transport vehicles to examine food, packaging and documents; verify relevant documents, records, identity, and business license; ensure proper weighing, and measurement of food items; take samples for food analysis; stop and detain vehicle transport with food suspected non-compliance	Inspection on compliance, internal audit, surveillance audit including lab analysis
Audit Criteria	Comply with food safety standards relating to importation, production, processing, storage, distribution, and exportation of food.	Regulatory: Comply with food safety standards and guidelines MeSTI: Comply with Food Hygiene Regulations 2009 requirements HACCP and GMP: comply with requirements of Malaysian Standards for GMP and HACCP	Comply with Food Safety Standards and Food Quality Standards.	Comply with Food Safety and Security Act 2025, License to Operate a Food Processing Establishments, workplace safety and health (WSH) standards, Food Safety Management System
Audit scope	Cleanliness, food quality and safety, food storage, equipment and utensils, food handlers, facilities available at the food premise, waste disposal, waste management, loading area, pest control.	Regulatory: Food premises including production, storage, distribution and retail MeSTI: implementation of MeSTI elements HACCP and GMP: implementation of HACCP/GMP system	Food Sanitation, Food Contaminant, Food Additives, prohibited materials as Food Additives and Food Packaging.	Safe handling and storage of food, prevent cross-contamination between raw material and final product, store food at required temperature, good personal hygiene for food handlers, equipment cleaned and sanitised, arranged from raw to cooked food
Audit Checklist	Not stated	Not stated for regulatory, GMP, HACCP. MeSTI: Checklist comprises of control of premises, food handler, training, maintenance and sanitation, raw material	Not stated	Not stated

Auditor requirements	Not stated	control, process, storage and traceability. HACCP and GMP: Competency in HACCP and/or GMP system and audit. Maintain confidentiality and abided Code of Ethics. MeSTI: attended training by the Food Safety and Quality Programme (FSQP); recognised as MeSTI Compliance Auditor and eligible to act as Lead Auditor or Auditor for Compliance; auditor code of ethics	Food Inspectors must be competent in the Food Safety sector which includes the Food Sanitation, Food Contaminant, Food Additives, prohibited materials as Food Additives and Food Packaging.	WSQ Food Safety Course (FSC) Level 3, attended WSQ FSC refresher training
Evaluation measurements	Percentages comprises of satisfactory, unsatisfactory where the manager or supervisor will be invited for counselling session and carry out rectification measures, and unsatisfactory where the premise will be ordered immediate closure.	Not stated	Not stated	Not stated
Frequency	Carried out routinely and is an essential component of any foodborne diseases outbreak investigations and public complaints	GMP and HACCP: at least once (1) audit within the validity period MeSTI: monitoring audit conducted once a year	Conducted regularly, intensively within a certain time, and in the case of the alleged violation	Frequency of the inspection depends on 1) past inspection and enforcement records 2) public feedbacks received 3) foodborne, outbreak. Additional inspection made for poor performers.

Source: Laws of Brunei, 2012; Laws of Malaysia, 2012; Putri, 2018; NAFDAC, 2019; BDFA,2022; BKMM, 2023; SFA, 2025

Audit Process

All four countries conduct compliance audit. However, Malaysia applies additional multiple audit types such as field, follow-up, adequacy, renewal, and surveillance under *MeSTI*, HACCP and GMP certification schemes (BKMM, 2023). Meanwhile, Singapore adopts a broader approach by including internal audit as well in their auditing practices, indicating comprehensive verification (SFA, 2025).

Audit Criteria

Brunei's audit criteria emphasize compliance with general food safety standards related to importation, production, and distribution (BDFA,2022). Meanwhile, Malaysia ensures more technical depth by clearly specifying requirements under the Food Act 1983, Food Hygiene Regulations 2009, GMP, and HACCP (BKMM, 2023). Moreover, Indonesia ensures the audit align with food safety and quality standards (Putri, 2018). Additionally, Singapore includes Food Safety and Security Act 2025 together with workplace safety and health (WSH) standards

and food safety management systems (SFA,2025). Therefore, reflecting that Singapore and Malaysia adopt a more structured and holistic framework.

Audit Scope

Brunei focuses on cleanliness, food quality, waste disposal, and pest control (BDFA, 2022). Malaysia's scope includes audits covering production and retail, while extending it to other schemes encompassing *MeSTI*, HACCP and GMP (BKMM, 2023). Indonesia's scope encompasses sanitation, additives, and packaging control, while Singapore emphasizes preventive control such as cross-contamination, temperature control, and hygiene management (Putri, 2018; SFA, 2025).

Audit Checklist

Only Malaysia specifies a detailed checklist, specifically under *MeSTI*, covering premises, handlers, maintenance, sanitation, and traceability (BKMM, 2023). As for HACCP and GMP in Malaysia, there are no official checklists provided but there is minimal manual stated in their schemes which could assist in the auditing (BKMM, 2023). On the other hand, the other three countries do not publicly outline their checklist format possibly due to confidentiality. This lack of standardized or transparent checklists in Brunei, Indonesia, and Singapore may lead to inconsistencies in audit implementation and interpretation especially towards internal auditor in food manufacturing companies.

Auditor Requirements

Malaysia requires auditors to be trained and certified under the Food Safety and Quality Programme (FSQP) and adhere to a code of ethics (BKMM, 2023). Indonesia entails food inspectors to demonstrate competence in food safety sector including contaminants, packaging, prohibited materials and additives. Singapore requires auditors to complete WSQ Food Safety Course Level 3 and refresher training (SFA,2025). In contrast, Brunei has no publicly stated auditor qualification criteria which could be confidential and possibly managed by relevant authorities only.

Evaluation Measurements

Brunei employs a grading system using percentages to evaluate audit results, with follow-up actions such as counselling or closure for non-compliance (BDFA, 2022). Malaysia, Indonesia, and Singapore do not specify any evaluation measurements used which could be due to confidentiality as well. However, Singapore provides Safety Assurance for Food Establishments (SAFE) Grade Projection Self-Help Tool graded from their food safety track record and implementation of food safety management system. A tool designed to assist in knowing potential grade for food establishment license under SAFE (SFA, 2025).

Audit Frequency

All countries conduct audits regularly. Brunei's inspections are routine and essential during foodborne diseases outbreaks (BDFA, 2022). Malaysia performs scheduled audits under GMP, HACCP, or *MeSTI*, typically once a year or within the validity period (BKMM, 2023). Similar

to Indonesia where audit is scheduled including where there is non-compliance (*Direktorat Standardisasi Pangan Olahan*, 2025). Singapore depends on establishment performance, complaints, and outbreak history, indicating a more adaptive approach (SFA, 2025).

Comparative Insights

Overall, it shows that Brunei Darussalam, Malaysia, Singapore and Indonesia shares similar regulatory purposes in assuring food safety. However, the level of integration and technical development varies in different countries. Brunei and Indonesia approach mainly compliance oriented, focusing on regulatory enforcement. Malaysia displays more structured and risk-based system through *MeSTI*, HACCP, GMP and their food standards acts while providing comprehensive checklist and general manual that can act as a reference for audit. Singapore is more towards operational, emphasizing food safety management system, operational control, and auditor competency.

Recommendation

Based on the comparative analysis of both halal and food safety auditing practices, Brunei can further strengthen its halal audit system by adopting systematic, risk-based and competency-driven approaches similar to practices observed in Malaysia, and Indonesia for halal auditing practices. This can be achieved by establishing a halal assurance framework such as HAS 23000-1 (Indonesia), and MHMS 2020 (Malaysia) in ensuring consistency, transparency and credibility across all audit activities regardless who is the auditor which will act as the official guidelines referred for halal audit. The same separate framework can also be adapted focusing on food safety audit in Brunei where relevant. Another key recommendation is by developing a comprehensive standardised auditing checklist integrating both halal and food safety elements. Brunei should also integrate risk assessment methods like HACCP and GMP to focus on areas with higher risk for non-compliance and strengthen preventive control measures. Similar to Malaysia where they offered different certification schemes for food safety audit including *MeSTI*, HACCP and GMP, these approaches can be incorporated in halal auditing practices to enhance halal quality assurance of the food manufacturing. This is the same approach reflected in Singapore through integration of FSMS in halal audit. Furthermore, continuous training and certification of auditors such as refresher auditor course are also essential to ensure they have the skills and knowledge to perform effective and consistent audit. These improvements would more greatly contribute to stronger halal governance, improved audit consistency, and enhancing halal quality assurance in Brunei.

Conclusion

This study highlights that Brunei, Malaysia, Singapore and Indonesia share similar goals in ensuring halal integrity and food safety, but their auditing approaches are different in structure and depth. To enhance its halal quality assurance, Brunei should develop a standardised, risk-based internal audit checklist that integrates both halal and food safety elements. Strengthening auditor competency and adopting a more structured approach will help improve consistency, credibility, and overall effectiveness of Brunei's audit system.

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AN INVESTIGATION INTO DEBATES OF DOUBLE-MAJOR STUDENTS

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Abstract: *Debate is a notable activity applied in different fields, especially in teaching and learning English as a second language. Henceforth, this research scrutinized into the debate activity of 59 double-degree students in a university. After a process of data analysis and synthesis with the assistance of qualitative and quantitative methods, it has been unveiled that there were not only plus points but also drawbacks when implementing debate on these kinds of participants. Students claimed that their language skills, idea brainstorming skill, argumentation skill, or critical thinking skills were significantly improved. On the other hand, external factors such as the lack of technological devices or heavy workload along with internal factors, led to numerous challenges for the students involved.*

Keywords: *Debate, teaching and learning English, university*

Introduction

It is common knowledge that there has existed an accelerating demand for English in general and effective communication in particular. A myriad of novel teaching approaches have changed English language teaching due to that trend. Being one of those most newly notable methodologies, Communicative Language Teaching (CLT) had been widely accepted by language teachers on a global scale since its emergence in the 1970s (Karakaş, 2013).

At the end of September 2008, Ministry of Education and Training (MOET) officially enforced “National Foreign Languages 2020 Project” pointing out national educational missions related to English language teaching. This project showed considerable concern for the utilization of CLT in educational public institutions in Vietnam. In other words, students’ oral skills have been of paramount importance.

Under this project’s requirements, a university modified English curriculum for mainstream sophomores. The new one integrated four previously separated skills namely Reading, Listening, Writing and Speaking into solely two subjects called English for Social Purposes and English for Academic Purposes.

With the purpose of enhancing learners’ presentation, debate and critical thinking skills which are crucial to good communicative competence in reality, the institution made debate one of two main projects in the subject of English for Academic Purposes. This project has been applied for double-major sophomores as well.

Debates have been applied in a wide variety of fields; for instance, politics as well as language teaching and learning. According to Snider and Schnurer (2006, p.207), debates had proved to

be prominently productive exercises for language acquisition. At this school, there were only two research papers on the topic of debate. The first one belonged to English for Academic Purposes, but it was only restricted to the improvement of critical thinking skills via debate, and the second was relevant to Fast-track program project, about fallacies. Between these two, nothing was a general investigation into debate. To the best knowledge of the researcher, no one used to thoroughly examine debate after its three years of implementation, especially on double-major learners. Consequently, so as to fulfill that gap, the researcher decided to conduct a research entitled **“An investigation into debates of double-major students”**.

Literature Review

Debate Activity

Definition of Debates

In the current formal education system, debate activities become more and more prevalent among different teaching methods. The utilization of debates is an outstanding phenomenon in education, specifically in foreign language teaching. Najafi, Motaghi, Nasrabadi and Heshi (2016) defined “the debate, which means scratching and digging, is a kind of dialogue to find answer or solution”. In other words, individuals share their viewpoints and listen to each other on the same topic.

Agreeing with this idea, professor Kennedy (as cited in Vargo, 2012) stated that “Debate refers to the process of considering multiple viewpoints and arriving at a judgment, and its application ranges from an individual using debate to make a decision in his or her own mind to an individual or group using debate to convince others to agree with them.” Meanwhile, McGough (as cited in Colbert, 1993) had an interesting view about debates when visiting a high school workshop and compared debates as “dungeons and dragons, the thrill of combat, and an imaginary universe” making it like “war games”. According to Želježič (2017), formal debates were commonly recognized in public meetings where people freely supported a random side; on the contrary, at universities, participants were basically assigned a particular side for which to advocate.

Regarding the number of sides, Snider and Schnurer (2006, p.6) argued that there were two or more sides in a debate. Nevertheless, Želježič (2017) ensured that debate was a formal information exchange where only two opposing sides participated in. This also matches the opinion of the researcher as she considered a debate involving various teams but only two sides entitled proponent as well as opponent ones. The former supports the topic resolution and the latter protects the contrasting ideas.

As cited in Parcher (1998), Matlon and Keele concluded that “there is an affirmative relationship between participation in competitive debate and the goals of higher education”. Supporting this idea, Colbert and Biggers (1986, p.14) agreed “training in debate has long been considered a vital part of the educational process”. Finally, Kruger (as cited in Parcher, 1998) assured that debate was the most “valuable” activity in a liberal arts curriculum.

Benefits of Debates in Teaching and Learning English as A Second Language

A plethora of researchers endorse the implementation of debates in the classroom because debates exert a great positive academic impact on the learners partaking in its procedure.

Soraya (as cited in Najafi et al., 2016) believed that debates had a considerable effect on the mental aspect of the human mind. According to Vo & Morris (2006, p.88), debates increased the plus points of the traditional lecture by engaging the learner in the material. Nasirodin Toosi (as cited in Najafi et al., 2016) complimented that participating in the process of "debate" was better than a one-month repetition of a lesson. A working group of the Quail Roost Conference on Assessment of Professional Activities of Directors of Debate (as cited in Parcher, 1998) also claimed "the benefits derived from debate thus seem particularly appropriate for, and consistent with, the emerging concerns and trends in higher education." Below are potential advantages that debate activity brings about.

In the first place, almost all of the reviewed research revolves around critical thinking abilities which are considered the most notable skills improved from debate activity. Debate could be seen as one of the best methods of learning and applying the principles of critical thinking (Freely, as cited in Parcher, 1998). Vargo (2012) regarded that debate offered an opportunity for students to move beyond the acquisition of basic knowledge and go into higher critical thinking skills. Colbert and Biggers, (1986, p.16), Parcher (1998), Walker and Warhust (as cited in Scott, n.d.), Dickson (2004, p.50) and Akerman and Neale (as cited in Želježič, 2017) shared a view in common about increasing critical thinking through the use of persuasive evidence with the assistance of debate activity. Critical thinking skills "include the ability to define a problem, select pertinent information for the solution of a problem, recognize stated and unstated assumptions, formulate and select relevant and promising hypotheses, and draw valid conclusions and judge the validity of inferences" (Watson & Glaser, as cited in Želježič, 2017). On the other hand, Facione (1990) came up with six clearer categories of critical thinking skills with Interpretation, Analysis, Evaluation, Inference, Explanation and Self-regulation (Self-reflection). The research follows this framework due to its unambiguous classification.

According to Dickson (2004, p.52), Akerman and Neale (as cited in Želježič, 2017), team-working skill would be also developed thanks to debates. The collaboration among team members allowed individuals to memorize information longer which was helpful for studying purpose (Gokhale, as cited in Vargo, 2012).

Besides, Parcher (1998) along with Akerman and Neale (as cited in Želježič, 2017) witnessed remarkable gains in research skills. The reason was that conducting extensive research was always simulated during the whole debate process (Colbert & Biggers, 1986, p.24).

James McBath (as cited in Parcher, 1998) stated that "debate is an educational activity which provides students with the opportunity to develop a high level of proficiency in language skills". Colbert and Biggers (1986, p.35), Parcher (1998), Vargo (2012), Akerman and Neale (as cited in Želježič, 2017) and Scott (n.d.) believed that debate would hone oral communication skills of debate participants via exchanging viewpoints on the topic. Vargo (2012) also added that students' listening skills to make rebuttals simultaneously was likely to be boosted. In addition to this, Osborne (as cited in Snider, n.d.) stated that debates helped students sharpen the reading skills.

Furthermore, Lewis and Wakefield (as cited in Parcher, 1998) emphasized a totally different aspect namely individual learning or learning autonomy enhancement in the debate process. Debate requires the learners to self-study, discover the subject matter via different materials,

prepare their arguments or rehearse their performance by themselves. Therefore, they completely gain the opportunity to improve this learning aspect via scrutinizing the issue for a long time thanks to debates.

Furthermore, personality could be affected positively to some extent on the grounds that Iberri-Shea (n.d.) and the studies of students in Chicago, Kansas City, St. Louis, Seattle and New York (as cited in Snider, n.d.) also supported the idea of diminishing high-risk behaviors (verbal aggression for instance), in other words, improving learning tolerance thanks to debate activity. Not only do they protect personal opinions, but students also have a golden opportunity to consider issues from various contrasting perspectives; therefore, subjectivity is avoided and they are likely to be more tolerant of other viewpoints. From then on, empathy could be developed (Vargo, 2012).

Finally, some other aspects promoted via debate in teaching and learning English as a second language were mentioned as well. First and foremost, Akerman and Neale (as cited in Želježič, 2017), Colbert (1993) and Parcher (1998) shared a similar perspective on the fact that debates enabled to enhance the learners' argumentation skills. These can be regarded as the ability to utilize logical arguments used support oneself's ideas. What is more, debate helped learners enhance their academic repertoire via internalizing a huge number of vocabularies in topic-related materials (Iberri-Shea, n.d.). In addition, Vargo (2012) proved that debate encouraged class participation, especially among those students who did not engage in class activities. Finally, as cited in Parcher (1998), the close relationship between a debate coach and debaters was another reason ensuring the educational value of debates. "Few student-teacher relationships are as close as that in debates, and probably few are as personally and intellectually rewarding" (Faules & Rieke, as cited in Parcher, 1998). Subsequently, Scott (n.d.) supported and explained "The combination of superior students, close student-teacher relationships, and high motivation all combine to require the student to develop habits of sustained mental discipline and a commitment to excellence."

Drawbacks of Debate in Teaching and Learning English as A Second Language

Along with a plethora of merits; nonetheless, with the nature of a complex public speaking form encompassing many skills and other elements, the real effects of implementing debate in teaching and learning English as a second language are open to question. Firstly, the formal debate can put language learners under intolerable pressures. It incorporated too many skills (Mark, Canale, & Baker, 1997, p.99) and Professor Tumposky (as cited in Vargo, 2012) also agreed on the fact that winning was the concentration of the debates was another pressure for the students. That students have to try to protect their arguments rather than heading to the best solution together makes the activity become unnecessarily competitive and too stressful. Besides, since formal debates are considered as one of the most complicated public speaking activities for advanced-level learners, students with weak linguistic competencies and subject knowledge maybe easily demotivated (Jing, as cited in Hua, 2017). They would be shy and might not dare to show their opinions. Furthermore, understanding of the debate's format was of paramount challenge. Jing (as cited in Hua, 2017) claimed that students needed to assimilate the roles of proposition and opposition. However, many students do not know debate jargons, their specific roles to take part in debate successfully. As mentioned previously, debate can be considered as a very complex public speaking form; therefore, it was difficult for students with the lack of confidence to engage in debate. Finally, professor Tumposky (as cited in Vargo,

2012) also emphasized that debates “oversimplify and misrepresent the nature of knowledge” since debates tended towards “dualism”. Rather than making students to consider multiple perspectives, debate might convince students to view a matter from two positions (yes or no).

Debate Models

Each format has its own value in the classroom. Depending on the level of students, course content, et cetera, debate activity in English speaking class can be held in a variety of formats with the discrepancy in rules and guidelines. These rules and guidelines inform the learners the number of teams, members per team and time allocation for the whole procedure, et cetera. On the other hand, the rigid similarity that lies in all debate models is the number of sides. It can be conducted with the participation of the flexible number of teams and team size, but only along with two sides. Some types of debate formats which can be applied for schools are illustrated below.

Public Forum Debate

According to National Forensic League (2009), in this debate format, two teams of Pro and Con with four members per team prepared all of the possible arguments for a monthly resolution topic on the grounds that they did not know their sides until the Coin Flip tossed. Thanks to that, all of the students could assimilate the whole context of subject matter without bias towards any sides.

Speeches and Time Limits

Speaker 1 (Team A, 1 st speaker)	4 min.
Speaker 2 (Team B, 1 st speaker).....	4 min.
Crossfire (between speakers 1 & 2)	3 min.
Speaker 3 (Team A, 2 nd speaker)	4 min.
Speaker 4 (Team B, 2 nd speaker)	4 min.
Crossfire (between speakers 3 & 4)	3 min.
Speaker 1 Summary.....	2 min.
Speaker 2 Summary.....	2 min.
Grand Crossfire (all speakers)	3 min.
Speaker 3 Final Focus.....	4 min.
Speaker 4 Final Focus	4 min.

Each team may use up to two minutes of prep time.

Figure 4: Public Forum Debate Format

Source: (National Forensic League, 2009)

Spontaneous Argumentation

According to Snider and Schnurer (2006, p.55), Spontaneous Argumentation (SPAR) debating was currently taking place at top American Universities. This exciting activity contains two students contemplating a topic all of a sudden and after a few minutes of preparation, they partake in a debate lasting for only 10 minutes. That means debaters could not conduct any research beforehand.

SPAR

Student	Activity	Time
Affirmative speaker	Speaks for one side of the topic	1 minute
Negative speaker	Asks questions of the first affirmative speaker	1 minute
Negative speaker	Speaks for the other side of the topic	1 minute
Affirmative speaker	Asks questions of the first negative speaker	1 minute
Audience	Asks questions and makes comments	5 minutes

Figure 5: Spontaneous Argumentation

Source: (Snider & Schnurer, 2006, p.55)

It is regarded as an effective way to minimize speakers' stress and make them more confident. Nonetheless, this activity does not involve a large number of students, and participants stand no chance of improving skills, language elements... during the preparation at home like other debate formats. It also can become a humorous activity rather than an educational one.

Roundtable discussion

Snider and Schnurer (2006, p.51) asserted that Roundtable discussion was relatively easy for beginners and useful for younger learners. Different from SPAR, it involves many students sitting at a table in a discussion. The format is illustrated below.

Roundtable Discussion

Student	Activity	Time
Chair	Introduces topic and asks for panel to participate	1 minute
Pro Student	Speaks in favor of the topic	1 minute
Con Student	Speak against the topic	1 minute
Neutrals	Asks questions, anyone debating can answer	4 minutes
All	Open discussion moderated by chair	6 minutes
Chair	Makes concluding statement identifying major issues	1 minute
Chair	Counts vote by student audience and announces a winner	1 minute

Figure 6: Roundtable Discussion

Source: (Snider & Schnurer, 2006, p.52)

According to Snider and Schnurer (2006, p.52), this format had several plus points such as creating friendly debate like SPAR with informal setting, reinforcing learnt knowledge through highlighting issues related to studied materials. Nevertheless, it is difficult to apply this format to complex issues.

Debates In English Speaking Lesson in Double-major Program

In Double Major Program of the university, the format of team debates is utilized as the final project which is considered the most well-rounded activity of the whole course. A brief overview of this project is provided below.

Objectives of the Debate Activity in English Speaking Lesson in Double-major Program

Be part of English course focusing on all of four integrated proficiency language skills namely listening, reading, speaking, and writing, Debate project is implemented in order for students to enhance all indispensable language skills. Additionally, the students are expected to boost specific skills such as presentation skills, debate skills and critical thinking skills.

Table 4: Skill Description

Presentation skills	Presentation skills refer to the skills needed in order to present an idea, argument articulately. These include language use, grammar accuracy, pronunciation and voice control, as well as non-verbal communication.
Debate skills	Debate skills refer to the ability to listen and respect the other team's opinions, the skills to understand their arguments and reflect on them.
Critical thinking skills	This refers the ability to recognize arguments, analyze them, and figure out the fallacies or the elements that weaken the arguments; as well as the ability to form a convincing argument.

Format of the Debate Activity in English Speaking Lesson in Double-major Program

According to the course guide, two opposing teams of four members are given equal chances to present their perspectives as well as answer questions from others in class. One is the proponent and the other is opponent team towards the topic resolution.

In terms of a sequence of a debate, each debate endures 40-45 minutes per week. Each week two groups will conduct a debate, the others become the audiences who keep time and evaluate on different rubrics compared with the teacher. Compared with three aforementioned debate formats, the procedure of this debate is quite similar to the Public Forum Debate with the bonus of rebuttal part and the voting. The specific task of each group and time allowance during the debate will be as follows:

Table 5: Debate Sequence

Participants		Task	Time allotment
Opening speech	Teacher	Teacher announces the "resolution" and the supporting and opposing teams	• 1 minute
Round 1- Position- presentation	Both teams	• Supporting team presents their arguments • Opposing team presents their arguments • Time out: each team think of the questions for the other team	• 4 minutes • 4 minutes • 1 minute

Round 2- Rebuttal	Both teams	- Supporting team raises the questions - Opposing team raises the questions - Time out: each team think of the ways to answer these question	2 minutes 2 minutes
Round 3- Grand crossfires	Both teams	- Supporting team answers the questions - Opposing team continues to questions the answer and the debate goes on until the teacher moves to the next part - Opposing team answer the question - Supporting team questions the answer and the debate goes on until the teacher ends it.	1 minute 4 minutes 4 minutes 4 minutes
Round 4	Both teams	- Supporting team summarizes their points - Opposing team summarizes their points	2 minutes 2 minutes
The voting	The audience and the teacher	The audience votes their winning team	5 minutes

Assessment Criteria

Students are evaluated based on two main criteria entitled content and process. The teacher evaluation form for in-class debate written in the course guide is redesigned as below.

Table 6: Teacher Evaluation Form For In-class Debate

1. Content

1	2	3	4	5	Overview (Review/posting of outline; Definition of key terms)
1	2	3	4	5	Quality of Arguments (Convincing, well-supported arguments with statistics, explanation, details, opinions)
1	2	3	4	5	Inclusion of Counter Arguments/Rebuttal
1	2	3	4	5	Summary/Conclusion (Short/ effective)

2. Process

1	2	3	4	5	Quality of Professional Attire/Grooming
1	2	3	4	5	Verbal Behavior (clarity/choice of words/voice level)
1	2	3	4	5	Nonverbal Behavior (posture; gestures/movement; eye contact; presence; use of notes/reading)
1	2	3	4	5	Variety in Style (discussion; game; role play; quiz)



1	2	3	4	5	Audiovisual Support (Transparencies; PowerPoint; blackboard; video)
1	2	3	4	5	Level of Audience Involvement (Stimulation/structuring of activity/disc)
1	2	3	4	5	Timing (Within limit; coordination; use of time)
1	2	3	4	5	General Coherence (Ability to follow points; quality of transitions)
1	2	3	4	5	Creativity/Psychological Impact

Note: 1 = Poor, 2 = Fair, 3 = Average, 4 = Good, 5 = Excellent

Based on this description, students can be aware of what they should focus on practicing to gain the maximum score in each criterion. From then on, these are also some of the benefits that they can improve during the preparation. For instance, argument quality, verbal or nonverbal languages, coherence and time management should be taken into consideration. If the students make great endeavors by relentlessly practicing at home, these can be developed dramatically and proved themselves in debate showcases.

Methodology

Participants

In accordance with the targeted research questions and instruments of data collection, there was one group of 59 participants involving in this research.

This group consists of two classes of 59 Double-major sophomores in a university. These participants are supposed to be at the age of from 19 to 22 years old. They were chosen as the participants due to some reasons. First and foremost, they are unique participants due to their varied majors and varied English competence in comparison with both mainstream and fast-track students. Furthermore, no research is implemented on these types of learners regarding the Debate project; therefore, any conclusions made from this research will be one the most crucial factors to assess this project on the same student type. Finally, all the students involved did have the chance to be the main speakers in one debate. Thus, they were qualified enough to provide reliable information to the investigation. All of the learners were asked to give consent to the use of their information, voices and images for research purpose.

All of them partook in the first two rounds of data collection entitled observations and questionnaires. There were six debates in total during the semester, and the researcher observed all of them to gain important information to the greatest extent. In terms of interviews, in-depth responses were achieved via the assistance of seven students.

Research Instruments

The researcher utilized both quantitative and qualitative method with observation, face-to-face questionnaire and face-to-face interview integrated to gather data for her research. In terms of data collection instruments, the researcher chose videotaping, audio recording, classroom observation sheet, survey and interview as the five major instruments.

Questionnaires

Le (2012), Mackey and Gass (2005) agreed that when dealing with a large number of research participants, surveys were one of the most appropriate methods of data collection. Additionally, questionnaires were defined as “any written instruments that present respondents with a series of questions or statements to which they are to react either by writing out their answers or selecting them among existing answers” (Brown, cited in Mackey and Gass, 2005). It is consequently reasonable for the researcher to have adopted the survey for 59 students. The primary purpose of the questionnaires is to discover the strengths of debate implementation on the speaking classes of the participants and their difficulties throughout this activity.

The questionnaire includes two parts with close-ended questions presented in the form of Likert scale. This questionnaire was designed based on language elements, language skills, soft skills and other components related to language communication.

The first part requires the students to assess the degree debate activity helped them improve certain components on a 5-point Likert scale (1 = not at all, 2 = least, 3 = moderately, 4 = highly, 5 = extremely highly).

The second part encompasses items indicating difficulties possibly happening to the respondents during debate activity. The students are asked to rate the challenges on 5-point Likert scale (1 = totally disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = totally agree).

Videotaping And Audio Recording

These two instruments were applied when the researcher observed the six debates of two classes. They made a great contribution to necessary changes decided by the researcher in the questionnaires before official distribution. Two cameras and two recorders were set up in the first or second students’ table to ensure the best sound and image quality of all debaters. The data collected demonstrated correctly all activities of the debaters in forms of images and sounds, as observation note failed to cover all the details of the debates.

Observation Sheet

According to Dörnyei (2007), classroom observation “provides direct information rather than self-reported accounts”. Therefore, observation helped the researcher to carefully double check some certain information collected from questionnaires, interviews and enriches the research findings. The researcher carried out observations in all of 6 debates in both two classes at semester I. Observations could support the data from videos and recordings in case they were not of high quality. Moreover, observation notes were also used to make changes to the questionnaires as videotaping and audio recording. An observation sheet whose main contents included the name of the class, groups, the debaters’ names, the topic of the debate and note columns was exploited during each debate.

Interviews

Besides questionnaires, the qualitative data of this study were collected via semi-structured interview as well. The semi-structured interview allows the researcher to “explore the topic in



depth” (National Science Foundation, 2002). To be more specific, semi-structured interviews were utilized as the researcher could exploit more valuable information that might be hidden via the other instrument, questionnaire. As the interviews were carried out face-to-face, interviewees’ difficulties in understanding the questions could be clarified by the interviewer. Detailed notes were carefully taken and simultaneously, audio recording devices were employed at the participants’ permission to aid the data collection process. All the interviews were carried out in Vietnamese only.

Data Collection Procedures

Data collection procedure endured about one month and a half with three main stages. The researcher observed, recorded and videotaped both classes with six debates in total, equivalent to approximately six hours of studying. At the teachers and students’ consent, debate observations along with videotaping and audio recording were conducted with the use of observation notes simultaneously. During three weeks, debates of two classes took place on the same days; thus, it was surely time-saving for the researcher to collect data.

When it came to the last day of the course, surveys were delivered to each student directly face-to-face and returned in class as well. 59 participants in two classes were asked to do the questionnaire, with 100% agreeing to finish and submit the questionnaires to the researcher. Instructions were given clearly to help students understand the wording in the questionnaires.

Finally, semi-structured interviews with the assistance of recorders were conducted with seven students. These students were chosen thanks to random sampling strategy. The interviews were recorded for further examination.

Data Analysis Tools

The quantitative and qualitative method required suitable tools for data analysis.

As for questionnaire, the analysis tool employed was Google form and Excel. While Google form was convenient due to its quick information synthesis and smart calculations, Excel provided tools for the researcher to create charts for analysis.

A different approach namely Grounded theory was appropriate for the interviews and observation. According to Smith and Davies (as cited in Dahlberg & McCaig, 2010), grounded approach formed theory based on the categories of the data without mentioning the previous framework.

Data Analysis Procedures

The results of each data collection tool were analyzed separately thanks to data analysis tools and subsequently combined to produce final conclusions.

The data gained through questionnaires were entered in Google form manually. Based on Google form’s calculations, the researcher was aware of the frequencies of each item response so as to write up major findings. The charts were then designed on Excel according to these frequencies.

The interview results and observations experienced a process of transcription, coding and interpretation with the assistance of Grounded theory. The results were transcribed from the notes, videos and audios. Based on the transcriptions, researchers then categorized and developed a set of coding categories. Coded data were ultimately interpreted to draw major findings.

Findings and discussion

Question 1: From Students' Perspective, What Benefits Do They Gain From The Debate Activity?

Language Skills

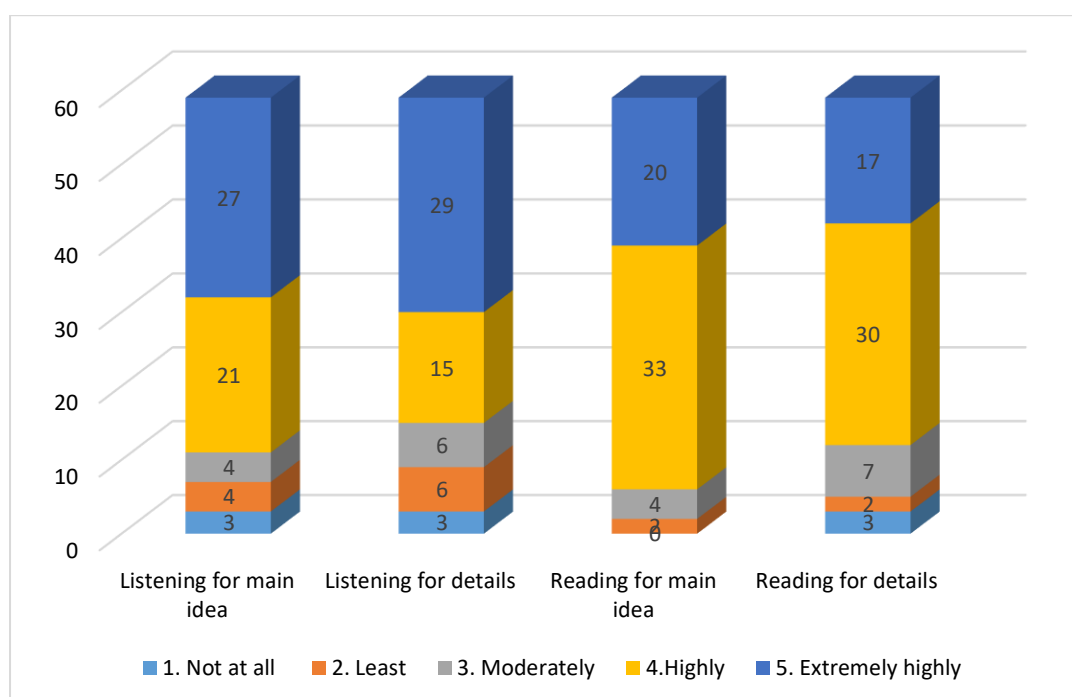


Figure 7: Listening Skills And Reading Skills

As illustrated in the chart above, it is notable that reading for main ideas and reading for details are the ones that the participants thought they could enhance the most thanks to the debate activity. Over half of students agreed that they made improvements in both skills. To be more specific, in the follow-up interview, students all agreed on the fact that a plethora of authentic articles or journals providing profound background knowledge of the topic during preparation led to their great enhancement in reading skills. Meanwhile, listening for main ideas and listening for details ranked the third and the fourth respectively. Nearly 82% of respondents said they improved both skills highly or extremely highly. Especially, approximately 30 students, equivalent to half of the students, reported to have significantly improved listening for details.

Idea Brainstorming Skill

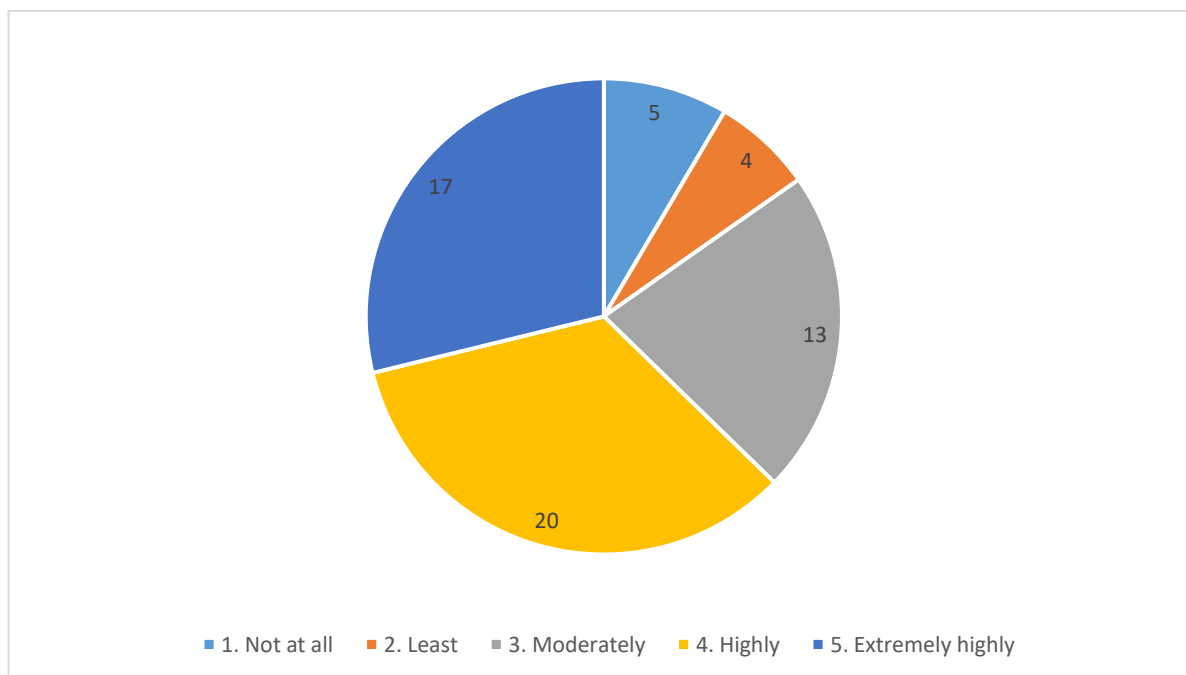


Figure 8: Idea Brainstorming Skill

Argumentation Skill

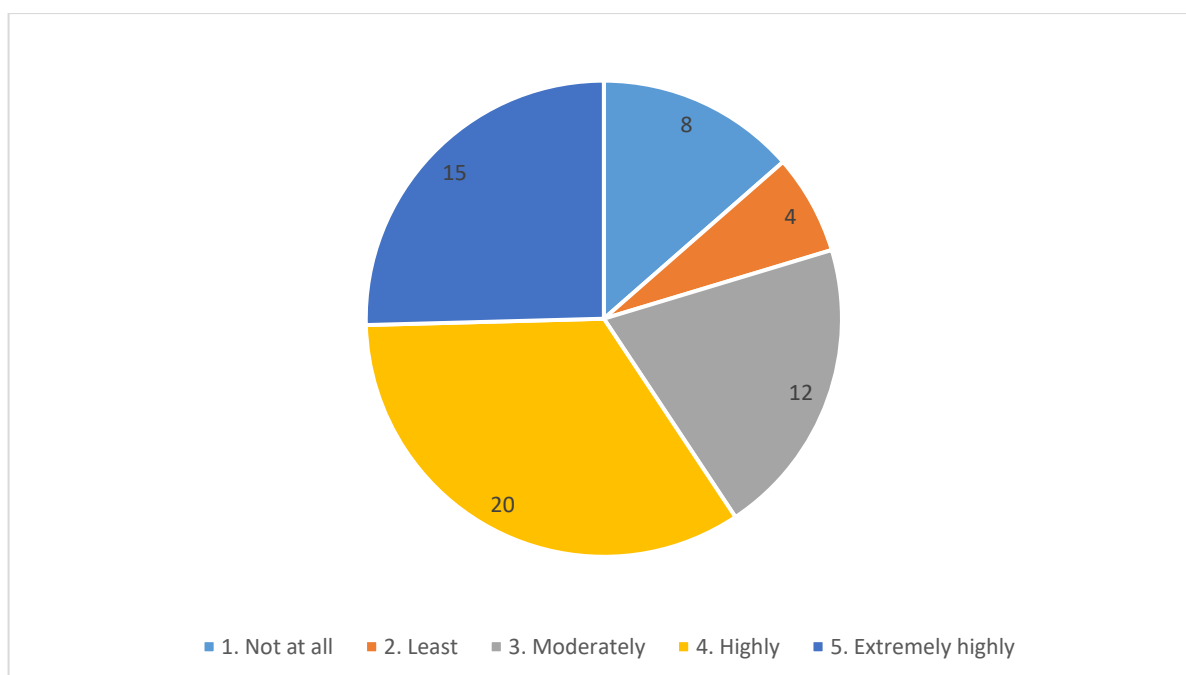


Figure 9: Argumentation Skill

In Figure 5, relatively 63% of the participants rated idea brainstorming skill as either highly improved or improved, which indicated that this element was highly taken into consideration.

Nearly analogous to Idea brainstorming skill, 59.3% of the respondents in Figure 6 recognized that their argumentation skill was sharpened dramatically. Four interviewees said that they had to try to contemplate logical arguments to prove their ideas more persuasive; henceforth, their argumentation skill was believed to have considerably improved.

Critical Thinking Skills

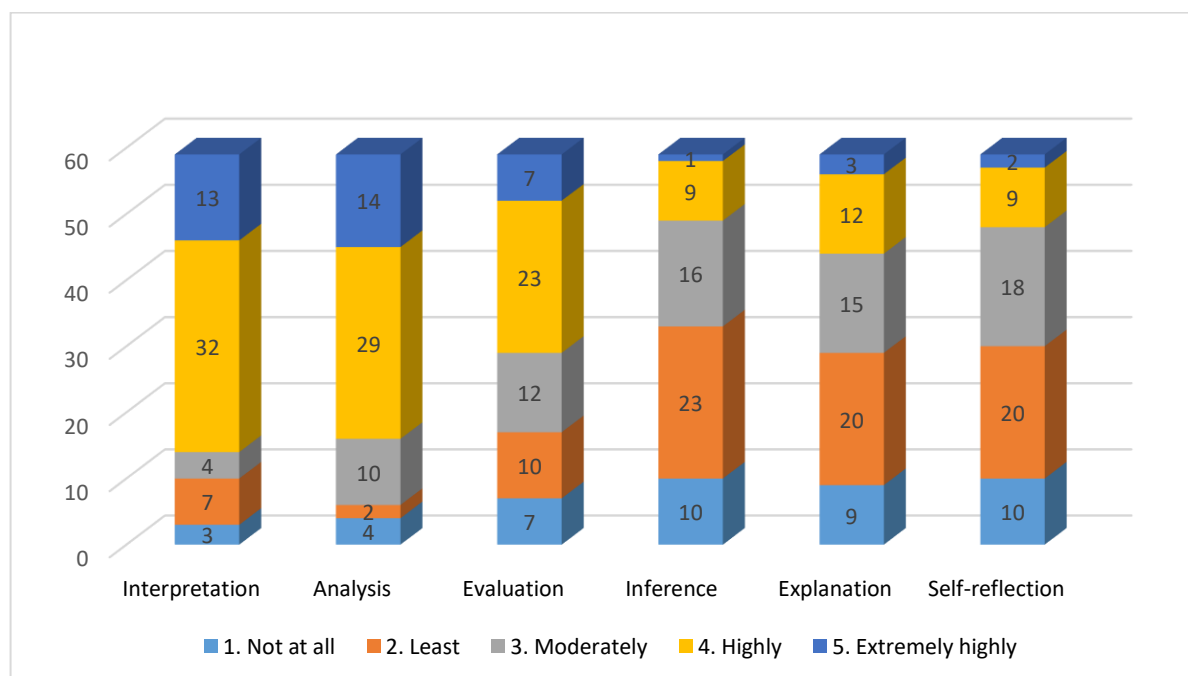


Figure 10: Critical Thinking Skills

From Figure 7, it is noted that critical thinking encompasses six sub-skills namely Interpretation, Analysis, Evaluation, Inference, Explanation and Self-reflection. Overall, the majority of students admitted that their critical thinking skills were developed. 76% of the students asked confirmed that Interpretation and Analysis were the most progressed among the other sub-skills. Meanwhile, the figure for people choosing “highly” and “extremely highly” increased Evaluation is a little lower with 30 students. In contrast, when being asked to what extent inference, Explanation as well as Self-reflection were improved, 56% of the students thought that no progress was made. Further explanation via interview revealed that the sophomores did not utilize any of these sub-skills during debate procedure.

To sum up, from the learners’ points of view, their language skills, idea brainstorming skill, argumentation skill, and critical thinking skills were dramatically enhanced.

Question 2: From Students' Perspective, What Are The Difficulties They Encountered During This Activity?

Internal Factors

Language Skills

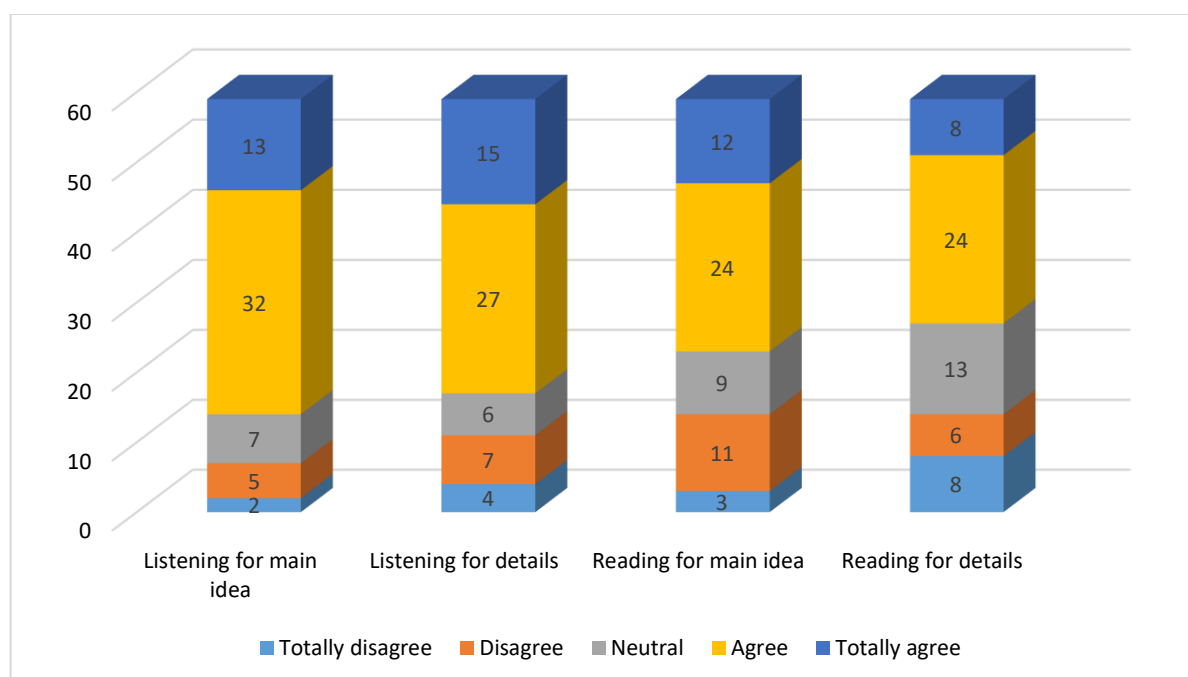


Figure 8: Listening Skills And Reading Skills

Overall, both listening skills and reading skills caused students great burdens. Listening skills were more problematic in students' opinion. Approximately 76% of the participants found not only listening for main idea but also listening for details troublesome. Interviewees said that they could not catch significant ideas in video clips related to the topic; therefore, it was totally challenging for them to gain insight into the matter and seek arguments. Via observation, the researcher has spotted that in the rebuttal part, some students seemed not to understand their rival's questions due to their unsatisfactory listening skill, not due to the nature of the questions. That could also be explained by their asking for the teammates' help to clarify the questions while the others all understood. In the second place, reading skills got 34 people "agree" and "totally agree". It means that the respondents had difficulty in overcoming obstacles posed by these skills. To be more specific, some students complained that they were unable to skim and scan reading texts, thereby not assimilating the topic in depth and identifying significant supporting ideas easily.

Idea brainstorming skill

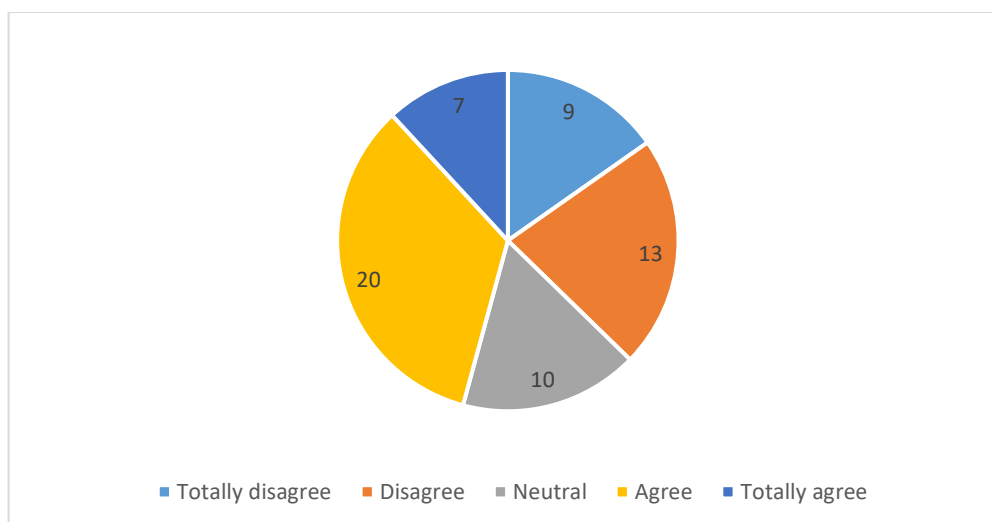


Figure 9: Idea Brainstorming Skill

Nearly half of the sophomores found that their idea brainstorming skill was a downside for themselves. Interviewees recognized that generating ideas required lots of effort, especially within a short time span such as in the refutation part. Some people even could not think of any ideas, then resorted to their teammates' support.

Argumentation Skill

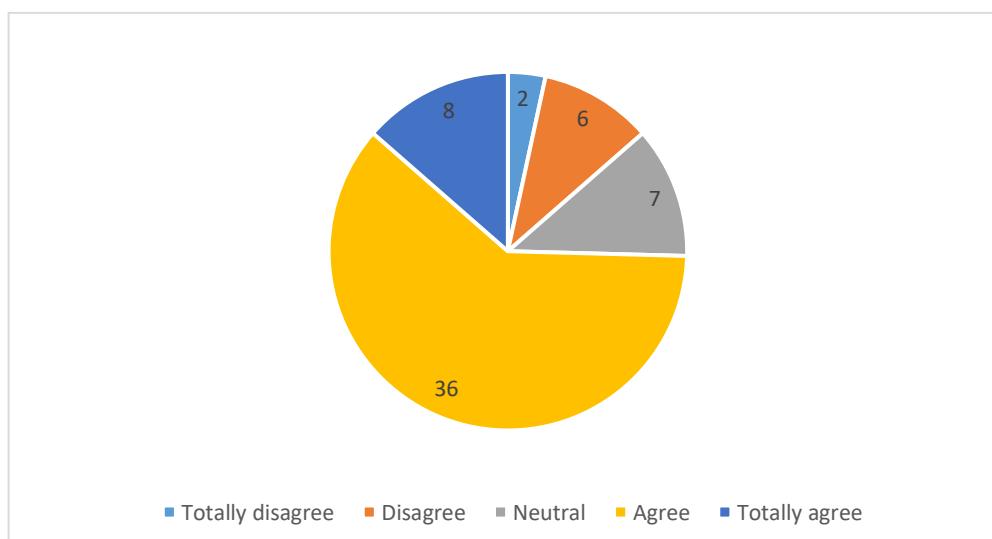


Figure 10: Argumentation Skill

Argumentation skill was a dramatic challenge for 74.6% of the participants, with 36 people selected "agree". All of the interviewees affirmed this skill was absolutely challenging when they had to figure out logical arguments that were strong enough for no one to refute.

Critical thinking skills

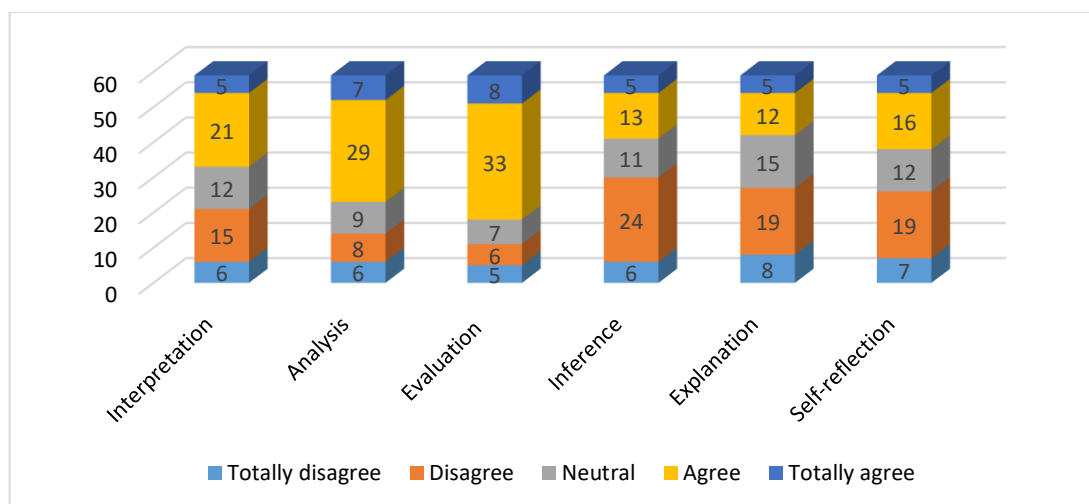


Figure 11: Critical Thinking Skills

Regarding critical thinking skills, Interpretation, Analysis and Evaluation were noted problems, especially Evaluation according to 41 people. The percentage of people finding Interpretation and Analysis difficulty was high as well, 61% and 41.1% respectively. On the other hand, Inference, Explanation and Self-reflection were difficult as well. However, these skills were not a matter of their concern since the interviewees thought they did not need to apply when engaging in the Debate project.

Soft skills

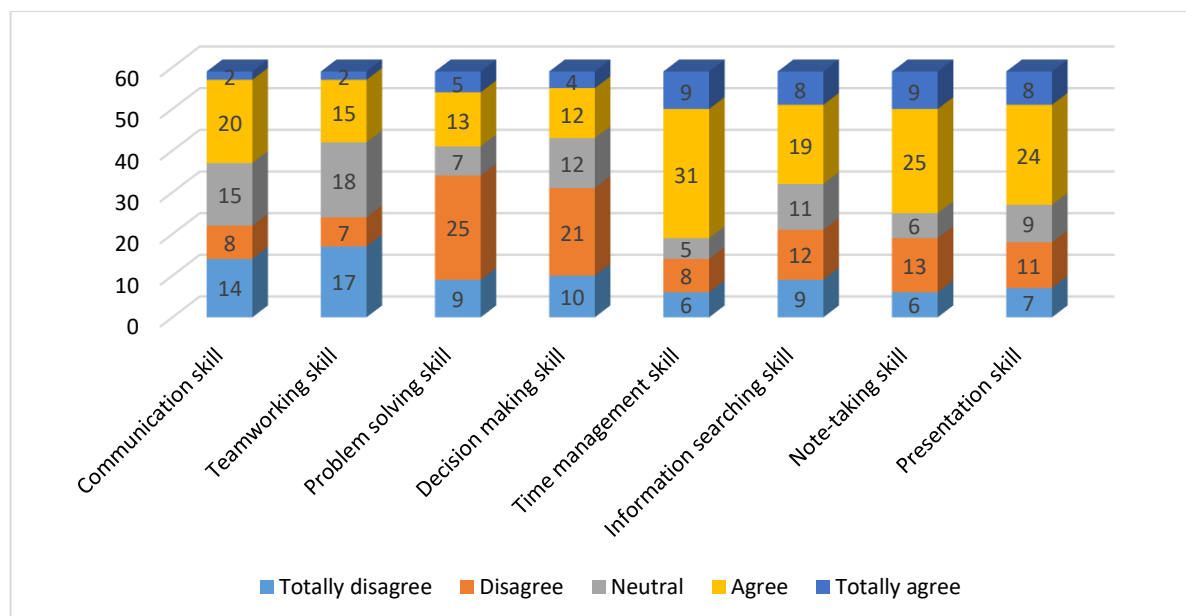


Figure 12: Soft Skills

Through this graph, time management skill was the biggest problem to the students. The proportion of 'agree' and 'totally agree' votes for this skill constitutes 67.8%, far greater than

any other soft skills. Interviewees admitted that they were so bad at taking time under control during preparation and presentation or rebuttal. Regarding preparation, their working capacity was negatively affected as they let several matters dominate more important work. Besides, during refutation, they craved for presenting two to three ideas; nonetheless, it was impossible for they spent too much time explaining solely one idea.

Secondly, 34 people chose “agree” and “totally agree” with the fact that their note-taking skill was problematic. Interviewees did not spend time on taking notes of the whole related videos because they were unable to catch important ideas with that method. 32 students thought that their presentation skill was an obstacle. Making a clear structure of presentation was hard, especially while in a rush or in rebuttal. Information searching skill was also rated as a big challenge by nearly half of the students. One student divulged that she selected websites based on innate feelings rather than knowing how to unearth prestigious sources.

With regards to communication skill, it is interesting to note that except for 15 neutral people, the others were divided into two opposing groups of equal number.

40.7% of the participants thought that their team-working skill challenged them considerably. Interviewees elucidated that they were introverts, so they could not express their opinions easily and argue persuasively.

In contrast, over half of the respondents disagreed that problem-solving skill and decision making skill were big problems. Two students said that these skills of theirs were sufficiently satisfactory, while the others said they were incompetent but no considerably negative influence was exerted on them. That was the reason why all of the interviewees belonged to “disagree” group.

Language Elements

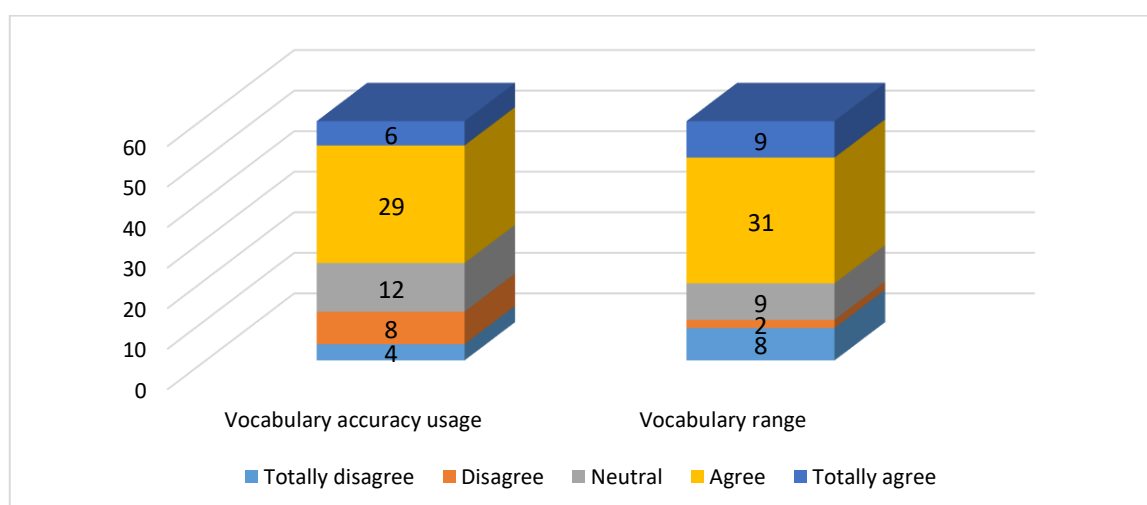


Figure 13: Vocabulary

As clearly illustrated in Figure 13, vocabulary caused great difficulties for the students. 40 over 59 participants found their vocabulary range limited; meanwhile, five interviewees clarified that insufficient academic vocabularies inhibited them from exploring the topics and expressing

ideas in the debate showcase. With a little lower number of votes from 35 students, using vocabularies accurately was considered difficult as well.

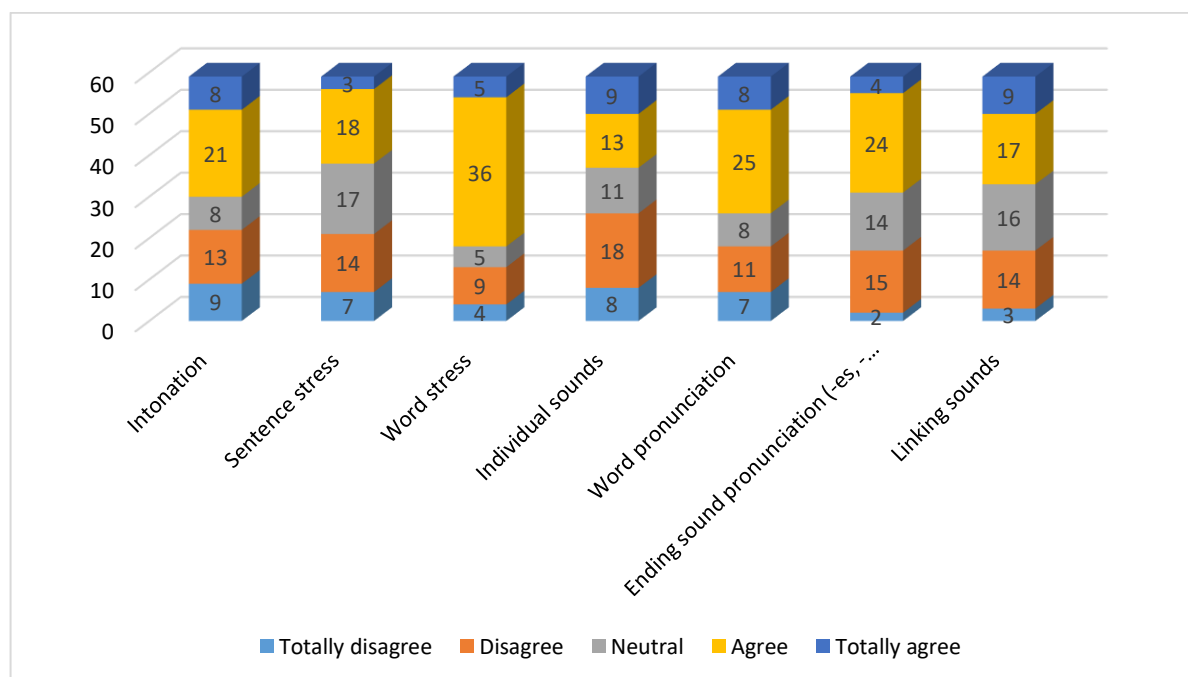


Figure 14: Pronunciation

Concerning pronunciation, word stress was evaluated as the most formidable obstacle with 69.5% of the votes. Word pronunciation, the closely linked factor and intonation made up roughly half of the choices. These could be regarded as top three most serious problems of pronunciation to the students. The others such as linking sounds and sentences stress were neglected during practice and actual presentation because one student said that “presumably the teacher does not pay much attention to such small points”.

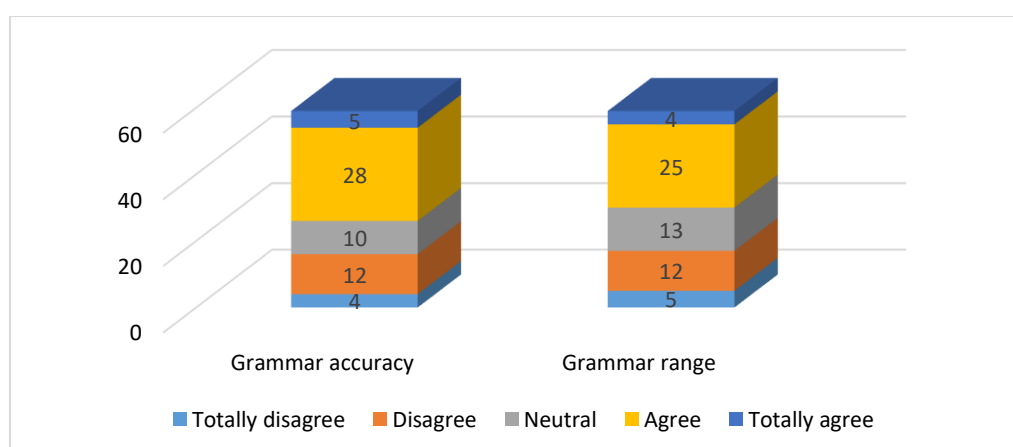


Figure 15: Grammar

Over half of the respondents regarded grammar accuracy as an insurmountable problem. In comparison with this one, with only a little lower number of choices, grammar range was also

a challenge for the students. Applying grammar accurately was more difficult than internalizing a variety of grammar structures.

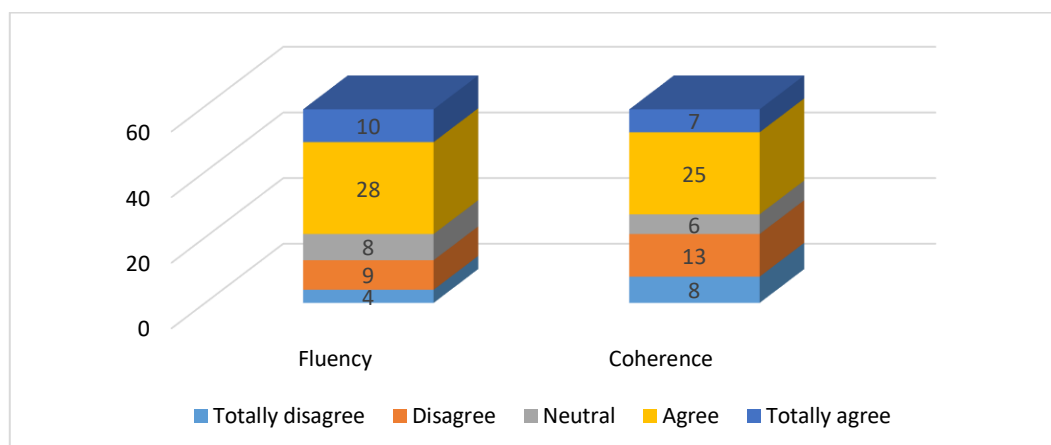


Figure 16: Fluency And Coherence

Fluency posed a graver problem to the participants than coherence did with 38 students' affirmation. Via debate observation, many students did not speak fluently without scripts. It was obvious in the rebuttal part, when these students could not anticipate their opponent teams' questions in advance to prepare satisfactory responses. In addition, coherence was a huge challenge as well since 32 participants thought that they encountered great difficulties during presentation due to their inadequate coherence.

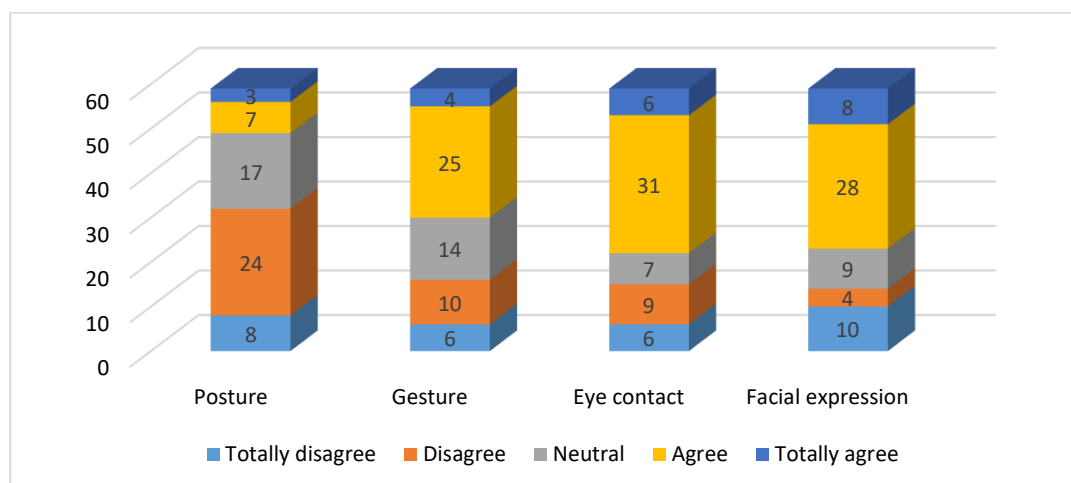


Figure 17: Non-verbal Languages

Among other sub-items, the number of students met difficulties with eye contact and facial expression was almost equal and as high as 37. Gesture was also a problem to nearly half of the respondents. Besides, although appropriate posture was not a plus point of many students; however, only ten participants found it troublesome.

Other difficulties

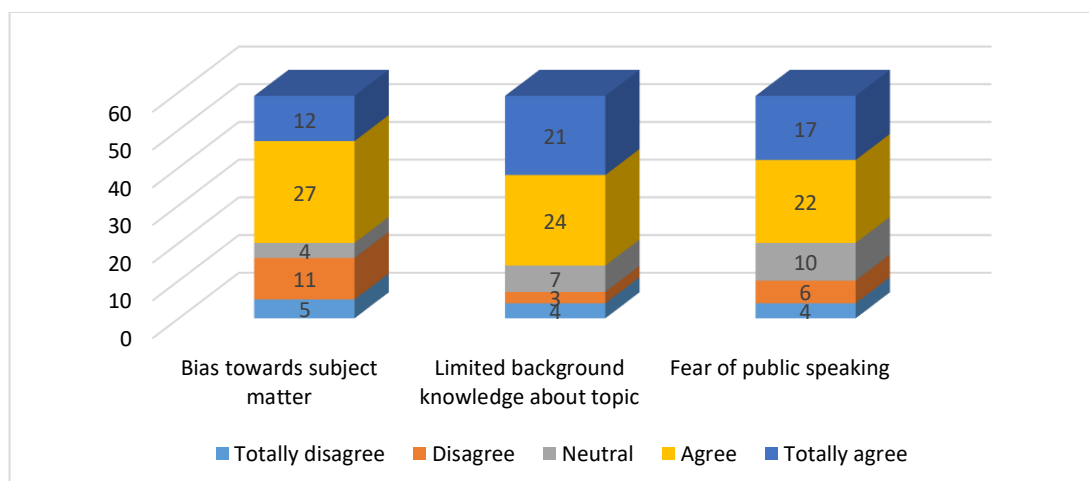


Figure 18: Other Difficulties

In Figure 18, these three factors prevented students from implementing debates. Limited background knowledge was the most noteworthy stumbling block. The majority of students had little or even no basic knowledge about the topic; therefore, it extended the time to dig deep into the topic and they would have insufficient time to do other important things. The fear of public speaking and bias towards subject matter made nearly 40 students uncomfortable as well. In spite of relentless practice and effort, they still faced up to these problems without knowing how to overcome. Via observation, the signals were spotted via the fact that some students trembled with their hands and spoke quite fast. That consequently affected their quality of arguments, fluency, grammar or pronunciation. With regards to the bias towards the subject matter, two respondents revealed that at first, they favored the opponent team. Nonetheless, it was compulsory for them to follow the proponent team; hence, they encountered many difficulties in finding materials. They felt uncomfortable with the side they were in charge of while being forced to belong to the team which they disliked.

External Factors

Teamwork

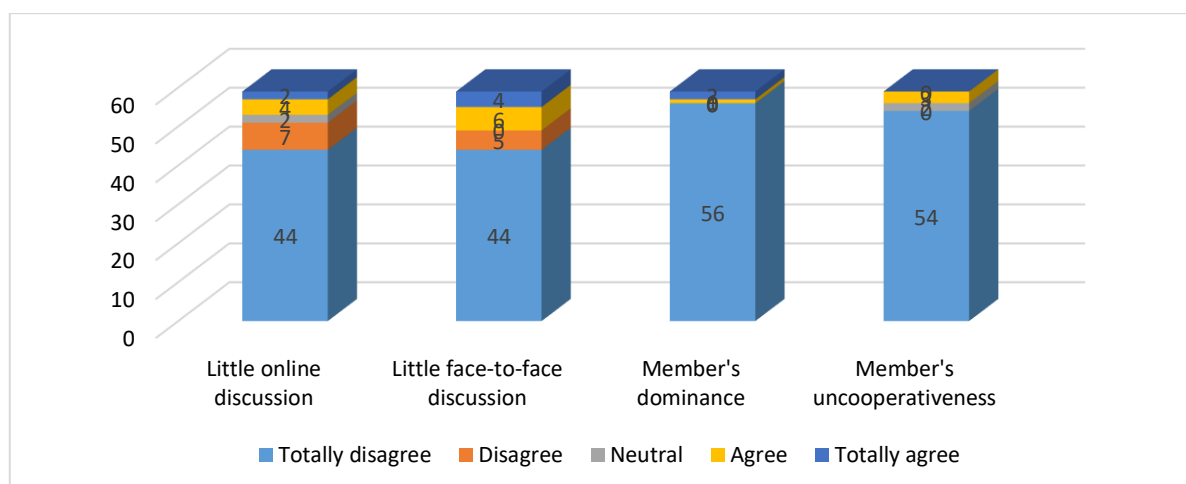


Figure 19: Teamwork

Member's dominance and member's uncooperativeness were considered trivial problem by almost all students. Although one interviewee stated that member's dominance affected her, it might be her character that caused difficulties in her turn-taking during the debate. From the researcher's observation, she did not show much engagement such as not taking any notes and not discussing in the refutation while the other members were seriously exchanging ideas.

Low frequency of online and offline discussion got the same number of 44 people choosing "totally disagree" to confirm they had no difficulty with these ones. However, one interviewee belonging to another group disclosed the side effect of her team's no face-to-face discussion. She felt anxious as standing no chance of sharing ideas clearly among the team. She was faced with lots of problems such as misunderstanding, member's dominance and failed to resolve these obstacles. Her teammates and she spent no time gathering as each person studied in different universities far away from each other.

The opponent team

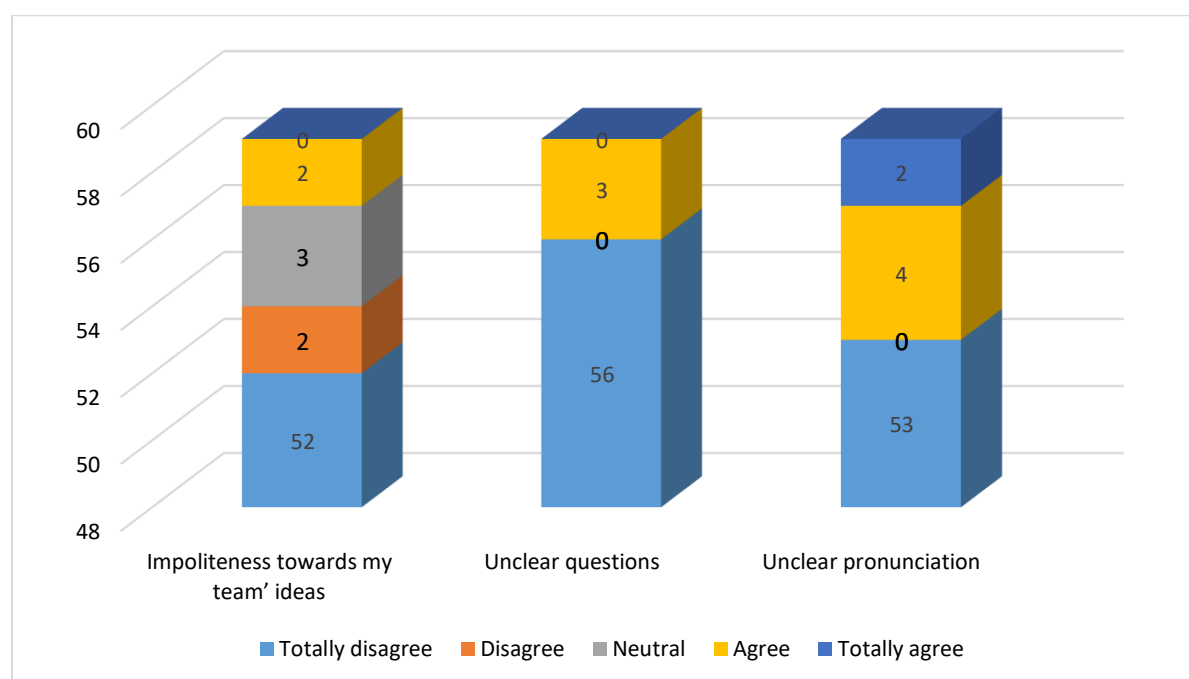


Figure 20: The Opponent Team

It is clearly stated from the chart that in each debate, no debate team from both classes had strong complaints towards their adversaries. The most extraordinary fact was that 56 people agreed that the opponents did not pose unclear questions. Only one interviewee replied that her rival's question was so ambiguous that she along with her teammates had to request repetition and clarification three times. Unclear pronunciation of the rivals was also not an outstanding matter to be taken into consideration with 53 participants.

In addition, 52 students chose "totally disagree" when being asked about impoliteness towards their ideas. Six out of seven interviewees confirmed that their rival team did not express impoliteness at all. Only one person admitted that one of the other team seemed not to be polite enough, but it did not bring about any profound effect on them.

Other difficulties

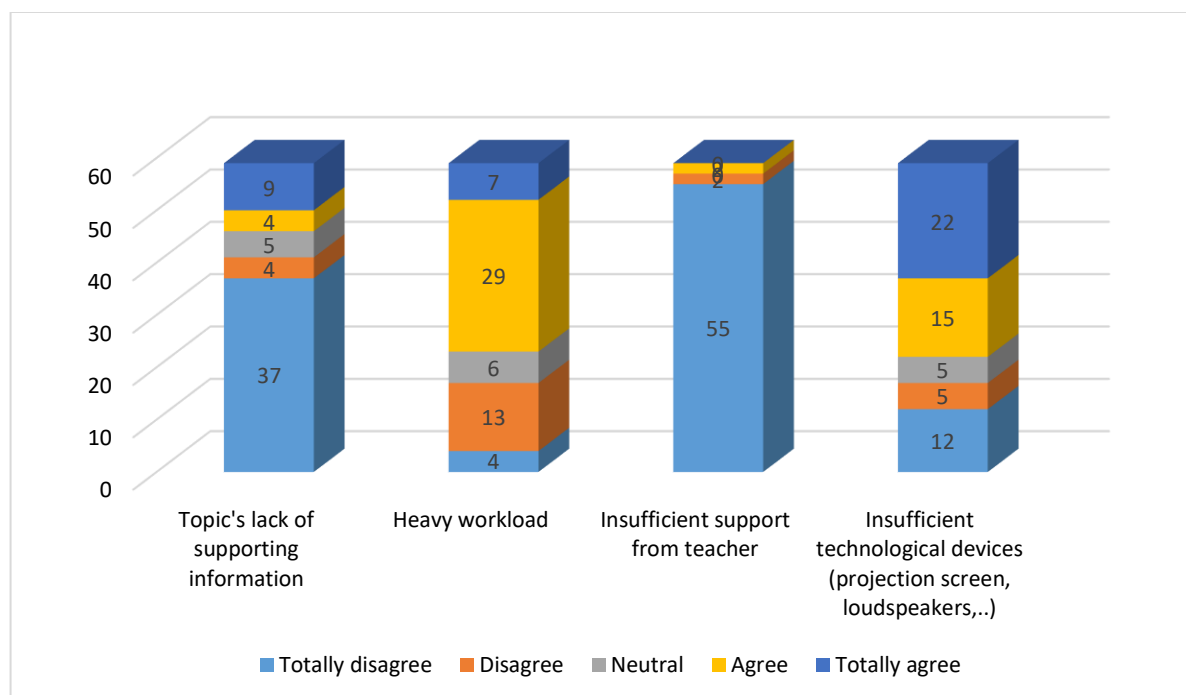


Figure 21: Other Difficulties

Insufficient technological devices and heavy workload were considerable challenges. When being asked about this matter, every single student complained about the devices in classroom and workload. They would like to show statistics, videos on screen for clarity; however, no screen and loudspeaker were available. Some decided to eliminate their examples, some had to print out the wasted handouts and then distribute to each of their classmates. They also felt great pressure due to the arduous preparation rather than preparing for simple presentations. On the contrary, insufficient support from teacher did not need considering on the grounds that 55 people felt no problem with teachers' support. In fact, one interviewee saw that her teacher did not specify roles of each team and the procedures of debate; consequently, she was worried and confused during preparation. Lack of supporting information seemed not to be a big problem to over half of the respondents. Nonetheless, one interviewee told that she could not find supporting arguments for their team because the supporting ones of the other team dominated. The researcher questioned her information searching skill, and she also found it difficult. Therefore, probably it was the matter of her skill, not the lack of information source.

In conclusion, students' lack of confidence, limited background knowledge, time management skill, bias towards subject matter, weak non-verbal languages or weak language proficiency were their shortcomings. The pressure that debate exerted on these respondents such as heavy workload, complex format and insufficient technological devices were troublesome external factors for the majority of students.

Conclusion

Conclusion and Implications

This research has brought about knowledge of the benefits and shortcomings of the debate implementation from students' perspective for students, teachers and course developers as well. A large number of dramatic results have been obtained after a long time of data analysis and synthesis. Consequently, the researcher believes that this study does wonders for other research' same topics, especially in this institution with the same types of participants namely double-degree sophomores. This study discovered new factors compared with literature review and also reinforced several previous findings.

From their perspective, their language skills, idea brainstorming skill, argumentation skill, and critical thinking skills were dramatically enhanced. Therefore, for these participants, apart from the improvement in critical thinking skill, argumentation skill, language skills proved in other research, idea brainstorming skill was sharpened as well.

Regarding difficulties, students' lack of confidence, limited background knowledge, time management skill, bias towards subject matter, weak non-verbal languages or weak language proficiency were their shortcomings. The pressure that debate exerted on these respondents such as heavy workload, complex format and insufficient technological devices were troublesome external factors for the majority of students. Henceforth, in addition to reinforcing debate challenges posed by previous researchers, a novel finding emerged from this study is of paramount importance. Those are students' bias, weak non-verbal languages, time management skill and insufficient technological devices.

These findings from the two research questions carried several remarkable implications.

Firstly, double-degree sophomores should practice more to enhance their language competency and sharpen confidence. Their proficiency and unconfidence can be regarded as one of the most considerable barriers in conducting debate. Secondly, teachers should provide students with more guidelines on debate format with related components, key terms in order that they do not encounter many difficulties during preparation and debate showcase. Furthermore, some basic knowledge of the debate topics and the ways to find out prestigious sources are highly recommended to be supplied. Teacher needs to create a friendly environment because these types of students are vulnerable to pressure, especially in front of the public. Thirdly, students should be given an equal chance of choosing their sides. Teachers are highly recommended to allow the two teams of each debate case to pick random papers having written sides to ensure the equality. What is more, teaching sessions are suggested to be furnished with technological devices such as screens, loudspeakers to ensure students' speech quality maximum. Otherwise, the criterion of Audiovisual Support in the marking rubric (Transparencies; PowerPoint; blackboard; video) needs ignoring to avoid mark invalidity.

Limitations

Despite the researcher's endeavors, limitations are inevitable. The quantity and quality of data obtained are limited due to some major reasons.



Firstly, the quality of the self-designed questionnaire has been guaranteed to some extent, its validity should have been examined thoroughly if resources had allowed. Additionally, the questionnaire was quite long, it might distract students' attention to produce the most appropriate choices.

Secondly, for this topic, in order to scrutinize exactly the benefits and difficulties students met, action research is highly recommended to double-check the data although the researcher triangulated information by checking some factors clearly taking place in debate showcases along with questionnaires and interviews.

Due to the time constraints, the researcher could only conduct seven interviews and each interview lasted for quite a short time. To arrange an appointment with each person, it took the researcher lots of effort, time and financial resources.

Ultimately, on the grounds that the number of participants was restricted to double-degree second-year students, it is difficult to make any generalization for other English learners at this school.

Suggestions For Further Research

Based on the aforementioned limitations, the researcher highly recommends that further studies of the same interest can make progress.

Firstly, the self-designed questionnaire can be piloted by some students before official usage in order to ensure the validity to a greater extent. Second, if the observation had been able to be extended to the preparation stage of each participant, the results would have been more significant. Finally, more interviewees should be approached to ensure the validity more effectively. In order to do that, the researcher needs to allocate more time and financial capacity to conduct more interviews with more detailed questions.

The researcher does expect that this study can lay a firm foundation for other research with a deeper insight into the similar topic.

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EQUITABLE AI IN INTELLECTUAL PROPERTY: BALANCING INNOVATION AND JUSTICE IN THE DIGITAL AGE

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Abstract: *The rapid advancement of artificial intelligence (AI) is fundamentally transforming the intellectual property (IP) landscape; however, existing legal frameworks are increasingly inadequate to address the complexities introduced by algorithmic creativity. A central challenge lies in reconciling traditional concepts of authorship, ownership, and access with the evolving role of AI in the creation of artistic works and technological innovations. This study critically examines the intersection of AI and IP through the lens of equity, underscoring the urgent need for comprehensive legal and ethical reforms. It begins by questioning whether current IP regimes can effectively accommodate AI-generated outputs and proceeds to explore the ambiguities that arise when human and machine contributions are interwoven. The discussion further highlights how algorithmic bias and unequal access to AI technologies exacerbate existing disparities, particularly for marginalized artists and inventors. These issues raise significant concerns regarding fairness, transparency, and inclusivity within IP systems. Additionally, the paper addresses global and cultural dimensions, such as the risk of AI appropriating Indigenous knowledge and the divergent treatment of IP across jurisdictions. In confronting these multifaceted challenges, the article advocates for the development of equitable frameworks that promote shared ownership, inclusive innovation, and culturally responsive governance. Ultimately, it calls for a fundamental reimagining of IP law—not merely to keep pace with technological advancements, but to ensure that the benefits of AI-driven innovation are distributed justly. Equity, therefore, must serve as a guiding principle in shaping the future of intellectual property in the era of intelligent machines.*

Keywords: *Artificial Intelligence, Intellectual Property, Equity, Algorithmic Bias*

Introduction

The rapid advancement of artificial intelligence (AI) within creative and innovative domains is profoundly reshaping the intellectual property (IP) framework. AI systems are increasingly demonstrating their capacity to generate diverse forms of output, ranging from music and visual art to novel technological inventions. This development challenges long-established assumptions regarding authorship and ownership. The integration of AI into creative processes presents both opportunities and challenges for IP law, which has traditionally been grounded in human-centred notions of creativity, originality, and control.

Although AI-generated works are becoming increasingly prevalent, existing legal systems remain ill-equipped to address the complex issues that accompany algorithmic innovation. Questions of authorship, inventorship, and ownership become particularly intricate when human and machine contributions are deeply intertwined. Furthermore, the growing



prominence of AI raises pressing ethical concerns related to fairness, transparency, and inclusivity, particularly as algorithmic bias and unequal access to AI technologies risk exacerbating existing disparities among creators and innovators.

This conceptual paper seeks to critically examine the intersection of AI and IP from an equity-centred perspective. It aims to explore fundamental questions: Can AI-generated outputs qualify for protection under current IP laws? How can legal systems reconcile human-machine collaboration in determining authorship and ownership? What are the implications of algorithmic bias and unequal access for marginalised communities? And how might IP frameworks be restructured to promote fairness and inclusion in the digital era?

The paper emphasises the centrality of equity as a guiding principle in shaping the evolution of IP law. Achieving equity necessitates not only legal reform but also a holistic re-envisioning of IP systems that foster collective ownership, inclusive innovation, and culturally sensitive governance. As AI continues to redefine the frontiers of creativity and invention, the development of equitable IP frameworks is imperative to ensure that the benefits of technological progress are distributed fairly across all segments of society.

Rethinking Authorship and Ownership in the Age of AI

The emergence of AI has introduced profound challenges to the foundational concepts of authorship and inventorship within IP law. Traditionally, IP frameworks have been premised on the assumption that creativity and invention are inherently human activities. Consequently, most existing legal systems—whether in Nigeria, the European Union, or elsewhere—do not recognise AI systems as legal authors or inventors. This anthropocentric approach has resulted in considerable legal ambiguity in addressing outputs autonomously generated by AI, raising complex questions about who, if anyone, should hold the rights to such creations (Adaka & Olubiyi, 2022; Buzu, 2024).

These challenges are further compounded by the absence of a unified international position. For instance, although the European Parliament has explored the possibility of introducing new legal instruments to safeguard AI-generated outputs, the European Commission has remained cautious, reflecting broader global uncertainty on the issue (Dornis & Dornis, 2021). The well-known DABUS case, in which an AI system was identified as the inventor in a patent application, has intensified this international debate. Most jurisdictions, including the European Union, have rejected the notion of non-human inventorship, thereby reaffirming the prevailing legal orthodoxy that only humans may be recognised as inventors (Buzu, 2024).

In response to these evolving challenges, scholars and policymakers have advanced a range of proposals. One approach advocates legislative reform to either amend existing IP statutes or establish new categories of rights tailored specifically to AI-generated works (Mahingoda, 2024; Bharati, 2024). Another perspective proposes attributing ownership to the individual or entity that operates or owns the AI system, thereby incentivising investment and innovation while maintaining human accountability (Fadavi & Alizadeh, n.d.). Judicial and policy interventions are also deemed critical, particularly in developing clear criteria to determine the degree of human involvement required to claim authorship or inventorship (Mahingoda, 2024; "Artificial Intelligence and Inventorship...", 2023).

Beyond legal considerations, the issue encompasses significant economic and ethical dimensions. Recognising AI-generated works within IP frameworks could stimulate innovation and economic growth by encouraging further investment in AI technologies. However, in the absence of clearly defined ownership rights, stakeholders may hesitate to invest due to legal uncertainty (Fadavi & Alizadeh, n.d.). Ethically, extending legal status to AI systems as authors or inventors raises complex concerns regarding the concentration of rights, the erosion of human dignity, and the potential disruption of established economic structures (Gulyamov, 2023). Furthermore, as most existing IP laws are predicated on human authorship and inventorship, they fail to adequately account for the autonomous capabilities of AI systems. Consequently, AI-generated outputs often fall outside the scope of legal protection, creating uncertainty about their treatment under current IP regimes (Dornis & Dornis, 2019; Fadavi & Alizadeh, n.d.).

A central issue lies in determining the ownership of AI-generated works. Should rights be attributed to the AI system itself, its developer, its user, or another party? Jurisdictions have adopted divergent approaches to this question. For example, the British model assigns ownership to the individual who enables the operation of the AI system. Nevertheless, this model raises further questions concerning the requisite level of human involvement necessary to justify such ownership claims (Fadavi & Alizadeh, n.d.; Bisoyi, 2022). The absence of clarity in ownership structures not only complicates legal enforcement but also undermines economic incentives to invest in AI technologies. Without clearly defined rights, stakeholders may be reluctant to finance or deploy AI systems, potentially hindering innovation in sectors where AI could otherwise drive significant advancement (Bisoyi, 2022).

To address these multifaceted challenges, scholars and policymakers have proposed a variety of reform measures. One approach advocates the creation of a distinct category of IP rights specifically designed for AI-generated works. Such a framework would establish clearer ownership criteria by considering factors including human contribution and the economic value of the output (Gulyamov, 2023; Rusinovich, 2023). Legislative reform is also viewed as essential to develop a robust and adaptable IP system capable of accommodating the evolving characteristics of AI technologies (Singh et al., 2024).

Beyond legal and economic considerations, ethical dimensions must be carefully integrated into future IP reforms. The attribution of rights to AI systems raises critical questions concerning human dignity, accountability, and the risk of excessive concentration of power. Therefore, transparency obligations and oversight mechanisms are vital to ensure responsible implementation and to mitigate risks such as algorithmic bias, exclusion, and inequitable access to innovation opportunities (Gulyamov, 2023; Rusinovich, 2023).

Algorithmic Bias and Inequitable Access

As AI systems increasingly contribute to the creation of artistic works and technological innovations, questions concerning the fairness and inclusivity of IP protection have become more pronounced. AI algorithms that exhibit bias can distort creative outputs, while unequal access to AI tools may exclude certain groups, thereby limiting their capacity for innovation. Ensuring that the benefits of AI are distributed equitably requires comprehensive and inclusive solutions. As the use of AI in the creation of IP continues to expand, it is essential to critically

examine how bias and disparities in access influence both the outcomes of innovation and the mechanisms of legal protection.

Bias in AI Systems and Creative Outputs

A central challenge lies in the inherent bias of AI systems. These systems frequently learn from extensive datasets that embed existing societal prejudices, which may inadvertently be transferred into algorithmic processes. Consequently, AI-generated outputs can reflect gender, racial, or cultural biases, distorting the representation and recognition of creative contributions from diverse populations (Pulivarthy & Whig, 2024; Min, 2023). The so-called “Butterfly Effect” in AI systems illustrates how seemingly minor biases in training data or algorithmic design can produce significant and unintended consequences, particularly for already marginalised populations, thereby intensifying existing inequalities (Ferrara, 2024). Such biases not only undermine the integrity of creative outputs but also constrain innovation by reinforcing stereotypes and narrowing the diversity of expressions acknowledged and protected under IP law (Singh, 2024). Addressing algorithmic bias is therefore essential to ensure that AI-generated works accurately reflect the breadth of human creativity and do not perpetuate systemic exclusion within IP recognition.

Disparities in Access to AI Tools

Simultaneously, disparities in access to AI technologies contribute to broader inequities in innovation. Structural barriers such as high costs, inadequate infrastructure, and limited technical expertise often prevent marginalised groups from leveraging AI tools for creative or inventive purposes (Farahani & Ghasemi, 2024). This digital divide enables only those with sufficient resources to harness AI’s potential, thereby exacerbating the gap between privileged and underrepresented communities (Lim, 2022). To address these inequalities, it is imperative to enhance the accessibility and affordability of AI technologies. Moreover, fostering diversity within AI development teams is crucial to ensuring that inclusivity is embedded in the design and implementation of these systems (Singh, 2024; Bhatia et al., 2024). Promoting equitable access to AI tools must therefore remain a policy priority to democratise innovation and prevent resource-rich entities from monopolising the creation and control of IP.

Implications for Fairness and Inclusivity in IP Protection

Algorithmic bias and unequal access to AI tools have profound implications for fairness and inclusivity in IP protection. Biased algorithms may result in inequitable IP determinations, such as the misattribution of creative works or the exclusion of particular groups from IP benefits (Lim, 2022). To mitigate these risks, AI systems utilised in IP evaluation and enforcement processes should be subject to fairness audits and transparency obligations. Such mechanisms can identify and rectify embedded biases, thereby promoting equitable IP governance across diverse communities (Lim, 2022; Tariq, 2024). Additionally, policymakers must adopt a holistic perspective that integrates ethical and human rights considerations into AI-related IP regulation. Future regulatory frameworks should be informed by principles of social justice, fostering inclusive governance structures that safeguard the rights and contributions of all creators and innovators (Min, 2023; Chadha, 2024). Embedding fairness and ethical oversight within AI-driven IP systems is not merely a legal necessity but a moral imperative to ensure that innovation benefits society equitably.

The convergence of AI, algorithmic bias, and access disparity presents a significant challenge to the equitable administration of IP rights. Achieving fairness in this evolving landscape requires comprehensive legal reform, robust ethical governance, and the inclusive development of technology. By confronting these challenges directly, IP systems can evolve to embody the values of diversity, justice, and collective creativity in the digital age. Ultimately, for AI-driven creativity to yield benefits for all, future IP frameworks must place equity at their core as a guiding and operational principle.

Global and Cultural Implications

The global and cultural dimensions of AI within the realm of IP create a complex landscape characterised by legal contradictions, ethical dilemmas, and the urgent need for culturally aware governance. As AI systems increasingly produce creative and original outputs, traditional IP regimes—originally designed to protect human authors and inventors—struggle to adapt. This tension has prompted extensive debate concerning authorship, ownership, and the legal validity of AI-generated works, particularly within a global context marked by significant jurisdictional divergence. Since AI technologies operate across borders, the harmonisation of IP governance has become imperative to ensure that regulatory frameworks remain responsive to technological developments, respectful of cultural diversity, and resilient against exploitation. Consequently, understanding the global implications of AI for IP requires a paradigm shift from purely technical regulation toward inclusive and culturally sensitive legal reform.

Cross-Border Inconsistencies in IP Treatment

Divergent national interpretations of AI-generated works have resulted in inconsistencies in IP protection and enforcement across jurisdictions. For example, the British model attributes ownership to the individual who initiates the AI's creative process, whereas other legal systems remain ambiguous about defining authorship in the absence of direct human input (Fadavi & Alizadeh, n.d.). These disparities hinder cross-border enforcement of IP rights, as countries apply differing legal standards to AI-generated content (Bharati, 2024; Munshi & Barai, 2022). In the absence of a unified international framework, inventors and innovators face uncertainty regarding the recognition and protection of AI-assisted works, which may discourage global collaboration and impede innovation. The fragmented nature of international regulation underscores the pressing need for intergovernmental cooperation to ensure that AI-generated IP is treated fairly, consistently, and transparently across jurisdictions.

Risks of AI-Enabled Appropriation of Indigenous and Traditional Knowledge

AI systems often rely on vast datasets that may include elements of indigenous and traditional knowledge, raising serious concerns regarding unauthorised use and cultural appropriation. When AI models are trained on such data without obtaining prior consent or providing equitable compensation, they risk exploiting the intellectual and cultural heritage of indigenous communities (Ghalayini & Awalmeh, 2025). This practice not only violates the rights of knowledge holders but also undermines traditional practices and erodes cultural identity (Haché, n.d.). The use of indigenous knowledge by AI systems without ethical safeguards can commodify and decontextualise cultural expressions, perpetuating historical patterns of exploitation. Protecting indigenous knowledge in the AI era therefore necessitates legislative

mechanisms that prioritise informed consent, cultural recognition, and the preservation of heritage.

Need for Culturally Sensitive and Globally Harmonised IP Governance

In light of these challenges, scholars and policymakers increasingly advocate for a globally harmonised IP framework that is both technologically adaptive and culturally responsive. Such a framework must recognise and respect the contributions of indigenous communities, ensuring that their knowledge is not appropriated or misused (Napitupulu et al., 2023; Mahingoda, 2024). Achieving this objective requires sustained international cooperation, the development of ethical standards, and active public participation to establish IP systems that preserve cultural integrity while fostering innovation (Napitupulu et al., 2023; Mahingoda, 2023). By embedding cultural awareness into IP governance, policymakers can advance inclusive innovation while safeguarding diverse knowledge systems. Accordingly, the establishment of a culturally informed and globally coordinated IP regime is essential to ensure that AI-driven innovation respects and protects the richness of human heritage.

AI presents both formidable challenges and unprecedented opportunities within the sphere of IP. When supported by a robust legal and ethical framework, AI can stimulate creativity, enhance global cooperation, and contribute to economic growth while safeguarding cultural diversity and equitable access to technology. However, if existing IP laws are not carefully reformed to accommodate the unique nature of AI-generated works, there is a significant risk of exacerbating social inequalities and perpetuating cultural insensitivity. To prevent such outcomes, policies must be developed that are globally relevant, culturally respectful, and oriented toward equitable benefit-sharing among all communities. The ongoing discourse reveals that although AI introduces complex legal and ethical questions, it also provides a critical opportunity to reform IP systems in ways that advance fairness, inclusivity, and collective progress. The future of IP in the age of AI will ultimately depend on proactive, inclusive governance that aligns technological advancement with cultural and social responsibility.

Conclusion and Path Forward

The integration of AI with IP introduces a complex array of legal, ethical, and cultural challenges. Emerging technologies are increasingly testing the capacity of existing IP frameworks to remain relevant and effective. There is significant ambiguity surrounding authorship and ownership of AI-generated works, while issues such as algorithmic bias and unequal access to AI resources exacerbate these challenges. Moreover, the diversity of legal interpretations across jurisdictions and the potential appropriation of indigenous and traditional knowledge by AI systems without consent further intensify these concerns. Collectively, these issues underscore the urgent need for both legal and ethical reforms. Contemporary legal doctrines must be reconceptualised to accommodate the creative and inventive capacities of AI while simultaneously safeguarding human dignity and cultural heritage.

To ensure that AI-driven innovation remains equitable and inclusive, IP systems must be grounded in the principle of equality. This involves fostering collective ownership, acknowledging diverse contributions, and ensuring that marginalised communities also benefit from technological progress. Equity should not be regarded as a peripheral consideration, but

rather as a central tenet in the design of future IP systems. Accordingly, equitable IP mechanisms are essential to prevent the monopolisation of AI-generated creativity by dominant actors and to promote innovation that is participatory and inclusive in nature.

Future legislative reforms should therefore aim to establish new categories of IP rights for AI-generated works, clarify ownership structures, and delineate frameworks for human-machine collaboration. Ethical governance must also be prioritised through the implementation of equality audits, algorithmic transparency, and culturally responsive policies. To ensure that IP regimes reflect global diversity and respect indigenous knowledge systems, international cooperation will be indispensable in setting coherent standards. A unified and transparent approach to IP governance is essential to address the multifaceted challenges posed by AI while upholding fairness, accountability, and cultural sensitivity.

In conclusion, while AI holds immense potential to transform creativity and innovation, its integration within IP systems must be approached with prudence and ethical foresight. Equity should serve as the guiding principle—not merely to keep pace with technological advancement, but to ensure that all societies benefit equitably from AI-driven innovation. By fostering IP systems that are fair, transparent, and culturally respectful, the global community can move toward a future where technology enhances collective progress rather than deepens inequality. Ultimately, morally grounded and forward-looking reform is imperative to ensure that IP law evolves in tandem with the intelligent technologies it seeks to regulate.

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ARTIFICIAL INTELLIGENCE IN WAQF MANAGEMENT IN MALAYSIA: A PATH TOWARD DIGITAL TRANSFORMATION

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Abstract: *Waqf (Islamic endowment) plays a vital role in Malaysia's socio-economic development, particularly in supporting education, healthcare, and community welfare. However, the management of waqf assets has long faced challenges such as inefficient record-keeping, underutilization of properties, and lack of transparency. As Malaysia moves toward digital transformation, Artificial Intelligence (AI) presents a promising avenue to enhance waqf governance and operational efficiency. This paper explores the potential of AI technologies—such as data analytics, geospatial intelligence, and natural language processing—in addressing key issues in waqf management. It begins by outlining the current landscape of waqf administration in Malaysia, highlighting institutional frameworks and existing limitations. The discussion then focuses on how AI can be applied to improve asset tracking, optimize land use, automate administrative processes, and analyze legal and historical documents. While the benefits are substantial, the paper also considers the challenges of implementation, including data privacy concerns, Shariah compliance, and institutional readiness. Ethical considerations and stakeholder trust are emphasized as critical factors in successful adoption. The paper concludes by recommending strategic steps for integrating AI into waqf management, including pilot projects, policy support, and interdisciplinary collaboration. By leveraging AI responsibly, Malaysia can unlock the full potential of waqf assets, ensuring their sustainable impact for future generations.*

Keywords: *Artificial Intelligence, Waqf Management, Islamic Finance, Digital Transformation*

Introduction

Waqf, or Islamic endowment, is a vital instrument in Malaysia's socio-economic landscape, contributing to public welfare through education, healthcare, and poverty alleviation. Administered primarily by State Islamic Religious Councils (SIRCs) and coordinated at the federal level by agencies such as Department of Waqf, Zakat and Haji (JAWHAR), waqf assets hold immense potential for sustainable development. However, despite their significance, waqf institutions in Malaysia continue to face persistent challenges in management and governance.

In this regard, waqf management in Malaysia continues to face inefficiencies stemming from fragmented data systems and manual record-keeping, which complicate the distribution process and raise concerns about whether aid reaches the intended beneficiaries (Razimi et al., 2016). These challenges are compounded by the absence of a centralized and standardized system for asset registration, making it difficult to track and manage both zakat and waqf assets effectively (Ghazali et al., 2021). Similarly, waqf management suffers from underutilization of assets, as many waqf properties remain idle or underdeveloped due to financial constraints, inadequate planning, and a shortage of skilled personnel (Ismail et al., 2015; Perai, 2005). The

situation is further exacerbated by the current waqf land registration system, which is burdened by lengthy and complex procedures that delay development and hinder optimal utilization (Ghazali et al., 2021). Moreover, limited transparency in asset management erodes public trust and diminishes the willingness of individuals to contribute to zakat and waqf initiatives (Abas & Raji, 2018).

In light of Malaysia's broader digital transformation agenda, there is an urgent need to modernize waqf management systems. Emerging technologies, particularly Artificial Intelligence (AI), offer promising solutions to these longstanding issues. AI can enhance data integration, automate administrative processes, and support strategic decision-making through predictive analytics and geospatial intelligence. Moreover, tools such as Natural Language Processing (NLP) can assist in analyzing legal documents, historical records, and fatwas, thereby improving compliance and governance.

This paper explores how AI can be effectively leveraged to address the structural and operational challenges in waqf management in Malaysia. It examines the current landscape, identifies key areas for AI application, and discusses the ethical and institutional considerations necessary for successful implementation. By embracing AI, waqf institutions can move toward a more transparent, efficient, and impactful future.

Current Landscape of Waqf Management in Malaysia

Waqf management in Malaysia operates within a complex institutional framework involving multiple stakeholders, including the SIRC, JAWHAR, and the Malaysia Waqf Foundation (MWF). These entities are entrusted with the governance, administration, and development of waqf properties, which play a significant role in supporting socio-economic initiatives such as education, healthcare, and poverty alleviation.

SIRCs serve as the primary custodians of waqf assets, responsible for strategic planning, budgeting, and performance monitoring. However, their effectiveness is often constrained by limited financial resources and administrative capacity (Siraj, 2012; Ismail et al., 2015). JAWHAR provides coordination and policy oversight across states, while MWF focuses on enhancing governance and accountability mechanisms (Siraj, 2012). In recent years, corporate waqf initiatives have emerged, allowing business entities to manage waqf assets for both commercial and philanthropic objectives, thereby increasing their value and impact (Saad et al., 2017).

Despite these efforts, waqf management in Malaysia continues to face significant challenges. One of the most pressing issues is the lack of a standardized and centralized system for asset registration, resulting in ambiguity over property ownership and difficulties in tracking and developing waqf lands (Yunus et al., 2024; Ismail et al., 2015). Transparency and accountability remain limited, partly due to the absence of a dedicated accounting framework for Islamic assets, which undermines public confidence (Siraj, 2012; Yunus et al., 2024).

Furthermore, many waqf properties are underutilized due to financial constraints, poor planning, and a shortage of skilled personnel (Pera, 2005; Mahmood et al., 2017). Governance issues, such as weak internal controls and fragmented coordination among stakeholders, further hinder effective asset management. These challenges are exacerbated by traditional

management systems that lack strategic planning, operate under a fragmented legal framework, and suffer from resource limitations (Siraj, 2012; Ismail et al., 2015; Ibrahim & Rahman, 2024).

Addressing these systemic issues is crucial for unlocking the full potential of waqf assets and ensuring their sustainable contribution to Malaysia's socio-economic development.

Potential Applications of AI in Waqf Management

AI presents a transformative opportunity for improving the management of waqf, an Islamic endowment of property dedicated to public welfare (Md Nor, Mohamad & Yaacob, 2016). In the Malaysian context, where waqf institutions often grapple with administrative inefficiencies, fragmented data systems, and underutilized assets, AI offers a strategic pathway toward modernization. By integrating AI technologies into waqf governance, institutions can significantly enhance operational efficiency, transparency, and accountability—key pillars for achieving sustainable development outcomes.

Data Management and Analytics

AI-driven data management systems can address longstanding issues in asset tracking and record-keeping. Through the use of digital platforms and blockchain technology, waqf institutions can maintain accurate and tamper-proof records, thereby reducing the risk of asset mismanagement and loss (Ali & Jadidah, 2024; Ulhusna et al., 2024). Furthermore, predictive analytics enable waqf administrators to forecast asset performance, facilitating informed decision-making in investment and development planning (Yusof, 2024). This not only improves resource allocation but also enhances the economic viability of waqf projects.

In addition, AI can be employed to analyze large and complex datasets for beneficiary profiling. By identifying patterns and trends in demographic and socio-economic data, AI systems can ensure that waqf resources are distributed equitably and reach the intended recipients. This targeted approach strengthens the social impact of waqf initiatives and supports more inclusive development (Dwairi & Ubadah, 2024).

Geospatial Intelligence

The integration of AI with Geographic Information Systems (GIS) offers powerful tools for mapping and managing waqf lands. Accurate geospatial data can help resolve land disputes, identify idle properties, and support strategic planning for land development (Fahmi & Sugiarto, 2015; Abdullah et al., 2019). Moreover, AI algorithms can analyze spatial patterns to recommend optimal land use strategies, aligning development plans with community needs and maximizing the socio-economic returns of waqf assets (Rohman et al., 2023; Nugroho & Fahmi, 2013).

Automation and Decision Support

AI technologies can significantly reduce administrative burdens by automating routine tasks such as data entry, financial transactions, and reporting. These functions, traditionally performed manually, are prone to errors and inefficiencies. Systems like e-Waqfuna in Indonesia exemplify the potential of digital platforms in waqf administration, offering

centralized access to asset records and enabling more efficient data processing and management (Iman et al., 2020). Beyond operational efficiency, AI also supports strategic decision-making through advanced analytics. Tools such as the Waqf Analytics Platform utilize predictive models to assess the performance and impact of waqf initiatives, thereby informing resource allocation and long-term planning (Yusof, 2024). This data-driven approach enhances the ability of waqf institutions to align their activities with socio-economic objectives and community needs.

Natural Language Processing (NLP)

AI-powered Natural Language Processing (NLP) offers valuable capabilities in the analysis of legal texts, historical documents, and fatwas. By automating the extraction and interpretation of complex legal content, NLP facilitates greater compliance with Shariah principles and improves access to legal resources (Nithya et al., 2024). Moreover, the development of automated fatwa systems using NLP can address the shortage of qualified Muftis by enabling scalable and responsive fatwa generation. These systems classify topics and model queries, thereby streamlining the issuance of fatwas and making religious guidance more accessible to the public (Munshi et al., 2021; Munshi et al., 2022).

Broader Technological Integration

The integration of fintech and blockchain technologies further strengthens waqf management. Blockchain ensures transparency and accountability in waqf transactions by providing immutable records, while fintech innovations enhance fundraising and disbursement mechanisms, connecting donors with waqf projects more effectively (Ali & Jadidah, 2024; Widiyanti, 2023). However, successful implementation of these technologies depends on stakeholder acceptance and trust. The Technology Acceptance Model (TAM) offers a useful framework for understanding user perceptions, emphasizing the importance of perceived usefulness and ease of use in promoting adoption (Zakariyah et al., 2022).

As discussed above, the convergence of AI, NLP, fintech, and blockchain presents a comprehensive digital ecosystem for waqf management. These technologies, when implemented thoughtfully and ethically, have the potential to transform waqf institutions into more transparent, efficient, and impactful entities.

Challenges and Considerations in Implementing AI in Waqf Management in Malaysia

The implementation of AI in waqf management in Malaysia presents a multifaceted challenge that spans technical, legal, ethical, and institutional dimensions. While AI offers promising avenues for enhancing operational efficiency and streamlining administrative processes, its adoption is not without significant obstacles. Addressing these challenges requires a strategic and holistic approach to ensure that AI technologies are effectively and ethically integrated into waqf governance.

Technical Barriers

One of the primary technical challenges lies in the availability and quality of data. AI systems rely on large, structured datasets to function optimally, yet the waqf sector in Malaysia suffers

from limited and fragmented data sources (Mahusin et al., n.d.; Awalluddin et al., 2024). Without comprehensive data, AI applications such as predictive analytics and asset tracking cannot be fully realized. Additionally, the lack of robust digital infrastructure further impedes the deployment of AI solutions. Compounding this issue is the shortage of skilled professionals with expertise in AI and data science. The limited availability of qualified personnel restricts the capacity of waqf institutions to develop, implement, and maintain AI systems (Mahusin et al., n.d.). Addressing this gap requires targeted investment in education, training, and capacity-building initiatives.

Legal and Ethical Concerns

Ensuring Shariah compliance is a critical consideration in the application of AI to waqf management. AI algorithms must be designed to align with Islamic legal principles, particularly in decision-making processes related to asset utilization and beneficiary selection (Yusof, 2024; Rahim et al., 2025). Failure to do so may result in outcomes that conflict with religious obligations and undermine the legitimacy of waqf operations. Moreover, the use of AI raises concerns about data privacy and stakeholder trust. Waqf institutions handle sensitive information, and the potential misuse or unauthorized access to data could erode public confidence. Transparent data governance frameworks and robust privacy protections are essential to foster trust among stakeholders (Hossain et al., 2024; Mufid, 2024).

Institutional Readiness and Change Management

Institutional resistance to technological change poses another significant barrier. Many waqf organizations may be hesitant to adopt AI due to limited awareness of its benefits or concerns about job displacement (Mahusin et al., n.d.; Awalluddin et al., 2024). Overcoming this resistance requires effective change management strategies, including stakeholder engagement, training, and demonstration of value. Furthermore, the successful implementation of AI depends on the presence of sound governance structures and internal controls. Clear policies, procedures, and accountability mechanisms must be established to guide AI adoption and ensure ethical and effective use (Mahmood et al., 2017; Ismail et al., 2015).

Conclusion and Future Direction

The integration of AI into waqf management in Malaysia holds transformative potential for addressing long-standing inefficiencies and unlocking the full value of waqf assets. Through applications such as data analytics, geospatial intelligence, automation, and natural language processing, AI can significantly enhance operational efficiency, transparency, and strategic decision-making. These advancements align with Malaysia's broader digital transformation agenda and offer a pathway toward more impactful and sustainable waqf governance.

However, realizing this potential requires overcoming a range of technical, legal, ethical, and institutional challenges. Issues such as data availability, infrastructure limitations, Shariah compliance, and stakeholder trust must be addressed through coordinated efforts. Institutional readiness and change management are equally critical to ensure that waqf organizations can adapt to and benefit from AI-driven innovations.

To move forward, this paper recommends the initiation of pilot projects that demonstrate the practical benefits of AI in waqf administration. These projects should be supported by clear policy frameworks and guided by ethical standards that uphold Islamic principles. Collaboration among stakeholders—including government agencies, religious authorities, academic institutions, and technology providers—is essential to foster innovation and ensure inclusive implementation. Furthermore, interdisciplinary research is needed to explore the intersection of AI, Islamic jurisprudence, and public administration. Capacity building through education and training programs will also be vital in developing a skilled workforce capable of supporting AI initiatives in the waqf sector.

Accordingly, by embracing AI thoughtfully and strategically, Malaysia can modernize its waqf institutions and ensure that these sacred assets continue to serve the public good in a more efficient, transparent, and equitable manner.

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DEVELOPMENT OF A 2U CUBESAT CAMERA MISSION PROTOTYPE FOR NATIONAL SATELLITE EXPERTISE DEVELOPMENT IN MALAYSIA

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Abstract: *This study focuses on the development of small satellites in Malaysia, aligning with the National Space Policy (DAN2030) to build internal expertise and collaboration. The National Remote Sensing Satellite Development Program (PSPJN) is developing a 2U small satellite based on the CubeSat standard for a camera mission. The primary objectives are to develop a functional camera capable of capturing images and to ensure hardware and software compatibility with Birds-2 operational performance, despite the challenge of integrating components in a compact structure. The proposed solution involves utilizing small-sized commercial off-the-shelf (COTS) camera components and a specifically designed Camera Mission Assembly (CMA) system for the 2U CubeSat platform, integrating a miniature optical camera module with a 5MP CMOS sensor, control electronics, data storage, and compact power and temperature control units. However, this approach faces limitations including restricted resolution quality, exposure to space radiation, temperature management challenges, and limited data processing and transmission capabilities. Additionally, talent and competency development are significant constraints. The research aims to develop a 1-module camera prototype for the 2U small satellite, which can be used for subsequent small satellite missions and contribute to continuous human capital development for national satellite development.*

Keywords: *National Space Policy (DAN2030), 2U Small Satellite, Camera Mission, Prototype, Competency*

Introduction

At present, the global community is experiencing rapid and highly aggressive growth in terms of technology and manufacturing. This technological advancement has entered the era of the Fourth Industrial Revolution (IR 4.0), where digital technologies such as Artificial Intelligence (AI), Big Data, robotics, the Internet of Things (IoT), and cloud computing enable faster innovation, higher productivity, and the creation of new socio-economic opportunities [1].

The use and adaptation of digital technology today are seen as highly significant. Information and Communication Technology (ICT) has also historically been considered a major driver of the global economy [2]. Digital technology is one of the key developments within space technology. There is a saying: “*Who controls technology will rule the world, and who controls space technology will rule the world.*” This expression reflects the strong influence of technology—particularly space technology—on human life.

Digital information technology and the internet now appear to dominate the world, as they significantly facilitate human activities, with many individuals depending on internet networks and digital platforms. Through internet connectivity, information can be disseminated efficiently and rapidly across the globe [3]. The convergence of digital technology and space technology has become a critical driver for national development in the 21st century. At present, many countries have placed strong emphasis on the development of space technology, recognizing its importance and necessity in advancing national growth and competitiveness.

The focus of space technology development varies across nations. For developed countries, their space programs are far more advanced and highly futuristic compared to those of developing nations, such as those in Southeast Asia. In this context, regional cooperation in space-related matters exists under the ASEAN Economic Community, particularly through the ASEAN Ministerial Meeting on Science and Technology (AMMST) under the Committee on Science and Technology (COST). Effective planning is essential, as space technology is a high-technology sector that requires substantial investment and long-term commitment. As highlighted: *“We must think not only of our national interests but posit them against regional interest—that is a new way of thinking about our problem”* [4]. The space economy, driven by the rapid growth of space technology and applications, opens up vast new opportunities for ASEAN member states—not only in terms of economic benefits but also with respect to broader sustainable development [5].

Malaysia’s Involvement in Space Technology

Malaysia’s participation in the space sector commenced in 1988 with the establishment of the National Remote Sensing Centre. As one of the earliest Southeast Asian nations to venture into space technology—following Indonesia—Malaysia demonstrated an early commitment to developing indigenous capabilities in remote sensing and related space applications.

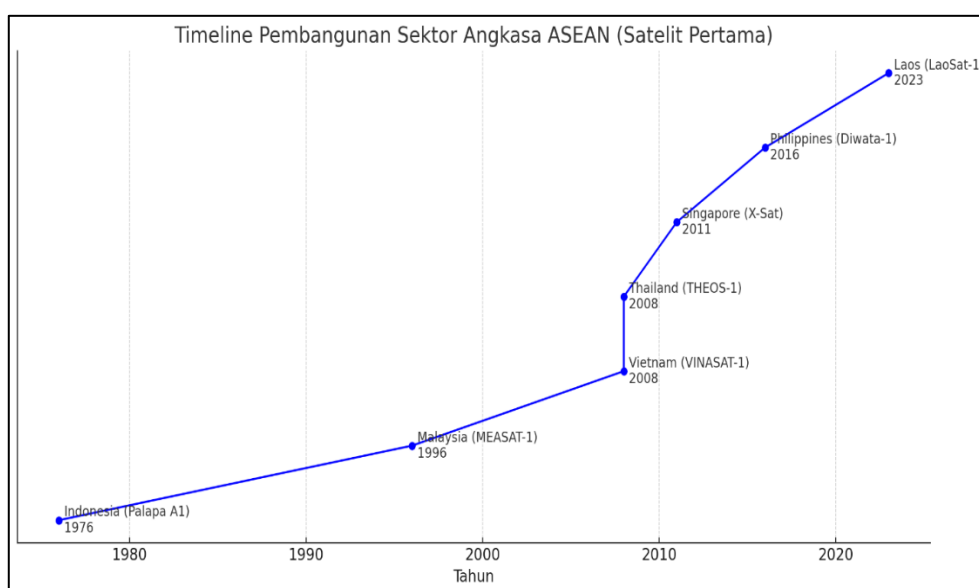


Figure 1: Shows The Involvement Countries Within ASEAN in Satellite Development
Source: The Indonesian Journal of Southeast Asian Studies

To strengthen national economic growth and support sustainable development, the Malaysian Government identified the necessity of establishing a centralized facility for remote sensing data management. This facility would enable systematic integration of development planning, land-use management, mapping, and research applications. As a result, the National Remote Sensing Centre (MACRES) was established in 1988, marking the institutional foundation of Malaysia's space technology program. The trajectory of Malaysia's space mission progressed further with the establishment of the National Planetarium in 1989, which functioned as a dedicated platform for outreach, education, and scientific dissemination. At that period, the Planetarium played a critical role as the only national institution disseminating public knowledge on space science, space technology, and space weather phenomena.

Table 1: Demonstrating Malaysia's Achievements in Space Technology Development and Exploration

Year	Achivements
1995	National Microsatellite Development Program , providing hands-on exposure to microsatellite engineering and laying the groundwork for local human capital development
1996	Successful deployment of MEASAT-1 and MEASAT-2 , Malaysia's first geostationary communication satellites, establishing a regional telecommunication and broadcasting infrastructure
2000	Launch of TiungSAT-1 on 26 September 2000, Malaysia's first remote sensing satellite , which validated local expertise in Earth observation applications, data processing, and satellite system integration
2002	Agensi Angkasa Negara (ANGKASA) was establish specifically to assist The Angkasawan Program, at that time.
2007	Implementation of the National Astronaut Program , culminating in Malaysia's first human spaceflight mission to the International Space Station (ISS).

Source: Dasar Angkasa Negara 2030

From 1988 to 2025, Malaysia's space technology development demonstrates a progressive national commitment towards space capability enhancement. This period reflects continuous investments in:

- Satellite manufacturing and operations (e.g., RazakSAT series, PSPJN initiatives).
- Policy frameworks such as the National Space Policy 2030 (DAN2030), anchoring space as a driver of national capacity and innovation.
- Competency-building programs aimed at developing a sustainable ecosystem of engineers, researchers, and technologists within the aerospace domain.

Collectively, these initiatives position Malaysia as an emerging spacefaring nation that integrates space technology into national development strategies, ensuring that space remains a strategic enabler for economic resilience, technological competitiveness, and future innovation capacity. Despite Malaysia's involvement in space technology development since 1988, culminating in the establishment of the Malaysian Space Agency (MYSA) in 2019, there was previously no dedicated, detailed, and long-term action plan to drive the national space sector. This absence of a comprehensive framework led to fragmented progress and caused Malaysia to fall behind other Southeast Asian nations in terms of space capability. Most importantly, it hindered the development of a sustainable pool of domestic expertise in critical space technologies. During this period, the majority of space-related initiatives were conducted

as one-off projects, often constrained by limited financial resources, resulting in outputs that remained primarily at the research and experimental stage without achieving continuity or operational maturity.

Recognizing these shortcomings, the Government approved the **National Space Policy 2030 (DAN2030)** in 2017. This policy document provides the **strategic reference framework** that defines the vision, mission, and direction of the Malaysian Space Agency in advancing the national space sector. The DAN2030 outlines **five (5) strategic pillars**, each with significant roles in ensuring the sustainable development of Malaysia's space program. Among the key priorities emphasized in this policy is the **development of indigenous expertise and competencies**, aimed at building a self-reliant national capability to design, develop, and operate space systems.

Table 2: Five Strategic Pillars- DAN 2030 Outlines

Pillar 1:	Strengthening governance to optimize the nation's access to space capabilities
Pillar 2:	Focusing on space technologies, infrastructure, and applications that are significant to the nation
Pillar 3:	Driving the development of space science and technology while building indigenous expertise
Pillar 4:	Contributing to the national economy and societal well-being
Pillar 5:	Enhancing and strengthening international cooperation and networks

Source: Dasar Angkasa Negara 2030

Expertise is essential to ensure that the development of the space sector can be carried out in a sustainable manner. The third pillar (Pillar 3) of the National Space Policy 2030 (DAN2030) states: *"Driving the Development of Space Science and Technology and Building Expertise."* Therefore, in order to ensure that the objective of capacity and expertise building is achieved, this research paper will focus on the methods and measures undertaken to develop such expertise. The central question is: What strategies and implementations are most appropriate to ensure that by 2030, Malaysia will be able to produce a significant pool of experts in the field of space, thereby contributing to both the short-term and long-term national economic agenda.

Implementation of human capital development and expertise (Literature)

Expertise development is a core element in ensuring the success of a nation's space technology development. Without skilled experts, space technology would only rely on imported equipment and external technical services. This undermines technological sovereignty and reduces the effectiveness of long-term development [6]. Expertise development also guarantees *technological sovereignty*. By having local engineers, scientists, and researchers skilled in satellite systems, mission control, and space data analysis, Malaysia can implement satellite projects comprehensively—from design, integration, and testing, to operations and data analysis [Malaysia Space Agency, 2021]. Many methods and approaches have been implemented in developed countries for their human capital development. For example, the NASA Exploration System Mission Directorate (ESMD) has provided a program for highly educated field workers. A robust space program requires a well-trained and highly educated workforce. As a result, NASA strives to contribute to Science, Technology, Engineering and Mathematics (STEM) education among U.S. youth—particularly in underserved and

underrepresented communities—in order to train and develop the highly skilled scientific, engineering, and technical workforce required to achieve the space exploration goals [7], [8]. This is in line with NASA’s vision of “*creating a constellation of new capabilities, supporting technologies, and foundational research that enables sustained and affordable human and robotic exploration*” [NASA Education Strategic Coordination Framework: A Portfolio Approach, June 2009].

In Russia, training and exposure to space technology began as early as the 1960s after the end of World War II. Russia considered outer space to be a strategic field. For that purpose, the government established a long-term planning structure that integrated:

- Academy of Sciences of the USSR – focusing on fundamental research.
- Design Bureaus (such as OKB-1, Energia, Lavochkin, Chelomei) – designing and developing space systems.
- Ministry of Defense & Defense Industry – providing large budgets, facilities, and testing [9].

These three entities became the backbone of expertise development in Russia. In addition, the establishment of educational and training institutions offering specialized courses in aerospace engineering, the presence of cadet programs and cosmonaut training conducted by the Yuri Gagarin Cosmonaut Training Centre, the availability of comprehensive facilities supported by clear policies, strong government backing, and international cooperation were among the key approaches to expertise development in Russia.

There are some differences in the way expertise was built among the people of Japan. Japan’s expertise development plan covers various aspects and age groups. Through the Japan Aerospace Exploration Agency (JAXA), Japan focuses on the training of researchers, engineers, scientists, and technical staff through education, practical training, and collaboration. At the early stage, JAXA introduced an informal education initiative known as the JAXA Space Education Program for Informal Education, which was offered to high school students. In this program, students were divided into teams and worked at JAXA. They were taught to plan “missions” and were assigned specific roles. This program not only introduced STEM knowledge but also built confidence and future career awareness [10].

Table 3: Comparison among Countries in Expertise Development Missions

Aspect	Russia	Japan (JAXA)	NASA (USA)
Approach	State-driven & centralized (Soviet legacy, government-controlled)	Triple Helix (academia–industry–agency collaboration)	Innovation-driven & diversified (agencies, universities, private companies)
Main Methods	Elite technical universities (MAI, Bauman); cosmonaut training at Star City; hands-on training via Soyuz, Progress, ISS; large facilities at Baikonur/Vostochny	JAXA–university–industry collaboration; CubeSat & BIRDS Project; Kibo ISS module; regional international training	Internships & Fellowships (Pathways, NPP); leading research universities; partnerships with SpaceX/Blue Origin; STEM outreach



Technology Focus	Rockets & crewed spacecraft; GLONASS; Lunar & planetary exploration	Small satellites & disaster applications; SLIM Lunar Mission; ASEAN/ISS collaboration	Lunar exploration (Artemis), Mars; frontier technologies (AI, quantum, nuclear propulsion)
Strengths	Comprehensive infrastructure; long historical experience	Global collaboration; application-oriented education; strong R&D discipline	Largest funding; open innovation ecosystem; dynamic commercial partnerships
Challenges	Funding constraints; Western technology sanctions; limited component innovation	Limited budget → need for focused priorities	Bureaucracy; high costs; budget dependent on Congress

Source: NASA Education Strategic Coordination Framework: A Portfolio Approach, June 2009.

Towards the Development of National Expertise (Methodology)

The Malaysian Space Agency (MYSA) has been mandated to drive the advancement of space technology under the National Space Policy 2030 (DAN2030). As part of this mandate, Malaysia envisions positioning itself as a regional leader in space research, technology development, applications, and scientific exploration within Southeast Asia. Achieving this aspiration requires a multi-dimensional readiness encompassing advanced facilities, sustainable technological capabilities, sufficient financial resources, strong political stability, and—most critically—a highly skilled space workforce.

Human capital development represents a pivotal foundation for sustaining national space capabilities. The cultivation of expertise must be strategically designed and implemented from the earliest stages of the education pipeline, with emphasis on STEM-based education to create a technically competent talent pool. This approach mirrors the long-term strategies adopted in countries such as Japan, where STEM integration is embedded into national education, and complements alternative models of capacity building, such as intensive training programs and specialized workforce development initiatives observed in Russia and South Korea.

Within the Malaysian context, expertise development in the space sector is systematically structured under DAN2030. The Malaysian Space Exploration 2030 Implementation Plan (MSE2030) provides both short-term and long-term roadmaps, with flagship initiatives including the National Remote Sensing Satellite Development Program (PSPJN, 2023–2025). These initiatives serve as practical platforms to integrate technical knowledge, strengthen indigenous satellite engineering capabilities, and foster the growth of Malaysia's domestic expertise in alignment with global space-technology standards.

The National Remote Sensing Satellite Program (PSPJN) has been established as a strategic platform to build domestic capabilities in satellite technology, with a particular focus on the remote sensing segment. The primary objective of PSPJN is to ensure that Malaysia is capable of developing its own satellites—covering the full mission lifecycle from design, assembly, integration and testing (AIT), to operations and data analysis. Beyond delivering technological outputs, PSPJN plays a critical role in strengthening national competency development by involving engineers, researchers, and students throughout the entire satellite mission chain.

As part of its phased approach, PSPJN began with the development of small satellites in the CubeSat form factor, serving as a training platform for hands-on technical skill development. This stepwise progression enables local teams to acquire practical experience in satellite mission integration before advancing to more complex phases, such as the development of a national-scale optical remote sensing satellite [11].

Methods, Approaches, and Implementation

To ensure the successful implementation of PSPJN and the achievement of its objectives, a Local Expertise Development Program through the Development of a 2U CubeSat has been established.

Development of the 2U CubeSat Project

The 2U CubeSat development project serves as the pilot expertise-building initiative under PSPJN. Through this project, it is expected that local/internal researchers will gain greater exposure to the end-to-end processes involved in satellite development.

The implementation of the 2U CubeSat project involves internal researchers serving at the Malaysian Space Agency (MYSA), representing diverse academic backgrounds and fields of expertise. Most of the participants had neither prior experience in satellite development programs nor formal training in related areas. Each researcher was therefore assigned specific roles according to their respective backgrounds and competencies to contribute effectively to the development of the 2U CubeSat.

Development of the 2U CubeSat Camera Mission

A CubeSat is a type of small satellite standardized in modular units of 1U (10 cm × 10 cm × 10 cm), while a 2U CubeSat has dimensions of 10 cm × 10 cm × 20 cm. This platform is designed based on a modular architecture, enabling cost reduction, shorter development timelines, and design flexibility. Within the context of PSPJN, the 2U CubeSat is developed as an approach to build domestic expertise, strengthen research and development capacity, and prepare for the realization of larger-scale national satellite programs. In any satellite development program, the definition of mission objectives is a critical step, as it directly influences cost, development schedule, and associated risks [12]. For the 2U CubeSat under PSPJN, the selected mission was a camera payload, serving as both a technical demonstration and a platform for capacity-building.

A key reference model is the Joint Global Multi-Nation Birds (JGMNB) project, or simply the BIRDS Project, which was specifically designed to enable researchers to learn the processes of satellite development through hands-on practice. The project not only leverages the inherent advantages of CubeSats—such as low cost and rapid development—but also provides a structured platform for developing countries to design, build, and launch their own satellites. Importantly, it facilitates human capital development, as each participating nation not only deploys a CubeSat but also trains a new generation of engineers who subsequently become an integral part of their respective national space programs [13].

In alignment with this approach, the PSPJN 2U CubeSat Camera Mission adapts the BIRDS project model by focusing on a camera-based payload. This mission provides hands-on exposure to critical processes such as payload integration, data acquisition, storage management, and image downlink operations. By replicating the experiential learning framework of BIRDS while tailoring the payload to remote sensing objectives, PSPJN not only strengthens Malaysia's technical readiness for future optical remote sensing satellites but also ensures that local engineers and researchers acquire the end-to-end competencies required for national-level satellite missions.

The primary mission of the 2U CubeSat expertise development program is to produce a 2U-sized CubeSat prototype that complies with the constraints and specifications outlined in the *JEM Payload Accommodation Handbook – Vol. 8 – Small Satellite Deployment Interface Control Document*. To achieve this, MYSA engineers adopted the development framework and methodologies applied in the BIRDS-2U program as a reference. In addition to serving as a prototype development exercise, the program also incorporates the design and integration of several functional CubeSat subsystems. Within the context of PSPJN, the targeted subsystems are as follows:

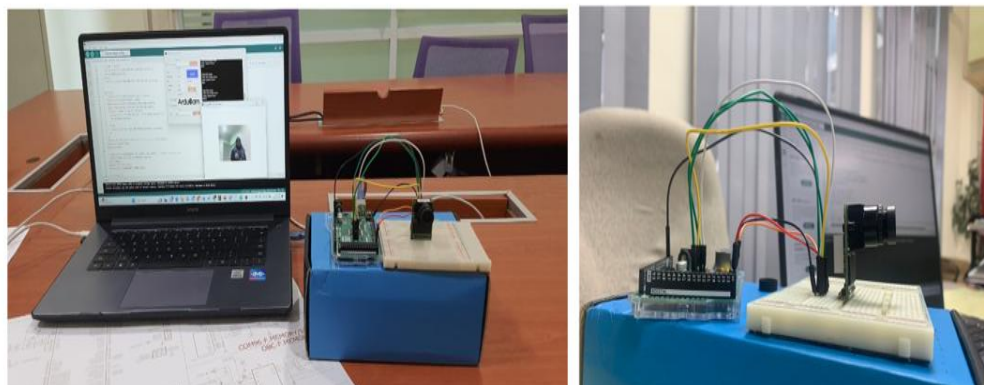
- Camera Mission
- Store and Forward Mission
- Software Backplane Board Mission

Among these, the Camera Mission was prioritized and emphasized, as it directly aligns with the core objective of PSPJN—to develop a National Remote Sensing Satellite through a skilled and knowledgeable local workforce with hands-on satellite development experience. For the Camera Mission, the defined goal was to ensure that the payload camera demonstrates the capability to successfully capture images. To evaluate the effectiveness of expertise development and mission readiness, a set of success indicators for the subsystem was established, including performance, reliability, and mission compliance criteria.

Table 4: Achievement Levels for the Camera Mission

Achievement Level	Mission	Outcome
Minimum	To fully assemble the hardware and software	Ensure compatibility with the operational performance of the ASEANsat camera
Operational	To compare the performance of the camera subsystem	Evaluate results before and after vibration and thermal testing

Source: MDR CubeSat Project for PSPJN



Picture

1: Shows the Component Being Assemble and Tested Using Certain Method and Distance

Source: MDR CubeSat Project for PSPJN

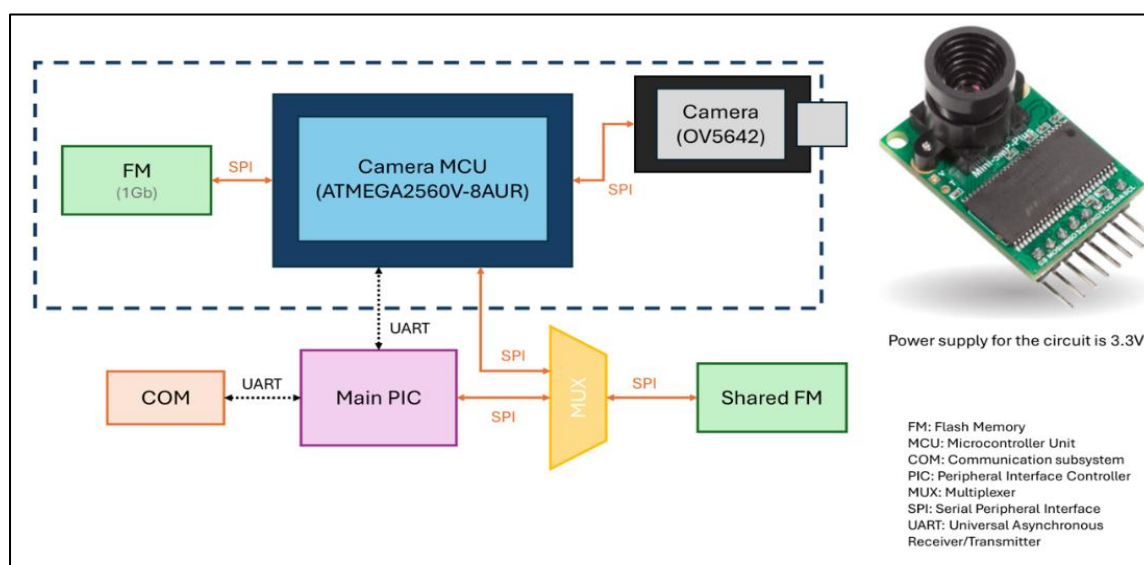


Figure 2: Camera System Architecture

Source: MDR CubeSat Project for PSPJN

Table 5: Camera Mission Subsystem Specifications

Parameter	Specification	Notes / Explanation
Camera Sensor	OV5642 (5 Megapixels)	Two identical camera modules are employed, each equipped with an OV5642 sensor.
Lens / Field of View	25 m per pixel (narrow-angle) 80 m per pixel (wide-angle)	Dual-lens configuration enables imagery with different resolutions: high-resolution (narrow) and wider coverage (wide).
Spatial Resolution (GSD)	5 Modes: Normal, Timer, Continuous, Video, Target	Nominal resolution values: narrow lens provides finer detail (~25 m/pixel), wide lens provides broader coverage (~80 m/pixel).

Camera Operating Modes	JPEG (RGB)	Supports multiple operational modes for both still image and video acquisition.
Image Format	ATmega2560V	Captured images are stored in JPEG format within the visible RGB color spectrum.
Control Microcontroller /	Dual Flash Memory Modules	Camera operations are controlled via ATmega2560V microcontroller interfaced through SPI & I ² C; enables communication with other subsystems.
Memory / Data Storage	SPI + I ² C	Images are temporarily stored in onboard flash memory prior to downlink to ground station.
Interface Communication with Subsystems /	Video recording capability during deployment from ISS	Camera modules interface with mission control and satellite bus subsystems using SPI (Serial Peripheral Interface) and I ² C (Inter-Integrated Circuit) protocols.
Additional Features / Video Function		Video mode specifically utilized to document satellite deployment sequence in the BIRDS-2 mission.

Source: CubeSat-PSPJN References to BIRDS-2

Camera Mission Process for the PSPJN 2U CubeSat Expertise Development

The camera mission process for the PSPJN 2U CubeSat expertise development began with the evaluation of the camera's basic functionality and image acquisition capability. The following activities were carried out systematically:

Phase 1:

- **Initial Camera Inspection and Sensor Validation**
The camera module was physically cleaned, and the OV5642 CMOS image sensor was subjected to preliminary functionality tests to verify responsiveness and signal output integrity.
- **Integration and Programming Phase**
The camera module was integrated with the CubeSat subsystem and programmed using KiCad-based firmware development workflows. Adjustments to the programming architecture were made to accommodate the requirements of the PSPJN training mission, which involved the operation of a single camera module instead of a dual-camera configuration.
- **Preliminary Imaging Test**
The camera successfully captured images at a distance of approximately 30 cm. However, the resulting images appeared blurred and lacked sharpness, indicating the need for lens focus calibration and exposure parameter adjustment.

Phase 2:

- **Focus and Image Quality Optimization**
A secondary testing phase was executed to improve image clarity. The distance between the target object and the sensor was precisely controlled, and lens focus adjustments were conducted to enhance brightness and sharpness of the captured imagery.

- **Sensor-Specific Evaluation**
Detailed performance validation was performed on the OV5642 CMOS sensor module, including sensitivity, resolution handling, and colour response. This step ensured that the sensor operated within expected parameters for CubeSat payload conditions.
- **Data Storage Format Study**
A dedicated study was undertaken to evaluate the camera's onboard data storage formats, focusing on file integrity, compression efficiency (JPEG), and compatibility with downlink and ground-segment processing requirements

Test Results

To ensure that expertise development in space technology could be effectively implemented, an initiative was undertaken to replicate the camera mission model developed by JAXA under the BIRDS-2 small satellite program. Nearly all procedures from the BIRDS-2 process were reproduced; however, due to several limiting factors, the development activities were halted at the camera sensor testing phase.

Despite this limitation, the integration between the camera hardware and software programming (implemented using Altium Designer) was successfully achieved. The system was able to capture a test image (a water bottle), thereby validating the initial functionality of the OV5642 CMOS camera module and its interfacing with the CubeSat's control electronics.

Discussion of Results

The preliminary testing successfully demonstrated the capability of the integrated camera system to capture imagery; however, several technical limitations were identified that highlight areas for further refinement:

- i. **Image Quality and Optical Calibration**
 - The captured image, while proving functional integration, exhibited blur and lack of sharpness.
 - This suggests that the lens focus and optical alignment require further calibration. The absence of fine-tuning mechanisms (e.g., adjustable mounts or software-based image correction) limited the clarity of the output.
- ii. **Sensor Performance Constraints**
 - The OV5642 CMOS sensor responded within expected parameters but showed sensitivity to short-distance imaging conditions (30 cm range).
 - To replicate real mission conditions, further validation at varying distances and under simulated orbital lighting environments (high contrast, low-light) is necessary.
- iii. **Firmware and Software Integration**
 - Programming using Altium Designer workflow proved functional for hardware-software interfacing.
 - Nonetheless, the system exhibited limitations in real-time parameter control (e.g., exposure, gain), which are essential for operational flexibility in space conditions.
- Iv **System-Level Continuity**

- Although the prototype successfully reached the image acquisition milestone, development was discontinued at this stage due to resource and time constraints.
- Full progression into environmental testing (vibration, thermal vacuum, radiation exposure) could not be performed, which restricted validation of the system's operational reliability for an actual space environment.

Conclusion

Overall, the local expertise development program, as outlined in the National Space Policy 2030 (DAN2030) under Pillar 3, has shown significant potential in bridging the long-standing capability gaps in Malaysia's space sector. Through the implementation of the 2U CubeSat mission, modelled after the BIRDS-2 program, local researchers were able to gain valuable hands-on experience spanning the entire mission lifecycle—from defining mission objectives, designing the structural framework of the camera system, to determining image resolution requirements that aligned with the camera mission goals.

Acknowledgment is extended to JAXA for providing access to the BIRDS-2 module, which served as a critical reference in building Malaysia's internal expertise. This initiative demonstrates that capacity building in space technology is neither simple nor short-term; rather, it requires a long-term, structured, and continuous development plan to ensure that expertise is sustained and not lost over time.

As space development is a strategic and high-cost endeavour, leveraging international collaborations is essential to overcoming technical and financial challenges. To ensure the continuity of expertise development, the 2U CubeSat camera mission will be succeeded by the development of a 3U CubeSat, carrying both a camera payload and the TeNeP (Temperature and Electron Density Probe) to measure ionospheric plasma properties. This program will serve as the next phase of Malaysia's satellite engineering capacity-building efforts. The 3U CubeSat is planned for launch in 2027, one year prior to the deployment of the National Remote Sensing Satellite, marking a critical milestone in the nation's journey towards independent space capabilities.

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PURPOSE OVER PRESSURE: RETHINKING ENTREPRENEURIAL SUCCESS AND MENTAL HEALTH THROUGH IKIGAI

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Abstract: *Entrepreneurial discourse has traditionally been dominated by performance-driven metrics such as profit, growth, and scalability, often at the expense of entrepreneurs' psychological health and sense of purpose. While research on entrepreneurial well-being has gained traction, there remains a lack of integrative frameworks that explicitly connect personal fulfilment with sustainable entrepreneurial success. This conceptual paper addresses this gap by proposing the Japanese philosophy of Ikigai as a theoretical lens for rethinking entrepreneurial motivation and outcomes. Drawing on positive psychology, Eastern philosophy, and entrepreneurship studies, the paper advances a model that situates entrepreneurial success at the intersection of passion, competence, social contribution, and financial viability. By reframing success through Ikigai, the paper contributes to the discourse on entrepreneurial resilience and well-being, offering a holistic pathway toward sustainable and human-centred entrepreneurship.*

Keywords: *Entrepreneur's Mental Health, Entrepreneurial Success, Ikigai, Pressure, Success*

Introduction

Entrepreneurship is widely lauded for its contributions to economic development, innovation, and personal freedom. However, it is also associated with high levels of stress, burnout, and mental health challenges (Ovharhe & Chukwuemeka, 2023). According to Yu, Sun, Foo, Zhang and Li (2025), entrepreneurs often operate in high-pressure environments characterized by financial uncertainty, long working hours, and social isolation. These factors contribute to elevated levels of stress, anxiety, and depression among entrepreneurs. A study by Stephen (2018) highlights that the unique challenges faced by entrepreneurs can harm their mental health and well-being. The dichotomy raises the question: Can success be redefined to include well-being, purpose, and personal fulfilment? The constant hustle culture and the stigma associated with discussing mental health issues further exacerbate these problems. Recent studies highlight alarming trends in mental health among entrepreneurs, with disproportionately high rates of anxiety, depression, and burnout. This paper explores the intersection of mental health and entrepreneurial success through the lens of Ikigai, a Japanese concept referring to one's reason for being.

Literature Review

Entrepreneurial Success and Mental Health



Previous studies showed that nearly 49% of entrepreneurs report having a mental health condition, with depression and anxiety being the most common (Cubbon et al, 2021). The entrepreneurial journey, filled with ups and downs, rejections, and failures, often demands emotional resilience and psychological strength. However, the current entrepreneurial ecosystem rarely provides sufficient mental health resources or coping mechanisms. A study by Mohamad et. al (2024), found that self-efficacy and alertness were significant to the success of women entrepreneurs in Malaysia. Successful entrepreneurs can inspire others by identifying key elements and aspects related to their success. Addressing the mental health needs of entrepreneurs is crucial for their well-being and the sustainability of their ventures. As such, mental health support should be integrated into entrepreneurial ecosystems to prevent long-term psychological distress.

Ikigai as a Conceptual Framework ***Origins and Philosophy***

Ikigai translates loosely to "reason for being." Rooted in Japanese culture, it emphasizes harmony, meaning, and balance in life. Unlike Western goal-oriented models, Ikigai encourages continuous self-reflection and integration of multiple life dimensions. This concept encourages individuals to pursue activities that align with their passions, skills, societal contributions, and financial viability. Unlike Western notions of success that often prioritize external achievements, Ikigai focuses on internal fulfilment and balance.

Sartore, Buisine, Ocnareescu & Joly (2023) propose an integrated cognitive-motivational model of Ikigai, emphasizing its relevance in professional contexts and its potential to enhance well-being and performance. The Ikigai framework provides a multidimensional understanding of purpose, combining personal satisfaction with social contribution and economic relevance. It offers a holistic perspective that counters the narrow, profit-centric approach common in traditional entrepreneurship.

Historically, Ikigai has been linked with longevity and happiness in Japanese culture. Studies on the Okinawan population—among the longest-living people globally—attribute part of their longevity to a strong sense of Ikigai. In this context, Ikigai serves as both a philosophical guide and a practical tool for entrepreneurs seeking purpose-driven success.



Figure 1.

Source Venn Diagram: Ikigai

(Ikigai Venn Diagram” is a 21st-century adaptation by Marc Winn that merges Western logical visuals with a Japanese cultural philosophy)

The Four Dimensions of Ikigai

- **What you love (Passion)**
This dimension represents the activities and pursuits that evoke joy, enthusiasm, and intrinsic motivation. When entrepreneurs engage in ventures aligned with what they love, they experience higher engagement, creativity, and resilience. Passion sustains entrepreneurs through uncertainty and challenges, transforming work into a fulfilling endeavor rather than a source of burnout.
- **What are you good at (Profession)**
This element emphasizes competence and mastery — the application of one’s skills and strengths to create value. For entrepreneurs, identifying their professional strengths enhances confidence and credibility, contributing to both personal fulfillment and business success. When entrepreneurs work within their areas of expertise, they are more likely to experience flow — a psychological state of deep focus and satisfaction.
- **What the world needs (Mission)**
This dimension reflects a sense of purpose and contribution to others. Entrepreneurs motivated by societal needs rather than solely profit often report greater psychological well-being and life satisfaction. This mission-oriented perspective connects personal values with community impact, fostering both ethical and emotional fulfillment.
- **What can you be paid for (Vocation)**
The final dimension emphasizes economic sustainability that transforms purpose and skill into a viable livelihood. For entrepreneurs, this means ensuring that their venture not only aligns with their passions but also meets market demand. Financial stability reinforces mental well-being, allowing founders to sustain their mission without chronic stress or burnout.

The intersection of these four elements produces a sense of purpose that is both personally satisfying and socially valuable.

Integrating Ikigai into Entrepreneurial Practice Rethinking Motivation

Entrepreneurs often start businesses driven by passion or market opportunity, but may lose touch with personal meaning over time. An Ikigai-informed approach encourages continuous alignment between individual values and business objectives.

Sustainable Work-Life Integration

Instead of work-life balance, which implies separation, Ikigai promotes integration. Entrepreneurs who live their Ikigai are more likely to experience flow, intrinsic motivation, and resilience, reducing susceptibility to burnout.

Decision-Making and Strategy

Ikigai can serve as a compass in strategic decision-making, helping entrepreneurs evaluate opportunities not only for-profit potential but also for alignment with personal values and long-term satisfaction.

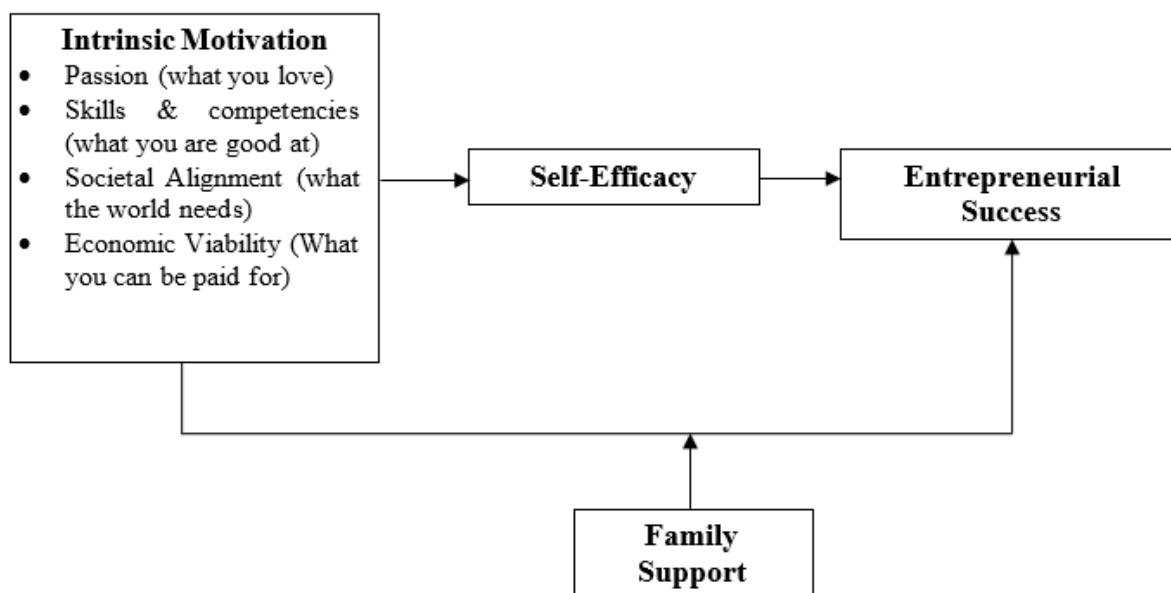


Figure 2: Proposed framework of Purpose Over Pressure: Rethinking Entrepreneurial Success and Mental Health Through Ikigai

Self-Efficacy

Self-efficacy acts as a psychological buffer for those who believe they can control outcomes are less likely to experience depression, anxiety, or entrepreneurial fatigue. When combined with a sense of Ikigai (purpose), self-efficacy reinforces personal meaning and life satisfaction, promoting holistic well-being. Within the Purpose Over Pressure framework, self-efficacy can mediate the relationship between Ikigai (sense of purpose) and mental health outcomes. When entrepreneurs align their passion, profession, mission, and vocation, they naturally build self-

confidence in pursuing meaningful goals, boosting self-efficacy and reducing psychological distress (Neck, Neck & Murray, 2023).

Family Support

Family support typically refers to the emotional, instrumental (practical help), informational, and sometimes financial assistance provided by family members (parents, spouse/partner, siblings) to an individual (whether in career, business, or life contexts). For entrepreneurs, family support can include encouragement, belief in the venture, direct task-help, financial backing, or simply providing a stable home environment. For example, one study defines family support in an entrepreneurial context as „the availability of familial resources (emotional/instrumental) and perceptions of trustworthy support from family members (Welsh, Botero, Kaciak & Kopaničová, 2021).

Methodology

This paper uses a conceptual research methodology to synthesize existing literature on entrepreneurship, mental health, and Ikigai. The approach includes a systematic review of scholarly sources, thematic analysis of theoretical models (e.g., Ikigai, well-being theories), and integration into a novel framework for redefining entrepreneurial success. The paper does not present empirical data collection but proposes a model to guide future qualitative and quantitative research on Ikigai-informed entrepreneurship. Future studies may use interviews, surveys, and case studies to test this model in diverse entrepreneurial contexts.

Implications

Entrepreneurs aligned with their Ikigai report higher levels of life satisfaction, emotional stability, and psychological well-being. This alignment acts as a buffer against the volatility and uncertainty inherent in entrepreneurial ventures, which enhances psychological resilience. Besides that, by legitimizing mental health and personal fulfilment as components of entrepreneurial success, the Ikigai model helps destigmatise vulnerability and encourages a more compassionate culture within entrepreneurial ecosystems in other words, it reduces stigma and broadens success metrics. This paper proposes a shift from linear, growth-centric success models to circular, meaning-driven models informed by Ikigai. The new model acknowledges mental health as a key performance indicator, purpose as a driver of long-term sustainability and entrepreneur as a whole person, not just an economic agent

Conclusion

Entrepreneurship should embrace a more human-centred approach where education includes self-reflection, values, and mental wellness, guided by the Ikigai concept for meaningful innovation. Incubators and accelerators can integrate Ikigai-based mentoring and broaden success metrics to cover personal growth, purpose, and well-being, not just financial milestones. Likewise, governments and institutions can support this shift by funding mental health initiatives and recognizing holistic measures of success in entrepreneurial policies, awards, and grants.



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PERCEPTION TO PREDICTION IN BUSINESS INTELLIGENCE (BI) LEARNING TOOL PREFERENCE: A MACHINE LEARNING APPROACH BASED ON THE UTAUT FRAMEWORK

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Abstract: *Business Intelligence (BI) tools are becoming more common in education, especially in courses that focus on data analysis and visualisation. This study aims to explore students' preferences between two BI learning tools, which are Microsoft Power BI and Google Looker Studio by using behavioral intention constructs adapted from the Unified Theory of Acceptance and Use of Technology (UTAUT) framework. The responses were collected through a four-point Likert-scale questionnaire focusing on six constructs: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Attitude Towards Use, and Behavioural Intention. A total of 78 responses were collected from the diploma level students at the Department of Information Technology and Communication, Polytechnic of Sultan Idris Shah, after they completed the dashboard development task in the BI course. The data were pre-processed in Microsoft Excel and analyzed using five machine learning models that are suitable for small datasets in WEKA. The models are Logistic Regression, J48 Decision Tree, Support Vector Machine (SVM), Naïve Bayes, and k-Nearest Neighbors (KNN). After tuning the model parameters to improve performance, the top two models that achieved high accuracy were J48 (96.15%) and SVM (91.03%), along with precision, recall, and F1-score. The results show that UTAUT constructs can be effectively used to classify BI tool preference among students. These findings highlight the potential of combining behavioral data and machine learning to better understand student technology adoption in practical learning environments.*

Keywords: *Business Intelligence Tools, Microsoft Power BI, Google Looker Studio, Student Perception, UTAUT Framework*

Introduction

Business Intelligence (BI) tools have become an essential component in higher education, especially in technology-related programs where students must not only analyse data but also present insights effectively. Within the Diploma in Information Technology program, the Business Intelligence course (DFP40162) exposes students to industry-standard BI platforms such as Microsoft Power BI and Google Looker Studio. Both tools offer powerful dashboarding and data visualisation capabilities, yet their suitability and ease of adoption among students remain open to discussion.

To better understand students' acceptance and behavioural intention in using BI tools, established theoretical frameworks such as the Unified Theory of Acceptance and Use of Technology (UTAUT) can be applied. At the same time, the increasing integration of machine learning (ML) methods into educational research provides opportunities to move beyond descriptive analysis. Instead of merely reporting student perceptions, ML can be used to predict preferences with higher accuracy, offering practical guidance for lecturers in tool selection.

This study therefore investigates students' experiences in using Power BI and Looker Studio, drawing upon the UTAUT framework and employing machine learning models to classify tool preference. By combining educational theory with predictive analytics, the study aims to contribute both to teaching practice and to methodological innovation in BI learning research.

Research Problems

Despite the growing importance of BI skills in industry, lecturers often face uncertainty in deciding which BI tool should be prioritised in classroom instruction. Student feedback suggests variation in perceived ease of use, performance expectations, and overall preference, but this feedback is rarely translated into actionable guidance. Moreover, existing research in polytechnic settings has largely focused on perception studies, without extending into predictive approaches that could support more evidence-based teaching decisions.

Another gap lies in the application of machine learning to educational technology adoption. While UTAUT has been widely applied in acceptance studies, its potential as a feature set for predictive modelling has not been fully explored. This creates a twofold research problem: (1) the lack of empirical evidence on students' preference between Power BI and Looker Studio in BI learning, and (2) the limited use of ML techniques to predict such preferences in a polytechnic education context.

Research Objectives

In addressing the problems highlighted, this study sets out the following objectives:

- i. To examine students' perceptions of Power BI and Google Looker Studio in the Business Intelligence course, based on the UTAUT framework.
- ii. To develop machine learning models that classify students' BI tool preference using UTAUT-based features.
- iii. To evaluate and compare the performance of selected machine learning models in predicting students' BI tool preference.
- iv. To provide insights for lecturers on the suitability of BI tools for enhancing teaching and learning in polytechnic settings.

Research Questions

Aligned with the above objectives, the study is guided by the following research questions:

- i. What are the key factors influencing students' perceptions of Power BI and Google Looker Studio, as explained by the UTAUT framework?

- ii. How effectively can machine learning models classify students' BI tool preference based on UTAUT features?
- iii. Which machine learning model demonstrates the best predictive performance for classifying BI tool preference?
- iv. How can the findings guide lecturers in selecting BI tools that align with students' learning needs and preferences?

Literature Reviews

The increasing integration of digital technologies in education has transformed how students interact with learning materials, instructors, and institutional systems. Among these technologies, business intelligence (BI) tools have gained traction in higher education, not only for administrative decision-making but also for teaching and learning purposes. BI platforms such as Microsoft Power BI and Google Looker Studio allow students to explore, visualize, and interpret data in real time, fostering analytical and critical thinking skills essential for 21st-century competencies. However, the effectiveness of such tools depends significantly on student acceptance and preference, which are shaped by factors such as usability, perceived usefulness, and contextual support. To evaluate these dynamics, two research streams are particularly relevant: the Unified Theory of Acceptance and Use of Technology (UTAUT) as a theoretical framework, and machine learning (ML) approaches as analytical methods for predicting or classifying student behaviors.

UTAUT Framework in Education

The Unified Theory of Acceptance and Use of Technology (UTAUT) developed by Venkatesh, Morris, Davis, and Davis (2003) has been widely applied to study technology adoption across contexts. The model posits that performance expectancy, effort expectancy, social influence, and facilitating conditions are key determinants of behavioral intention and use behavior. Later extensions, such as UTAUT2, introduced constructs like hedonic motivation and habit to better capture consumer contexts (Venkatesh, Thong, & Xu, 2012).

In educational settings, UTAUT has demonstrated strong explanatory power. For instance, Tahir (2023) applied an extended UTAUT model to examine students' behavioral intention toward online education and found that performance expectancy, effort expectancy, and social influence significantly predicted adoption. Similarly, Sudan (2024) investigated mobile learning adoption among medical students and reported that facilitating conditions and behavioral intention had direct effects on use behavior. A study by Moghavvemi et al. (2016) in Malaysian universities also found that effort expectancy and social influence strongly shaped students' intention to use e-learning platforms. These findings highlight the importance of user perceptions and contextual support when introducing new learning technologies.

Research also suggests that UTAUT constructs are particularly relevant in blended and online learning environments. For example, Islam (2013) demonstrated that UTAUT variables explained a large proportion of variance in students' acceptance of e-learning systems. More recently, Maisha & Shetu (2023) emphasized the role of performance expectancy and facilitating conditions in post-pandemic e-learning adoption, particularly in developing countries where infrastructure and access remain critical concerns. Collectively, these studies

confirm that UTAUT is a robust framework for understanding technology adoption in education and can be adapted to study students' preferences toward specific BI tools.

Business Intelligence Tools and Dashboarding in Education

The use of BI tools in education has primarily been explored from the perspective of institutional analytics and student performance tracking. Dashboards are widely recognized for their ability to transform complex datasets into intuitive visualizations, aiding both educators and students in making informed decisions. According to Ifenthaler et al. (2019), learning analytics dashboards provide timely feedback that supports self-regulated learning. Similarly, Schwendimann et al. (2017) reviewed learning dashboard designs and concluded that usability, interpretability, and alignment with learning objectives are critical factors influencing effectiveness.

Practical implementations of BI dashboards demonstrate their potential in higher education. Jade (2025) developed a Power BI-based college analysis dashboard that visualized intake trends, course offerings, and student distribution, showing how dashboards can enhance institutional planning. Aldowah et al. (2019) also highlighted the role of dashboards in monitoring student engagement, arguing that visual analytics can identify at-risk students and guide timely interventions. While Google Looker Studio has been less studied compared to Power BI, both tools share similar functionalities in creating interactive dashboards. The choice between platforms often depends on perceived ease of use, integration with existing systems, and accessibility by all factors closely tied to UTAUT constructs such as effort expectancy and facilitating conditions.

Despite growing interest, comparative research on student preferences for different BI tools remains limited. Most existing studies focus on e-learning platforms or generic analytics systems rather than head-to-head evaluations of BI software in classroom settings. This creates an opportunity to investigate not only how students adopt such tools but also which specific features influence their preferences.

Machine Learning Applications in Education

Machine learning (ML) has emerged as a powerful approach for analyzing educational data, particularly in predicting academic performance, dropout risks, and learning behaviors. For example, Ahmed et al. (2024) applied classification algorithms such as decision trees, support vector machines, and k-nearest neighbors to predict student performance, achieving high levels of accuracy. Likewise, Dutt et al. (2017) reviewed predictive analytics in higher education and concluded that ML models are effective in identifying patterns that traditional statistical methods may overlook.

Recent studies have also emphasized interpretability in ML applications. Kalita et al. (2025) used a Bi-LSTM model with SHAP values to predict and explain students' GPA outcomes, demonstrating how interpretable ML can provide actionable insights for educators. Meanwhile, Hussain et al. (2019) showed that ML-based early warning systems could accurately identify at-risk students, allowing institutions to intervene proactively. These studies illustrate the versatility of ML in educational research, ranging from performance prediction to behavioral analysis.



Although ML has been extensively applied to predict academic outcomes, fewer studies have explored its use in modeling student preferences for educational technologies. Tahir (2023) and Sudan (2024) used structural models rather than ML techniques, leaving a methodological gap in applying classification algorithms to understand tool adoption. Combining UTAUT constructs as features with ML algorithms for classification could yield deeper insights into the factors that drive students' choices between BI tools like Power BI and Looker Studio.

Synthesis and Research Gap

The reviewed literature demonstrates three key trends. First, the UTAUT framework has been consistently validated as a robust model for explaining student adoption of digital learning tools (Tahir, 2023; Sudan, 2024; Moghavvemi et al., 2016). Second, BI dashboards have shown promise in enhancing both institutional decision-making and student learning experiences, but empirical research directly comparing specific BI platforms such as Power BI and Looker Studio remains scarce (Jade, 2025; Ifenthaler et al., 2019). Third, machine learning has been widely used to predict student performance and engagement (Ahmed et al., 2024; Kalita et al., 2025), yet its application in predicting or classifying student preferences for educational tools is still underdeveloped.

This gap suggests a need for research that integrates UTAUT constructs with ML-based classification to explore student preferences between BI tools in a classroom context. Such a study would not only extend the application of UTAUT in educational technology adoption but also contribute to the growing body of ML-based educational analytics by shifting the focus from performance outcomes to technology preference and usability.

Research Methodology

This study employed a systematic methodology to address the research objectives and questions outlined earlier. The approach combined survey-based data collection with machine learning (ML) techniques to capture both students' perceptions and predictive insights into Business Intelligence (BI) tool preferences. A structured process was followed, beginning with the identification of the study population, followed by instrument development, data collection, and subsequent analysis. This section outlines the research design, sampling, instrumentation, data collection procedure, data analysis methods, and ethical considerations undertaken in the study.

Research Design

This study adopted a quantitative research design utilizing a survey-based approach combined with machine learning (ML) analysis. The purpose of the study was to examine students' perceptions of Business Intelligence (BI) learning tool preference using the UTAUT framework and subsequently predict these preferences through ML models. The design allowed both descriptive analysis of survey responses and predictive modeling of preference patterns.

Population and Sampling

The population of this study consisted of Diploma in Information Technology (IT) students at Polytechnic Sultan Idris Shah who were enrolled in the DFP40162 Business Intelligence course during Session II 2024/2025. A total of 78 students participated, representing the entire cohort for that semester. As the sample included all students, a census sampling technique was employed.

Instrumentation

The research instrument was a structured questionnaire developed based on the UTAUT constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions). The items were adapted from existing validated scales in prior studies and modified to suit the BI learning context. Responses were measured using a four-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) to avoid neutral choices.

Validity and Reliability

To ensure content validity, the questionnaire was reviewed by two lecturers with expertise in educational technology and data analytics. Their feedback was used to refine the wording and alignment of items with the intended constructs.

Data Collection Procedure

Data were collected through an online questionnaire administered via Google Forms. The survey link was distributed to students during class and made available for two weeks. Participation was voluntary and anonymous, and students provided informed consent before completing the questionnaire.

Data Analysis

The data analysis was conducted in two stages:

i. Descriptive Analysis

Descriptive statistics were used to summarize demographic information and students' perceptions of BI learning tool preferences.

ii. Machine Learning Analysis

For predictive modeling, data were preprocessed (cleaning and feature selection) and analyzed using WEKA software. Several ML algorithms suitable for small datasets were explored, including K-Nearest Neighbors (KNN), Naïve Bayes, J48 Decision Tree, Logistic Regression, and Support Vector Machine (SVM). Model performance was evaluated using standard classification metrics: accuracy, precision, recall, and F1-score.

Ethical Considerations

Ethical guidelines were strictly observed throughout the study. Participation was voluntary, anonymity was maintained, and informed consent was obtained from all respondents. Expert review and institutional protocols were followed to ensure the study met ethical research standards.

Data Analysis and Findings

Table 1: Respondent Demographic Analysis

Demographic	Frequency	Percentage (%)
Semester		
4	77	98.72%
5	1	1.28%
Gender		
Male	48	61.54%
Female	30	38.46%

Table 1 shows that the survey involved 78 student respondents, with the majority being Semester 4 students (98.72%, n=77) and only one respondent from Semester 5 (1.28%) also shown in Figure 1. In terms of gender distribution, 61.54% were male (n=48) and 38.46% female (n=30) also shown in Figure 2. This demographic composition indicates that the findings largely reflect the experiences of Semester 4 male students, although both genders were adequately represented.

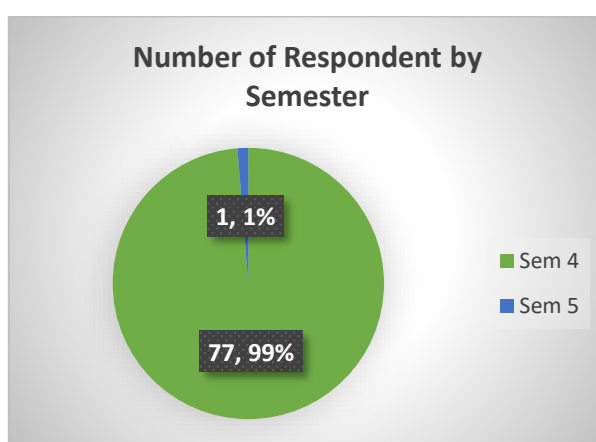


Figure 1: Number of Respondent by Semester

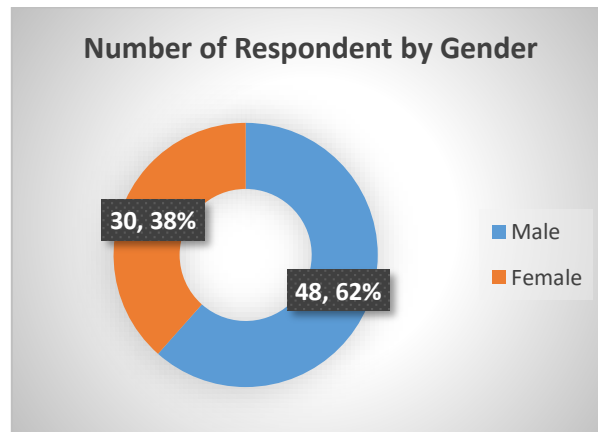


Figure 2: Number of Respondent by Gender

The data analysis based on the UTAUT framework as depicted in Table 2 revealed that Google Looker Studio (GLS) consistently outperformed Microsoft Power BI (PBI) across all constructs.

- Performance Expectancy: Students reported higher expectations of improved performance with GLS ($M = 3.453$, $SD = 0.585$) compared to PBI ($M = 3.282$, $SD = 0.656$).
- Effort Expectancy: GLS ($M = 3.390$, $SD = 0.596$) scored higher than PBI ($M = 3.210$, $SD = 0.784$), suggesting that students perceived GLS as easier to use.
- Social Influence: Students believed GLS ($M = 3.405$, $SD = 0.531$) was more positively influenced by peers and instructors than PBI ($M = 3.269$, $SD = 0.624$).
- Facilitating Conditions: GLS ($M = 3.378$, $SD = 0.518$) again scored higher than PBI ($M = 3.227$, $SD = 0.660$), implying that support and resources were seen as more favorable for GLS adoption.
- Attitude Towards Use: The most notable gap emerged in attitudes, with GLS ($M = 3.387$, $SD = 0.588$) outperforming PBI ($M = 3.159$, $SD = 0.763$). This indicates students had a stronger inclination to accept GLS.
- Behavioral Intention: Similarly, GLS ($M = 3.346$, $SD = 0.670$) scored higher than PBI ($M = 3.149$, $SD = 0.837$), suggesting students were more likely to use GLS in the future.

Overall, the mean score for GLS ($M = 3.394$) was higher than that of PBI ($M = 3.214$). The results clearly suggest that students perceived Looker Studio as more effective, easier to use, and more supported in their learning context.

Table 2: Data Analysis based on UTAUT Framework

Constructs	Mean		Standard Deviation	
	Microsoft Power BI	Google Looker Studio	Microsoft Power BI	Google Looker Studio
Performance Expectancy	3.282	3.453	0.656	0.585
Effort Expectancy	3.21	3.39	0.784	0.596
Social Influence	3.269	3.405	0.624	0.531
Facilitating Conditions	3.227	3.378	0.66	0.518
Attitude Towards Use	3.159	3.387	0.763	0.588
Behavioural Intention	3.149	3.346	0.837	0.67

Further analysis was carried out to classify respondents based on their individual-level preferences. The results are as follows:

- Strong Preference for GLS: 30 respondents indicated a clear preference for Google Looker Studio.
- Strong Preference for PBI: 31 respondents showed a stronger inclination toward Microsoft Power BI.
- Equal Preference: 17 respondents rated both tools similarly, reflecting no strong bias toward either platform.

The classification highlights an interesting split, where nearly equal numbers of students leaned toward GLS and PBI. However, when aggregated, GLS consistently achieved higher mean scores across all constructs, reinforcing its comparative advantage.

While Google Looker Studio was overall more positively evaluated, the close distribution between those preferring PBI and GLS suggests that Power BI retains value for a significant proportion of students, possibly due to familiarity or perceived industry relevance. The findings therefore highlight that while GLS may be more user-friendly and positively perceived in the classroom setting, both tools serve complementary roles in supporting data visualization learning.

Table 3: Classification by Machine Learning (ML) Model

ML Models	Accuracy	Precision	Recall	F1 Score
Logistic Regression	78.00%	0.813	0.750	0.765
J48 Decision Tree	96.15%	0.963	0.962	0.961
Support Vector Machine (SVM)	91.03%	0.916	0.910	0.911
Naïve Bayes	73.08%	0.787	0.731	0.744
k-Nearest Neighbors (KNN).	75.00%	0.750	0.750	0.750

To test whether student preferences could be predicted using UTAUT constructs as input features, several ML algorithms were applied as shown in Table 3. The results revealed clear differences in predictive performance:

- The J48 Decision Tree achieved the highest performance, with 96.15% accuracy and F1 score of 0.961, demonstrating its strength in modeling student preference patterns.
- The Support Vector Machine (SVM) also performed strongly, with 91.03% accuracy and balanced metrics (precision = 0.916, recall = 0.910, F1 = 0.911).
- Logistic Regression achieved moderate accuracy (78.00%) and F1 score (0.765), while Naïve Bayes (73.08%) and KNN (75.00%) were the least effective, likely due to their limitations with small, complex datasets.

The descriptive analysis showed that students perceived Google Looker Studio as easier to use and more effective overall, while preferences for Power BI were still notable among a sizeable portion of the cohort. When predictive models were applied, the Decision Tree (J48) model outperformed others, suggesting that student preferences follow discernible decision rules shaped by UTAUT constructs. The strong performance of SVM further indicates that student perceptions can be reliably mapped to tool choices.

This integration of descriptive and predictive findings highlights two important insights:

- Google Looker Studio is generally favored among students, particularly in terms of ease of use and intention to continue using.
- Machine learning provides a powerful extension of UTAUT, not only explaining but also predicting technology adoption patterns, thereby offering a practical tool for evidence-based teaching decisions.

Conclusion and Future Works

This study examined student perceptions of Google Looker Studio and Power BI using UTAUT constructs, supported by descriptive and predictive analyses. Descriptive findings showed that Google Looker Studio was generally perceived as easier to use and more favorable overall, although Power BI retained notable appeal among some students. On the predictive side, the J48 Decision Tree achieved the highest performance (96.15% accuracy, F1 = 0.961), confirming its ability to model student preferences effectively. These results highlight the value of combining descriptive insights with machine learning to better understand technology adoption in educational settings.

Future research could expand the dataset across multiple institutions to enhance generalizability. Additional machine learning models, such as ensemble methods (Random Forest, Gradient Boosting), could be explored for improved predictive power. Longitudinal studies are also recommended to assess how preferences evolve over time and whether UTAUT constructs remain stable predictors. Integrating qualitative data (e.g., interviews or open-ended surveys) would further enrich the understanding of why students favor certain tools.

From a practical standpoint, these findings suggest that educators should consider leveraging Google Looker Studio in introductory courses, given its ease of use and student acceptance, while positioning Power BI for more advanced analytics tasks. Predictive insights can also guide instructors in tailoring teaching strategies, ensuring that students who may struggle with more complex tools receive targeted support. Ultimately, aligning tool selection with student readiness can improve both learning engagement and outcomes.

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ENHANCING TOURISM INTENT THROUGH IMMERSIVE TECHNOLOGIES: AN EMPIRICAL STUDY OF AR/VR APPLICATIONS IN MUKAH, SARAWAK

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Abstract: *Tourism is a key pillar of Malaysia's economy, yet less-visited regions like Mukah, Sarawak need innovative approaches to stand out. This study explores how augmented and virtual reality (AR/VR) experiences influence the travel intentions of 422 students from Mukah's higher-education institutions. Participants—mostly women aged 19–25—completed a mixed-methods survey evaluating visual clarity, interactivity, emotional engagement and behavioural intention. Overall mean scores were high, particularly for informativeness ($M = 4.55$) and satisfaction ($M = 4.48$). A significant positive correlation ($r = 0.68$, $p < .01$) emerged between satisfaction and intent to visit, indicating that a compelling immersive experience directly fosters interest in a real-world trip. Thematic analysis of open-ended responses revealed three dominant themes—immersion, ease of use and informative content, while respondents suggested richer interactivity, improved audio-visual quality and personalised content. These results highlight that AR/VR applications not only enhance tourism marketing but also serve as educational platforms for cultural learning. The findings align with global evidence that virtual tourism can support multiple Sustainable Development Goals. By investing in immersive storytelling and co-creating content with students, tourism authorities and educational institutions can modernize destination marketing while promoting sustainable development.*

Keywords: *AR/VR Tourism, Smart Tourism, Demographic Segmentation, Malaysia, Exploratory Factor Analysis, Visitor Intention*

Introduction

Tourism is a vital sector in Malaysia's socio-economic development, contributing significantly to national income and cultural exchange. In an increasingly competitive tourism market, destinations must differentiate themselves through innovative means. The integration of digital technologies, particularly immersive tools such as Augmented Reality (AR) and Virtual Reality (VR), presents a promising avenue for enhancing tourism experiences and attracting younger, tech-savvy travelers. Mukah, located in Sarawak, is a culturally rich yet relatively underexplored destination that stands to benefit from such innovations.

Although AR and VR have demonstrated strong potential in global tourism, research in Malaysia remains fragmented and largely concentrated on specific contexts such as theme parks and entertainment attractions. In tourism, AR and VR serve not only as tools for

visualization but also as mediums for storytelling, emotional connection, and cultural preservation. While global studies have documented the growing application of these tools, empirical research in the Mukah, Sarawak, Malaysia context particularly among youth segments such as Politeknik Mukah Sarawak, UiTM Sarawak Mukah Branch, Centex's, and Sarawak Skill students remain limited. This study aims to fill that gap by investigating the extent to which AR/VR applications influence tourism intent among higher education students, focusing on their user experience, satisfaction, and behavioral intentions. By focusing on this youth demographic, the research contributes both to academic literature on smart tourism and to practical strategies for local stakeholders aiming to modernize tourism outreach. To address these issues, this study aims to investigate the role of AR and VR in influencing tourism intent among higher education students. Specifically, it seeks to examine the extent to which immersive applications shape students' willingness to engage in tourism, evaluate their user experiences and satisfaction levels, and assess the relationship between user experience, satisfaction, and behavioral intention toward tourism engagement. The study also seeks to provide data-driven recommendations for designing AR/VR-based tourism experiences that align with the preferences and expectations of student travelers in Sarawak.

Literature Review

Research demonstrates the transformative role of augmented reality (AR) and virtual reality (VR) in tourism. A meta-analysis highlights how these immersive technologies enhance tourist experiences across planning, on-site exploration, and post-visit engagement. A systematic review underscores their capability to simulate realistic experiences without physical travel and emphasizes the dual benefit for developers and tourism providers. Recent literature has synthesized AR and VR studies systematically. One comparative review analyzed 84 articles, revealing methodological evolution and theoretical trends, and recommended a unified research agenda for immersive tourism. Another study focused specifically on VR in tourism and hospitality, providing insights into current advancements and identifying research gaps.

A Malaysian study by Abidin et al. (2024) extended the Technology Acceptance Model (TAM) to examine the adoption of mobile AR in the tourism industry, demonstrating that interactivity, vividness, and information quality significantly influenced perceived usefulness and ease of use, which in turn encouraged customer engagement and intention to use. Similarly, Chin and Tan (2024) explored VR applications in Malaysian theme parks and found that visitors' intention to reuse VR was shaped by both experiential satisfaction and technological novelty, reinforcing VR's potential to sustain tourism demand. These findings underscore the relevance of immersive tools in Malaysia's tourism sector, though research to date remains limited to specific contexts. Globally, AR and VR have been recognized not only as visualization tools but also as powerful mechanisms for storytelling, cultural preservation, and tourist engagement. Yoo and Kim (2024), in their comparative review, identified distinct roles for AR and VR, with AR enhancing on-site experiences through digital overlays and VR offering fully immersive environments that shape decision-making and pre-visit expectations. Complementing this, Zhang et al. (2024) conducted a bibliometric analysis of AR, VR, and MR in cultural heritage, highlighting their role in virtual museums, digital heritage preservation, and gamified tourism experiences. These studies demonstrate how immersive technologies can foster emotional connections and enrich cultural tourism beyond traditional methods. In the educational domain, scholars have emphasized the strong alignment of AR/VR technologies with the digital literacy of younger audiences. Wu et al. (2022) confirmed that

constructs such as perceived usefulness, hedonic motivation, price value, and attitude significantly influenced students' acceptance of AR/VR in tourism education. More recently, Al Mahmoud et al. (2025) revealed that VR was more effective than AR in fostering creative thinking among higher education students, suggesting that full immersion provides deeper engagement and adaptability. Collectively, these studies highlight AR/VR's potential to resonate with digitally proficient student populations. However, empirical evidence from Malaysia, particularly in Sarawak, remains underexplored. Addressing this gap, the present study investigates how AR/VR applications influence satisfaction, behavioural intention, and tourism engagement among Malaysian university and polytechnic students.

The Technology Acceptance Model (TAM) and Theory of Planned Behavior (TPB) in theorizing AR/VR tourism consumption among Malaysian university students. TAM assumes perceived usefulness and perceived ease of use lead to the technology use attitude of the consumer. For AR/VR, such models are synonymous with user satisfaction variables such as interactivity, visual salience, and informational richness. TPB complements TAM in calculating behavioral intentions as a function of attitude, subjective norms, and behaviorally controlled acts. Such characteristics are particularly evident in a student demography, where peer influence and technological self-efficacy are predictors in the determination of behavioral endpoints. A fusion of TAM and TPB provides a holistic view insofar as determining the strength of immersive technologies in summoning tourism behavior, particularly in a digitally literate student demography. It allows hypothesis such as high-level satisfaction in immersive content induces high travel intent. It also forecasts students who are favorable in attitude towards digitized tools with high peer reinforcement are predisposed towards word-of-mouth and consumption of tourism destinations presented in AR/VR platforms."

Methods

This study focused on higher institutions students from higher institutions across Mukah, Sarawak. Their participation reflects an informed, digitally confident demographic essential for evaluating AR/VR tourism technologies. Statistical analyses included descriptive statistics, demographic segmentation, thematic analysis, Pearson correlation, and exploratory factor analysis (EFA) using SPSS v27. Recognizing their familiarity with digital media, the study contextualizes findings within this cohort, which often influences early adoption and demand for technological innovation. A structured questionnaire was administered via Google Forms to 422 students. The survey was divided into quantitative components with Likert-scale questions assessing visual appeal, interactivity, informativeness, usability, emotional connection, learning utility, and behavioral outcomes, and qualitative components where participants described their AR/VR experience, highlighted strengths, and proposed suggestions for improvement.

Findings

Descriptive analysis assessed central tendencies and respondent segments, particularly gender and age groups (19–25 and 36–50). Thematic analysis was applied to open-ended responses, categorizing user feedback into emergent themes and identifying frequency of mention for each qualitative domain. Pearson correlation examined the strength and significance of the relationship between satisfaction and tourism intention. The study was conducted in adherence

to institutional ethical guidelines. Participants provided informed consent, and all responses were anonymized to protect privacy. Data usage was strictly confined to research purposes.

Section A; Demographic Profile

The descriptive analysis showed high mean ratings across all AR/VR features, with the informativeness of content ($M = 4.55$, $SD = 0.75$) and user satisfaction ($M = 4.48$, $SD = 0.71$) scoring the highest. Most respondents are **female (67.54%)**, indicating a strong representation of women in the sample. The **dominant age group is 19–25 years (59.24%)**, followed by respondents under 18 (38.63%), suggesting that the study primarily reflects the perspectives of youth and young adults. Very few participants fall within the 26–35 age range (2.13%), indicating minimal input from older adults. Overall, the data highlights that the findings are most representative of a younger, predominantly female population.

Table 1: Demographic Profile of Respondents

	Frequency	Percentage (%)
Gender		
Female	285	67.54
Male	137	32.46
Age Group		
<18	163	38.63
19-25	250	59.24
26-35	9	2.13

Section B: AR/VR Technical and Visual Experience

This section evaluates the visual clarity, interactivity, multimedia richness, and ease of navigation in the AR/VR tourism experience. All items in this section scored high, with the highest mean (4.55) observed for the informativeness of content. This indicates users found the AR/VR tool highly effective in conveying information about Mukah's attractions.

Table 2: Mean and Standard Deviation AR/VR Technical and Visual Experience

Item	Mean	Standard Deviation
B1. The AR/VR visuals were clear and immersive.	4.45	0.80
B2. I could interact effectively with the AR/VR content.	4.35	0.78
B3. The content was informative about Mukah's attractions.	4.55	0.75
B4. The experience included rich multimedia (audio, video, 3D elements).	4.49	0.75
B5. Navigation within the experience was intuitive and easy.	4.46	0.71
C1. I felt as if I was physically present in Mukah while using AR/VR.	4.22	0.88
C2. The AR/VR experience made me feel emotionally connected to the culture.	4.29	0.83
C3. I enjoyed the overall AR/VR experience.	4.34	0.77

C4. I found the AR/VR experience to be useful in learning about Mukah.	4.41	0.78
C5. I would prefer using AR/VR over brochures or websites for tourism info.	4.33	0.79
D1. I am more interested in visiting Mukah after this AR/VR experience.	4.24	0.82
D2. I would recommend this experience to other travelers.	4.37	0.78
D3. I would like to explore more destinations using similar technology.	4.43	0.75
D4. I am satisfied with the AR/VR application as a promotional tool.	4.48	0.71

Section C: Emotional & Cultural Engagement

This section measures emotional connection, enjoyment, and cultural learning from the AR/VR experience. All items scored above 4.3, with cultural connection being particularly strong.

Table 3: Mean and Standard Deviation for Emotional & Cultural Engagement

Item	Mean	Standard Deviation
C1. I felt as if I was physically present in Mukah while using AR/VR.	4.22	0.88
C2. The AR/VR experience made me feel emotionally connected to the culture.	4.29	0.83
C3. I enjoyed the overall AR/VR experience.	4.34	0.77
C4. I found the AR/VR experience to be useful in learning about Mukah.	4.41	0.78
C5. I would prefer using AR/VR over brochures or websites for tourism info.	4.33	0.79

Section D: Behavioural Intentions & Satisfaction

This section explores participants' intent to visit Mukah, recommends AR/VR experiences, and their satisfaction with the AR/VR application. The results reflect a highly favourable response, although the conversion to visit intention has slightly lower mean scores (4.24).

Table 4: Mean and Standard Deviation for Behavioural Intentions & Satisfaction

Item	Mean	Standard Deviation
D1. I am more interested in visiting Mukah after this AR/VR experience.	4.24	0.82
D2. I would recommend this experience to other travelers.	4.37	0.78
D3. I would like to explore more destinations using similar technology.	4.43	0.75
D4. I am satisfied with the AR/VR application as a promotional tool.	4.48	0.71

Thematic Analysis

Open-ended responses were analysed to capture user sentiments and qualitative feedback. The analysis revealed three dominant themes across responses: "immersive," "easy to use," and "informative." These themes were frequently mentioned, indicating high levels of user appreciation for the AR/VR experience. Additionally, common suggestions included enhanced interactivity, better visual/audio quality, and more personalized experiences.

Table 5: Summary of Thematic Analysis

Theme	Frequency of Mentions	Example Keywords
Immersive Ness	126	"Engaging," "realistic," "felt present"
Ease of Use	97	"user-friendly," "simple," "smooth"
Informative	88	"Educational," "insightful," "learned a lot"
Suggested Improvements	104	"Better interaction," "improve visuals," "more content"

These qualitative insights enrich the quantitative findings by confirming user expectations and preferences. They indicate the growing demand for more dynamic, personalized, and high-fidelity immersive tourism content.

Correlation Analysis

To examine the relationship between user satisfaction and tourism intention, a Pearson correlation analysis was conducted. Results revealed a strong, statistically significant positive correlation ($r = .68$, $p < .01$), indicating that higher satisfaction with the AR/VR experience is associated with a stronger intention to visit Mukah.

Table 5: Correlation Between Satisfaction and Travel Intention

AR/VR Technical and Visual Experience	Emotional & Cultural Engagement	Pearson r	Significance (p-value)
Overall Satisfaction	Travel Intention	0.68	< .01

This result highlights the strategic importance of enhancing user satisfaction through immersive technology, as it plays a direct role in influencing behavioural intentions.

Discussion and Conclusion

The study's findings offer compelling evidence of the positive role that immersive technologies can play in shaping tourism intent, particularly among university students in Malaysian higher education institutions. This demographic, typically characterized by digital fluency and high engagement with technology, responded favorably to the AR/VR applications in terms of usability, informativeness, and emotional impact. The thematic analysis revealed that immersion, ease of use, and informative content were primary drivers of satisfaction. These align closely with the expectations of tech-savvy students who are accustomed to interactive and engaging digital platforms. Suggestions for improvements such as increased interactivity and personalization further reflect a demand for experiential depth and relevance, pointing toward the potential for co-creative or adaptive AR/VR tourism content in the future.

Quantitative findings reinforce these themes. The strong positive correlation ($r = .68$) between user satisfaction and travel intention demonstrates that immersive experiences can effectively convert interest into behavioral intent. This is especially significant within a student population, where affordability and informational wealth often guide travel decisions. Factor analysis further validated the integrity of the measurement model, with a unidimensional construct capturing interconnected aspects of user experience. The high internal consistency across visual, emotional, and behavioral dimensions suggests that students perceive immersive applications holistically supporting their use not only for tourism promotion but also for cultural education and engagement. Together, these findings underscore the capacity of immersive technologies to function as both promotional tools and educational platforms, particularly suited to the learning styles and media consumption habits of higher institutions students.

This study affirms the significant role of AR/VR technologies in enhancing tourism intent and cultural connection, especially among Malaysian university students. The convergence of immersive engagement, user satisfaction, and increased travel interest underscores the effectiveness of AR/VR as a promotional medium tailored to the preferences of digitally native audiences. Given the strong influence of satisfaction on behavioral intent, strategic investments in interactive features, personalized content, and educational design can amplify both user engagement and destination appeal. For institutions and tourism agencies, the findings suggest that integrating AR/VR into broader smart tourism strategies can be particularly impactful when targeting student populations. Future development efforts should consider co-design approaches involving students as content contributors or testers, fostering a sense of ownership and cultural relevance. Moreover, collaboration between tourism boards and academic institutions could serve dual purposes: promoting lesser-known destinations like Mukah while enriching experiential learning opportunities. By leveraging immersive technology in culturally meaningful and demographically attuned ways, stakeholders can better position destinations like Mukah within the evolving landscape of smart, student-centered tourism.

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INTEGRATING NAQLI APPROACHES IN MATHEMATICS LEARNING: DETERMINING THE QIBLAT DIRECTION USING SPHERICAL TRIGONOMETRY

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Abstract: *This research proposal examines the integration of Naqli approaches in mathematics learning, with a focus on determining the Qiblat direction through the application of spherical trigonometry. The study aims to bridge religious knowledge (Naqli) and rational knowledge (Aqli) by demonstrating the relevance of mathematical concepts in fulfilling essential Islamic practices. Determining the Qiblat is a significant aspect of Muslim worship, requiring accurate calculations based on the Earth's spherical geometry. By employing spherical trigonometry, this research introduces a learning module that connects mathematical problem-solving with practical religious applications. The approach not only enhances students' understanding of mathematical concepts but also promotes meaningful learning by situating mathematics within their spiritual and daily lives. Furthermore, this integration supports holistic education, fostering both intellectual growth and religious appreciation. The expected outcomes are to highlight the pedagogical value of blending Naqli and Aqli knowledge in mathematics education, while offering an innovative framework for teaching and learning that enriches students' cognitive and spiritual development.*

Keywords: *Spherical Trigonometry; Qiblat Direction; Gifted Education; INAQ*

Introduction

In Islamic education, the integration of *Naqli* (revealed knowledge from the Quran and Sunnah) and *Aqli* (rational or empirical knowledge) is essential in nurturing balanced individuals who are intellectually competent and spiritually conscious, to provide a more holistic and meaningful learning experience. In facing the Qibla, which is the direction of the Kaaba in Mecca, is a fundamental requirement for performing prayers. While determining this direction is straightforward in proximity to Mecca, but it becomes complex for Muslims residing in distant locations. This study addresses this challenge by employing spherical trigonometry, a branch of mathematics that deals with the relationships between angles and distances on the sphere's surface, to calculate the Qibla direction accurately.

By integrating Naqli elements, such as references from the Qur'an, particularly from Surah Al-Baqarah (Verse 149), which discusses the change of Qibla direction. The study underlines the synchronisation between religious teachings and scientific methods. The calculated Qibla

azimuth for the Tamhidi Centre is $292^{\circ} 35' 44.4''$ from true north, demonstrating the practical application of spherical trigonometry in fulfilling religious obligations (Shapiee et al., 2022).

This integration of Naqli and Aqli knowledge not only enhances the accuracy of religious practices but also enriches the educational experience by demonstrating the relevance of mathematical concepts in real-life religious contexts. Previous studies have applied spherical trigonometry to compute Qiblat direction in various contexts, demonstrating both the feasibility and the accuracy of mathematical methods (Maknun, 2021; Wahyuni et al., 2024).

Wahyuni et al. (2024) used spherical trigonometry to compute the Qiblat direction at different locations across Indonesia. They emphasized that having accurate geographic coordinates and using the great-circle arcs are key to obtaining correct results. Nuril Fathoni Hamas and Abdul Ghofur (2024) addressed common errors caused by incorrect quadrant placement in spherical trigonometry computations, proposing modern computational tools to minimize such errors.

However, there remains a gap in explicitly embedding *Naqli* perspectives in how such mathematical content is taught not just presenting the computations, but connecting them to Islamic worldview, jurisprudence, and spiritual meaning. In the Malaysian context, students may perform trigonometric computations well but may lack understanding of why determining the Qiblat direction is of religious significance or how it aligns with revealed sources.

Therefore, this study seeks to explore how Naqli approaches can be integrated in teaching spherical trigonometry, specifically by guiding students to determine the Qiblat direction mathematically while simultaneously deepening their religious understanding. The research aims to investigate how this integration affects students' conceptual understanding, motivation, and ability to apply spherical trigonometry accurately in real-world religious contexts.

Literature Review

Spherical trigonometry is a field of mathematics focused on the relationships between the angles and sides of spherical polygons, particularly spherical triangles (Palen, 2020). It specifically examines how angles and distances interact on the surface of a sphere such as the Earth. This branch of mathematics plays a crucial role in determining locations, charting routes, and navigating across long distances, making it essential in the evolution of navigation methods.

The origins of spherical trigonometry can be traced back to ancient civilizations, where early astronomers and mathematicians began recognizing the Earth's curvature and its impact on navigation (Toomer, 1984). Pioneers such as Ptolemy and Islamic scholars like Al-Biruni made notable contributions to the advancement of this field. For centuries, spherical trigonometry has served as a fundamental tool in navigation (Bowditch, 2017), enabling navigators to calculate unknown distances and angles on the Earth's surface for accurate positioning and route planning. The application of this mathematical discipline by early explorers laid the groundwork for modern navigation, with continuous advancements improving both accuracy and dependability (Wright, 2019).

Spherical trigonometry is also integral to Great-Circle sailing, a navigation method that follows the shortest route between two points on a sphere. This technique is crucial for long-distance

sea travel as it reduces both journey time and distance. The Great-Circle path is derived through spherical trigonometric equations, incorporating the Earth's radius and the angular separation between locations (Vanicek & Krakiwsky, 1986). Accurate computation using spherical trigonometry is necessary to identify intermediate waypoints along this route (Bowditch, 2017).

Modern technologies like the Global Positioning System (GPS) continue to depend on the core principles of spherical trigonometry. While advanced algorithms now handle the complex calculations, the fundamental mathematical relationships remain unchanged. Recent research has explored the integration of spherical trigonometry with contemporary navigation tools, including GPS and electronic chart systems (Hofmann-Wellenhof et al., 2001). GPS, which operates using satellite signals, has greatly enhanced the accuracy of position determination. However, a solid understanding of spherical trigonometry remains vital for interpreting and validating the data produced by these systems. Combining traditional navigation methods with modern technologies provides redundancy and enhances the overall reliability of navigation.

Methodology

This study employed a qualitative design with an applied mathematical approach, focusing on the integration of *Naqli* and *Aqli* knowledge in mathematics learning.

Research Design

The study adopted a case-based instructional design where the teaching of spherical trigonometry was embedded within the context of Qiblat determination. This design was chosen to connect mathematical computations with real-life religious practices, aligning with the objective of integrating *Naqli* approaches in mathematics education (Abd Rahman, 2018).

Data Collection

Data were collected through:

- Document Analysis: Review of Qur'anic verses, Hadith, and classical Islamic jurisprudence texts relating to Qiblat direction to identify *Naqli* elements
- Mathematical Formulae: Referring to spherical trigonometry formulae used in Qiblat calculations (Maknun, 2021; Wahyuni et al., 2024).
- Instructional Materials: Development of lesson plans that merged *Naqli* texts with trigonometric problem-solving.

Procedure to Determine the Qiblat Direction/Angle

1. Identifying *Naqli* elements: Qur'anic verses (for example Surah al-Baqarah verse 2:144 on facing the Ka'bah in prayer) and relevant Hadith were selected to provide theological grounding.
2. Embedding in mathematical formulae: Students were introduced to spherical trigonometry concepts such as great circles, spherical triangles, and azimuth angles. These were contextualized through Qiblat problems.

3. Practical calculation using real geographic coordinates (latitude and longitude): Qiblat direction was calculated through spherical trigonometry formulas with Qiblat Azimuth angle, Q :

$$\tan(Q) = \frac{\sin(\lambda_2 - \lambda_1)}{\cos(\phi_1) \tan(\phi_2) - \sin(\phi_1) \cos(\lambda_2 - \lambda_1)}$$

where

ϕ_1 : latitude of observer (your location)

ϕ_2 : latitude of Kaaba ($21.4225^\circ N$)

λ_1 : longitude of observer

λ_2 : longitude of Kaaba ($39.8262^\circ E$)

4. Learning evaluation: Students' understanding was evaluated through written tasks, reflective discussions, and their ability to connect mathematical results with *Naqli* justifications.

Spherical Geometry

Spherical geometry is a non-Euclidean geometry that describes the properties and relations of points, lines, and shapes on the surface of a sphere. A sphere is a three-dimensional shape where all points on the surface are equidistant from the centre. Great circles are the largest circles on a sphere, representing the shortest path between two points (Bowditch, 2002). A triangle is essential for understanding figures on the surface of a sphere. A spherical triangle is three great circle arcs on the sphere. The principles of a spherical triangle solve navigational problems. The sides of a spherical triangle are measured by the central angles subtended by the arcs. Spherical triangle properties, precisely the sides and angles used to solve various navigational problems relating to course and distance.

Data Analysis

Thematic analysis was used to assess:

- Accuracy of mathematical computations (*Aqli* aspect).
- Integration of *Naqli* elements in justifying the significance of Qiblat direction.
- Pedagogical effectiveness in enhancing conceptual understanding and motivation.

Results

The application of spherical trigonometry successfully produced accurate Qiblat directions when compared to verified data from established astronomical references and official fatwa institutions. For example, when calculating the Qiblat direction for Kuala Lumpur ($3.1390^\circ N$, $101.6869^\circ E$), the spherical trigonometry formula produced an azimuth angle of approximately 291.0° from true north, which closely matched official values reported by Jabatan Mufti Malaysia.

In this research, Surah al-Baqarah (2:144) was used to highlight the divine command of facing the Ka'bah in prayer which is:

“Indeed, We see the turning of your face, [O Muhammad], toward the heaven, and We will surely turn you to a Qiblah with which you will be pleased. So turn your face toward al-Masjid al-Haram. And wherever you [believers] are, turn your faces toward it [in prayer].”

This verse provides the religious foundation for Muslims in determining the Qiblah direction. In the modern context, the application of spherical trigonometry serves several purposes such as to calculate the Qiblah direction with precision from any location across the globe (Maknun, 2021), to demonstrate the practical validity of this Qur’anic command through the disciplines of astronomy and mathematics (Wahyuni et al., 2024), and to establish a meaningful connection between *Naqli* (revelation) and *Aqli* (reason, science, and mathematics), in line with the objectives of Islamic education to harmonize spiritual and intellectual knowledge (Al-Attas, 1993; Abd Rahman, 2018).

Case Study: Calculation the Qiblat direction (Azimuth Angle) from Kuala Lumpur, Malaysia to the Kaaba in Makkah.

$$\tan(Q) = \frac{\sin(\lambda_2 - \lambda_1)}{\cos(\phi_1) \tan(\phi_2) - \sin(\phi_1) \cos(\lambda_2 - \lambda_1)} \quad (1)$$

where

ϕ_1 : latitude of location, Kuala Lumpur ($3.139^\circ N = 0.0548 \text{ rad}$)

ϕ_2 : latitude of Kaaba ($21.4225^\circ N = 0.3739 \text{ rad}$)

λ_1 : longitude of location, Kuala Lumpur ($101.6869^\circ E = 1.7741 \text{ rad}$)

λ_2 : longitude of Kaaba ($39.8262^\circ E = 0.6950 \text{ rad}$)

$$\lambda_2 - \lambda_1 = 39.8262^\circ - 101.6869^\circ = -61.8607^\circ \text{ or } -1.0791 \text{ rad}$$

Substitute the values in radians into Equation (1), yields:

$$\tan(Q) = \frac{\sin(-1.0791)}{\cos(0.0548) \tan(0.3739) - \sin(0.0548) \cos(-1.0791)}$$

$$\tan(Q) = \frac{-0.8829}{0.36772} \approx -2.404$$

$$Q = \arctan(-2.404) \approx -67.46^\circ$$

Since azimuth is measured clockwise from True North, added 360° to get a positive bearing:

$$Q = -67.46^\circ + 360^\circ = 292.54^\circ$$

Using the spherical trigonometry formula, the Qiblat direction from Kuala Lumpur, Malaysia to Kaaba, Makkah is:

$$Q \approx 292.54^\circ$$

This means the Qiblat direction is about 292.5° clockwise from True North (West-Northwest) direction.

Discussion

The results demonstrate that contextualizing spherical trigonometry through the Qiblat problem not only enhances computational accuracy but also provides meaningful connections to Islamic practices. This aligns with prior research that emphasizes the importance of authentic contexts in improving mathematical understanding (Maknun, 2021). By situating trigonometric concepts within the lived experience of Muslim students, abstract knowledge becomes more relevant and applicable.

The inclusion of Qur'anic verses (e.g., Surah al-Baqarah 2:144) and Hadith in the teaching process fostered a dual awareness among learners: mathematics is not merely a technical subject, but also a tool for fulfilling religious obligations. This supports earlier works that stress the harmony between revelation (*Naqli*) and reason (*Aqli*) in Islamic education (Al-Attas, 1993). The results suggest that such integration nurtures a holistic educational experience that transcends the boundaries of secular and religious knowledge.

Students reported increased motivation and engagement when lessons were anchored in Qiblat determination. This aligns with theories of meaningful learning (Ausubel, 1968), which argue that knowledge retention is enhanced when new concepts are linked to learners' existing value systems. In this case, the integration of *Naqli* perspectives allowed learners to see mathematics as not only intellectually challenging but also spiritually purposeful.

Conclusion

This study has demonstrated that the integration of *Naqli* approaches in mathematics learning, specifically in the context of determining the Qiblat direction using spherical trigonometry, provides both academic and spiritual value. The findings confirmed that spherical trigonometry enables precise calculation of the Qiblat direction, aligning closely with official astronomical references. More importantly, embedding Qur'anic and Hadith perspectives into the learning process transformed the mathematical task into an act of fulfilling religious duty, thus fostering deeper meaning for learners. The integration of *Naqli* and *Aqli* knowledge encouraged students to appreciate mathematics not merely as an abstract discipline but as a tool for religious practice. This duality of purpose enhanced their motivation, engagement, and reflective thinking, while also promoting a holistic worldview in line with the aims of Islamic education.

Based on the findings, several recommendations are proposed such as Mathematics curricula in Islamic schools and universities should explicitly incorporate *Naqli* perspectives, ensuring that mathematical concepts are linked with Qur'anic injunctions and Hadith wherever relevant. Educators should be equipped with both mathematical knowledge and the ability to integrate Islamic perspectives. Professional development programs can help teachers design lessons that balance rigor with spiritual significance. Moreover, further studies should be conducted with larger and more diverse student groups to validate the effectiveness of *Naqli* integration across contexts. comparative studies between conventional and *Naqli*-integrated mathematics teaching would provide deeper insights into long-term impacts.



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INTEGRATING NAQLI AND AQLI KNOWLEDGE IN MATHEMATICS EDUCATION: QIBLA DETERMINATION USING TONGKAT ISTIWA'

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Abstract: *The integration of naqli (revealed knowledge) and aqli (rational knowledge) has long been emphasized in Islamic education as a means of fostering holistic learning. This study explores the pedagogical potential of Qibla determination through the use of the tongkat istiwa' (shadow stick method) as a practical approach to integrating Islamic values into mathematics education. By applying principles of geometry, measurement, and astronomical observation, the calculation and verifying of the Qibla direction using the sun's position during specific times of the year are done. At the same time, the activity connects with naqli sources by highlighting Quranic verses and Hadith related to Qibla orientation, thereby strengthening the spiritual dimension of the lesson. This research adopts a qualitative approach and the observation to examine the effectiveness of the method. Findings indicate that the integration of naqli and aqli elements not only enhances conceptual understanding in mathematics but also promotes spiritual appreciation, critical thinking, and contextualized learning. The study concludes that the tongkat istiwa' method serves as a valuable model for faith-based STEM education, bridging scientific reasoning with Islamic worldview.*

Keywords: *Naqli, Aqli, Mathematics Education, Qibla, Tongkat Istiwa'*

Introduction

In Islamic education, the integration of *naqli* (revealed knowledge derived from the Qur'an and Hadith) and *aqli* (rational, intellectual knowledge) represents a balanced approach to cultivating holistic learners. This integration ensures that the pursuit of scientific and mathematical knowledge is not separated from spiritual values, but instead supports a meaningful understanding of both material and spiritual dimensions of life (Hashim & Rossidy, 2000; Osman, 2010). Mathematics, as a universal discipline, offers a powerful medium for this integration, particularly when concepts are applied in real-life contexts that resonate with Islamic practices and beliefs.

One of the most significant applications of mathematics in Islamic tradition is the determination of the Qibla direction, which is central to the performance of daily prayers. The Qur'an explicitly commands believers to face the Sacred Mosque in Makkah during worship: "*So turn your face toward al-Masjid al-Haram. And wherever you [believers] are, turn your faces toward it*" (Qur'an 2:144). Throughout history, Muslim scholars such as Al-Biruni and Al-Khwarizmi developed advanced mathematical and astronomical methods to establish accurate Qibla orientations for different regions (King, 1999; Saliba, 2007). These contributions illustrate how *aqli* knowledge was harmonized with the *naqli* obligation of facing the Kaabah in worship.

In the contemporary classroom, the use of traditional tools such as the *tongkat istiwa'* (shadow stick) provides an opportunity to revive this integration by linking mathematical concepts such as geometry, measurement, and solar movement with the spiritual act of prayer orientation. The *tongkat istiwa'* method employs the phenomenon of *istiwa' a'zam* (the sun's zenith over the Kaabah) to determine the exact direction of the Qibla. By observing and analyzing the shadow of a vertical stick at specific times of the year, students can directly apply mathematical reasoning to solve a problem of great religious significance (Shaharuddin, 2017). This experiential approach not only deepens their understanding of abstract mathematical concepts but also cultivates an appreciation of the harmony between divine revelation and human reasoning.

Given the growing emphasis on faith-based STEM education, this study examines how the integration of *naqli* and *aqli* knowledge through Qibla determination using the *tongkat istiwa'* can enhance mathematics learning. The approach aims to foster critical thinking, contextual application, and spiritual awareness among students. In doing so, it contributes to the broader objective of producing learners who are not only competent in academic knowledge but also firmly rooted in Islamic values and worldview.

Literature Review

Integration of Naqli and Aqli Knowledge in Education

The integration of *naqli* (revealed knowledge) and *aqli* (rational knowledge) has been a central discourse in Islamic educational thought, especially in efforts to overcome the dichotomy between religious and secular sciences. Hashim and Rossidy (2000) emphasized that true knowledge in Islam should reflect a synthesis of revelation and reason, ensuring that education nurtures not only intellectual competence but also spiritual consciousness. Similarly, Osman (2010) argued that contemporary Islamic education must embrace an integrative approach that equips learners with critical thinking skills while grounding them in Islamic values. Within mathematics education, this integration can manifest through contextualizing abstract concepts within meaningful Islamic practices, thus enhancing both cognitive and affective learning outcomes.

Mathematics and Islamic Pedagogy

Mathematics has historically played a vital role in Islamic civilization, particularly in areas such as astronomy, geometry, and geography. Muslim scholars like Al-Khwarizmi and Al-Biruni contributed significantly to algebra, trigonometry, and spherical geometry, motivated in part by the need to determine prayer times and Qibla orientation (King, 1999; Saliba, 2007).



Their work demonstrates how *aqli* knowledge served religious obligations, reflecting the integration of rational inquiry with spiritual practice. In modern classrooms, incorporating Islamic contexts in mathematics teaching can increase student motivation and engagement. Research by Abdullah (2018) suggests that faith-based contextualization in STEM education can foster deeper connections between learners and the subject matter, providing relevance that extends beyond the classroom.

Qibla Determination and the Tongkat Istiwa' Method

The determination of the Qibla has been a longstanding practical application of both mathematical and astronomical knowledge. Traditional methods included the use of sundials, astrolabes, and gnomons, which relied on solar movements and geometric principles (King, 1999). One of the most accessible and accurate traditional methods is the *tongkat istiwa'* (shadow stick), which utilizes the solar phenomenon of *istiwa' a'zam*, when the sun is directly overhead the Kaabah. During this event, the shadow cast by a vertical stick aligns precisely with the Qibla direction. Shahrudin (2017) highlighted that this method remains highly accurate and provides a unique opportunity for experiential learning in both religious and scientific contexts. Moreover, incorporating the *tongkat istiwa'* into mathematics lessons allows students to apply geometric concepts, such as angles and measurement, while reinforcing their spiritual awareness of Qibla orientation.

Contemporary Relevance of Integrative Approaches

In recent years, there has been an increasing emphasis on faith-based STEM education, where science and mathematics are taught in relation to religious values and practices (Nasr, 2012). This approach not only strengthens students' academic performance but also fosters a holistic worldview that harmonizes intellectual pursuits with spiritual growth. The integration of *naqli* and *aqli* knowledge in mathematics through Qibla determination offers a practical model for such pedagogy. By employing the *tongkat istiwa'* method, educators can bridge traditional Islamic scientific heritage with contemporary classroom learning, ensuring that students develop both conceptual mastery and spiritual consciousness.

Methodology

Research

This study adopted a **qualitative classroom-based research design** to explore how the integration of *naqli* and *aqli* knowledge through the *tongkat istiwa'* method can enhance mathematics learning. A qualitative approach was selected because it allows for in-depth investigation of students' understanding, reflections, and experiences in connecting mathematical concepts with religious practices (Creswell, 2014). The research emphasized experiential learning, in which students applied abstract mathematical principles in a practical, faith-based context.

Participants

The participants consisted of **20 upper secondary school students** (aged 14 years old) enrolled in a gifted secondary school in Malaysia. The school was selected because of its dual curriculum structure, integrating religious and academic subjects. Students were purposively

sampled as they had prior exposure to both geometry concepts and basic Islamic knowledge related to prayer practices, which supported the aims of this study. Two mathematics teachers and one Islamic education teacher were also involved to facilitate lessons and provide observations.

Research Setting

The study was conducted within the school compound, utilizing an open space that allowed direct observation of the sun's position without obstruction. The research took place during the annual solar phenomenon known as *istiwa' a'zam*, which occurred on 28 May at 5:16 p.m. and 16 July at 5:28 p.m. (Malaysia Standard Time). These dates were chosen because the sun is positioned directly above the Kaabah, allowing accurate determination of the Qibla direction.

Instruments and Materials

The main instrument used for data collection was the **tongkat istiwa'** (a vertical stick placed on a flat surface), supported by:

- Worksheets containing guiding questions linking geometry and Qibla determination.
- Student reflection journals documenting their experiences.
- Teacher observation checklists to capture student engagement and understanding.

Procedure

The research was carried out in three stages:

1. **Pre-lesson briefing** – Students were introduced to the concept of *naqli* and *aqli* knowledge integration, as well as the importance of Qibla determination in Islamic practice. Relevant Qur'anic verses (e.g., Qur'an 2:144) and Hadith were shared by the Islamic education teacher.
2. **Practical activity using the tongkat istiwa'** – During the solar zenith event, students observed the shadow of the stick and recorded its direction. They then applied geometric reasoning to determine the Qibla orientation, comparing their results with compass and digital Qibla applications for verification.
3. **Post-activity reflection** – Students completed reflection journals describing how mathematics and Islamic teachings were integrated in the activity. Group discussions and teacher-led debriefing sessions further explored their understanding of the integration process.

Data Collection and Analysis

Data were collected through multiple sources:

- **Student worksheets and journals** provided insight into mathematical reasoning and spiritual reflection.
- **Teacher observations** documented levels of student engagement, accuracy of calculations, and ability to relate *naqli* and *aqli* knowledge.

Data were analyzed using **thematic analysis** (Braun & Clarke, 2006). Responses were coded into themes such as: (a) mathematical understanding, (b) connection to Islamic values, (c) experiential learning outcomes, and (d) challenges encountered. Triangulation of data sources enhanced the trustworthiness of findings.

Findings and Discussion

Enhanced Mathematical Understanding

The findings revealed that the use of the *tongkat istiwa'* significantly enhanced students' comprehension of mathematical concepts such as angles, measurements, and solar geometry. Students were able to translate abstract geometric principles into a practical, observable phenomenon by recording and analyzing the direction of the stick's shadow during the *istiwa' a'zam*. Many participants reported that this hands-on activity deepened their understanding of how mathematical knowledge operates in real-life contexts. This supports Abdullah's (2018) assertion that contextualized mathematics instruction increases conceptual mastery and retention. Figure 1 shows the *tongkat istiwa'* that has been used in this research.



Figure 1: Tongkat Istiwa'

The *tongkat istiwa'* is frequently used in determining the true north direction based on the position of the Sun in the sky. This method can provide greater accuracy compared to magnetic compasses or other instruments that rely on the Earth's magnetic field. However, the use of the *tongkat istiwa'* requires an extended observation period, beginning with the Sun's appearance in the east during the morning until its position in the west in the afternoon, with several shadow markings recorded throughout the day. According to the concept of the Sun's apparent motion across the sky, the Sun rises in the east, ascends toward the center of the sky, and reaches its highest point at noon. This zenith position is known as *istiwa'*, and in astronomical terms, it corresponds to the Sun crossing the meridian. The meridian line represents the maximum altitude of the Sun's daily motion. After crossing the meridian, the Sun descends westward. At equal altitudes in the morning and afternoon, the Sun casts shadows that align along the same circular path. For example, when the Sun reaches an altitude of 45 degrees in the east during the morning, it will also reach 45 degrees in the west during the afternoon. The midpoint or perpendicular bisector of this circular path, determined using the *tongkat istiwa'*, accurately indicates the true north direction.

For the location of this school, the Qibla bearing is 293 degrees. During the occurrence of the *Istiwa' A'zam* phenomenon, the Sun is positioned precisely at a bearing of 293 degrees, which aligns directly with the Qibla direction. At this moment, the shadow cast by a vertical object will point toward a bearing of 113 degrees, which is the exact opposite direction of the Qibla. This natural alignment provides a highly reliable method of verifying the Qibla direction using the *tongkat istiwa'*, making it both scientifically accurate and spiritually significant. Figure 2

shows the schematic figure of Sun's path, tongkat istiwa', Qibla shadow alignment and qibla bearing.

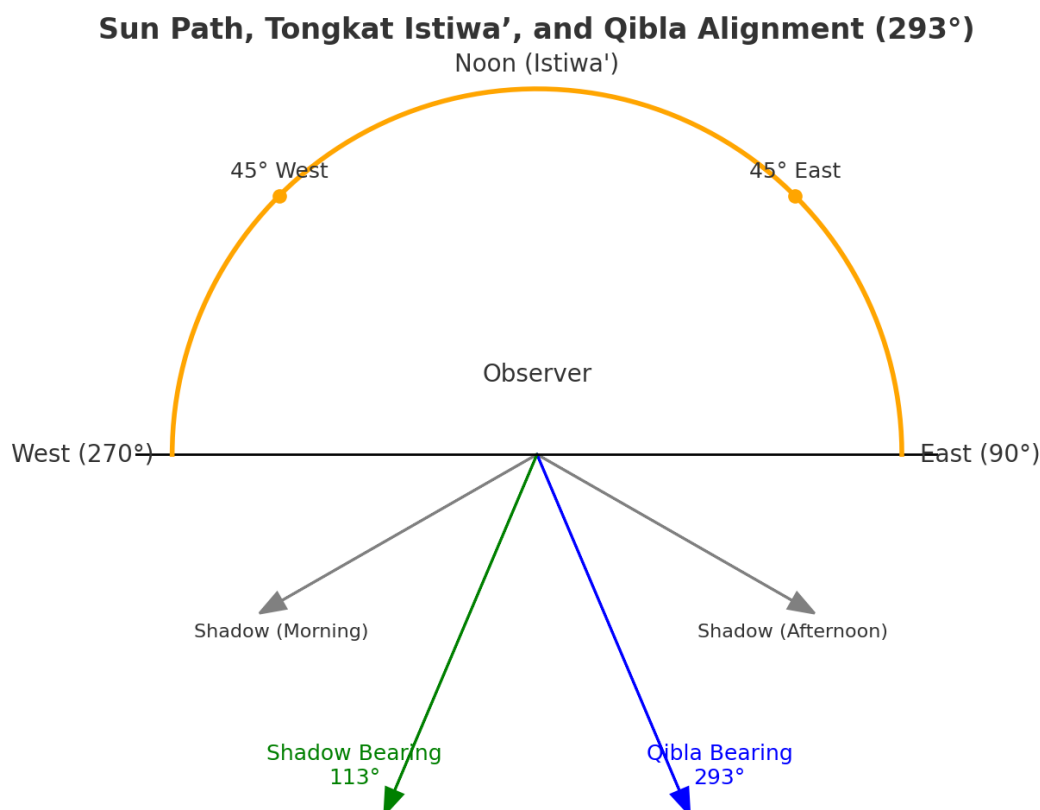


Figure 2: Schematic Figure of Sun's path, Tongkat Istiwa', Qibla Shadow Alignment and Qibla Bearing

Strengthening the Connection Between Naqli and Aqli

The integration of Qur'anic verses (e.g., Qur'an 2:144) and Hadith into the lesson created an explicit connection between *naqli* and *aqli* knowledge. Students reflected in their journals that the activity reminded them of the divine command to face the Kaabah and how mathematics serves as a tool to fulfill this spiritual obligation. This illustrates how mathematics can move beyond abstract problem-solving to serve as a bridge between faith and reason. The findings echo the arguments of Hashim and Rossidy (2000) and Osman (2010), who emphasized that integrated learning fosters holistic development encompassing both intellectual and spiritual dimensions.

Development of Spiritual Awareness and Reflection

Reflection journals demonstrated that students gained not only mathematical insights but also heightened spiritual awareness. Many participants expressed appreciation for the harmony between divine revelation and human reasoning, noting that observing the shadow's alignment reinforced their sense of connection to God during prayer. This indicates that the integration of

naqli and *aqli* knowledge does not only meet cognitive objectives but also nurtures affective learning outcomes, consistent with the goals of Islamic pedagogy (Nasr, 2012).

Challenges and Limitations

Despite the positive outcomes, some challenges were observed. Weather conditions, such as cloud cover, posed difficulties in accurately observing the shadow during the *istiwa' a'zam*. Additionally, a few students struggled to connect the mathematical calculations directly with their spiritual significance without guided facilitation from teacher. This suggests that teacher scaffolding and preparation are essential for maximizing the effectiveness of integrative lessons.

Discussion

The findings demonstrate that integrating *naqli* and *aqli* knowledge in mathematics education through the *tongkat istiwa'* method can simultaneously enhance cognitive and spiritual learning. By situating mathematics within an Islamic context, students were able to see the relevance of their learning in fulfilling religious obligations, thereby achieving both academic and moral objectives. The results reinforce the historical legacy of Muslim scholars such as Al-Biruni and Al-Khwarizmi, who harmonized astronomy, geometry, and theology to determine Qibla orientation (King, 1999; Saliba, 2007).

Furthermore, this study contributes to the discourse on faith-based STEM education by providing empirical evidence that integrative approaches can increase engagement, motivation, and holistic understanding. It also highlights the importance of incorporating traditional Islamic scientific practices, such as the *tongkat istiwa'*, into contemporary classrooms to bridge heritage, knowledge, and faith.

Conclusion and Recommendations

Conclusion

This study has demonstrated that the integration of *naqli* and *aqli* knowledge in mathematics education through the use of the *tongkat istiwa'* method provides significant educational benefits. The findings show that students developed a stronger grasp of mathematical concepts such as geometry, angles, and solar movements when these were linked to the practical and spiritually meaningful task of Qibla determination. The activity not only promoted critical thinking and experiential learning but also deepened students' appreciation of the harmony between divine revelation and rational inquiry.

By incorporating Qur'anic verses and Hadith alongside mathematical reasoning, the lesson embodied the holistic educational vision of Islam, where intellectual pursuits are inseparable from spiritual growth. This integrative approach echoes the legacy of Muslim scholars who historically employed mathematics and astronomy in service of religious practice. Ultimately, the study affirms that mathematics learning can be enriched when contextualized within faith-based applications, producing students who are both academically competent and spiritually conscious.

Recommendations

Based on the findings, several recommendations are proposed:

1. For Teachers

- Mathematics educators should incorporate faith-based applications, such as Qibla determination, to contextualize mathematical concepts.
- Cross-curricular collaboration with Islamic education teachers can provide students with richer, integrative learning experiences.
- Teachers should prepare scaffolding activities and guiding questions to help students explicitly connect mathematical reasoning with *naqli* references.

2. For Schools

- Schools should encourage outdoor experiential learning opportunities during significant astronomical events such as *istiwa' a'zam*.
- Resources such as simple *tongkat istiwa'* kits and integration-focused lesson plans should be made available to support teachers.
- Professional development programs should be provided to equip teachers with strategies for integrating *naqli* and *aqli* knowledge in STEM subjects.

3. For Curriculum Developers

- Integrative modules that align mathematics with Islamic practices should be embedded into national and school curricula.
- Curriculum planners should draw on the Islamic scientific heritage to design activities that link modern STEM education with traditional practices.
- Assessment frameworks should not only evaluate mathematical accuracy but also students' ability to reflect on the moral and spiritual dimensions of knowledge.

4. For Future Research

- Further studies could employ a mixed-methods approach to quantitatively measure improvements in mathematical achievement alongside qualitative insights into spiritual growth.
- Comparative research across different age groups and school settings could provide a broader understanding of the effectiveness of integrative approaches.
- Exploration of other Islamic scientific practices, such as determining prayer times or lunar observations, could expand the range of faith-based STEM learning opportunities.

The *tongkat istiwa'* serves not only as a simple astronomical tool but also as a pedagogical bridge between faith and reason. By integrating *naqli* and *aqli* knowledge in mathematics classrooms, educators can cultivate learners who embody both intellectual excellence and spiritual awareness, thus advancing the holistic aims of Islamic education.

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DIGITAL TECHNOLOGIES AND CIRCULAR ECONOMY INSIGHTS FROM GLOBAL RESEARCH TRENDS

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Abstract: *The convergence of Industry 4.0 (I4.0) digital technologies and circular economy (CE) principles forms a promising research frontier marked by challenges in coordination and synthesis. This study uses bibliometric and network analysis on 689 Scopus-indexed papers, revealing China as the dominant contributor, followed by the UK and US. The analysis surfaces seven key thematic clusters that include core themes of technology enablers, circular business models, and environmental performance, and nine country collaboration clusters, with emerging hubs in Malaysia and India. The UK plays a critical role in global research connectivity. Findings highlight areas like digital finance and circular business models as underexplored yet promising, emphasizing the need for causal empirical research and cross-disciplinary collaboration. The study calls for focused research integrating causal identification, multi-level data, and reproducibility to advance theory and inform policies in digitally enabled circular economy transitions, synthesizing the growing but fragmented literature into a cohesive intellectual framework for sustainable business transformations. This synthesis aids future research and policymaking to harness I4.0 for circular economic practices.*

Keywords: *Digital Technologies, Circular Economy, Industry 4.0,*

Introduction

Industry 4.0 (I4.0) integrates advanced digital technologies such as IoT, AI, blockchain, and big data analytics that significantly boost operational efficiency and enable sustainable practices under the Circular Economy (CE) framework. CE emphasizes resource optimization and waste reduction through closed-loop systems involving reuse and recycling. This synergy between I4.0 and CE is gaining traction across academia, industry, and policy sectors for fostering sustainable development and resource efficiency. The present study explores how I4.0 facilitates the transition from linear to circular economic models, addressing key research questions on trends, influential research, global contributions, thematic keywords, and collaboration patterns, thus providing a comprehensive understanding of this evolving research landscape (Elghaish et al., 2022; Singh et al., 2025; Hadi et al., 2025).

Literature Review

The integration of Industry 4.0 (I4.0) technologies, such as IoT, blockchain, and AI into Circular Economy (CE) practices is evolving, primarily conceptual at this stage with limited practical applications (Elghaish et al., 2022). These technologies help optimize asset tracking, reuse, recycling, and extend operational lifetimes. However, the nuanced link between I4.0 and CE necessitates advanced information systems to better support CE operations (Singh et al., 2025). Circular open innovation fosters digital transformation aligned with sustainability, enabling scalable business models through transparency and AI analytics, though empirical studies show no clear environmental impact dominance of I4.0 over traditional technologies (Hadi et al., 2025; Akkad et al., 2022). Challenges remain in managing complex flows within circular manufacturing, with IoT widely used, but AI, blockchain, and big data analytics are still emerging (Schöggl et al., 2023). Transitioning from linear to circular systems requires combining I4.0 with circular innovation to ensure sustainable outcomes (Hadi et al., 2025), with joint adoption showing improved social performance (Lopes de Sousa Jabbour et al., 2022). This study addresses five research questions on trends, influential articles, country contributions, keyword themes, and collaboration patterns, employing bibliometric and network analysis to provide insights critical for sustainable industrial transformation.

Methodology

This study adopts bibliometric analysis, a rigorous and systematic method to collect, organize, and analyze scientific literature related to Industry 4.0 (I4.0), digital technologies, and the Circular Economy (CE) (Alves et al., 2021; Assyakur & Rosa, 2022). Unlike basic descriptive statistics, bibliometric techniques such as document co-citation and network mapping provide deeper insights into intellectual structures within the field (Wu & Wu, 2017). The study focuses on high-impact journal articles indexed in Elsevier's Scopus database from 2015 to 2025, yielding a carefully curated dataset of 689 documents through keyword searches targeting digital transformation, I4.0, and CE (Al-Khoury et al., 2022; di Stefano et al., 2010). Data cleansing and harmonization were conducted using OpenRefine, resolving discrepancies in author names, affiliations, and keywords, thereby enhancing dataset reliability (Ahmi, 2023). For in-depth analysis, VOSviewer software was employed to generate network visualizations, cluster related items, and detect hidden patterns and intellectual connections (Van Eck & Waltman, 2010, 2017). This methodological approach underpins the study's capacity to answer key research questions on publication trends, influential works, leading countries, keyword themes, and patterns of co-authorship collaboration in the domain integrating digital technologies and CE within I4.0.

Findings

This study investigates the intersection of digital technologies and the Circular Economy (CE) within the Industry 4.0 (I4.0) framework using bibliometric and network analysis to address five key research questions (RQs) aimed at informing scholars, policymakers, and practitioners. The findings reveal a substantial growth in publications from 2015 to 2025, notably surging post-2020 due to increased emphasis on digital transformation, Sustainable Development Goals, and rapid technology adoption during the COVID-19 pandemic. This trend highlights the expanding scholarly and policy interest in harnessing technologies such as AI, IoT, and big data analytics to support CE and sustainability efforts. Regarding influential



publications (RQ2), the study identifies seminal and highly cited works that link digital enablers that including IoT, blockchain, AI, robotics, and digital finance, to CE outcomes. Foundational papers from 2017 to 2019 remain influential, while more recent empirical studies leverage large, cross-regional datasets addressing critical policy and industrial questions. High-impact research is distinguished by robust theoretical framing, advanced empirical methodologies such as quasi-experiments and panel models, and explicit policy and managerial implications supported by reproducible data. Country-level analysis (RQ3) demonstrates China's dominance in scholarly output with 251 publications, more than doubling the second-ranked Russian Federation. Europe (notably the UK and Italy) and the US also contribute substantially, reflecting mature research infrastructures and sustainability agendas. Emerging economies such as India, Malaysia, and Indonesia are increasing participation, underscoring a broadening global engagement with I4.0-CE research despite uneven resource distribution.

Keyword co-occurrence analysis (RQ4) reveals seven thematic clusters emphasizing core concepts like “digital economy,” “digital technologies,” and “environmental technology,” showcasing the multidimensional integration of economic, technological, and environmental research streams. Supporting clusters focus on topics such as information systems, carbon emissions, and regional spillovers, illustrating efforts to bridge global economic frameworks with local environmental challenges. Practical industry contexts, for example, construction and building information modeling, emerge as applied sectors within this research landscape. In addition, international co-authorship networks (RQ5) comprise 42 countries clustered into nine groups, where China stands out as a prolific production hub with extensive collaborative ties, the UK functions as a central connector among clusters, and the US contributes impactful but fewer publications compared to China. Emerging players like Malaysia, India, Saudi Arabia, and Pakistan diversify the geographic spread of research activities. These patterns expose opportunities for capacity building and bridge formation to foster a more inclusive, interconnected global research community, essential for accelerating digital and circular economy transformations.

Overall, the study underscores a vibrant and evolving research domain where digital innovation and CE increasingly coalesce within I4.0. The integration of theoretical, empirical, and policy-relevant insights fosters sustainable industrial transformation while revealing research gaps and promising avenues for future work. Employing a dataset of 689 Scopus-indexed documents, cleansed and analyzed with Scopus Analyzer and VOSviewer, this research systematically maps the intellectual landscape of CE and I4.0, establishing a foundational guide to advancing theory, policy, and practice.

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A BIBLIOMETRIC REVIEW OF ARTIFICIAL INTELLIGENCE IN ADAPTIVE TEACHING AND LEARNING

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Abstract: *The rapid advancement with regard to Artificial Intelligence (AI) has transformed multiple educational domains, particularly in adaptive teaching and learning, where AI technologies play a crucial role in personalizing instruction and enhancing learning outcomes. Despite its increasing significance, there remains a lack of comprehensive bibliometric evidence that maps the intellectual structure, research patterns, and emerging trends in this field. This study addresses this gap by conducting a bibliometric analysis of AI-assisted adaptive teaching and learning to identify publication dynamics, research hotspots, and global collaboration networks. Data were collected from the Scopus database via advanced search strategies incorporating the keywords “Artificial Intelligence,” “Adaptive,” “Teaching,” and “Learning,” which yielded 866 relevant publications. The dataset was cleaned and harmonized using OpenRefine to ensure consistency, while statistical and graphical analyses were performed through the Scopus analyzer. Visualization of co-authorship, keyword co-occurrence, and thematic clustering was generated using VOSviewer to offer a deeper comprehension regarding the field’s conceptual and intellectual structures. The results reveal a significant growth trajectory of publications over the past decade, dominated by contributions from China, the United States, India, and the United Kingdom, highlighting the global nature of research in this area. Keyword co-occurrence analysis identified core themes, for example, intelligent tutoring systems, machine learning (ML), adaptive learning environments, and collaborative learning, with emerging interest in areas like deep learning, educational data mining, and personalized learning pathways. These research findings demonstrate that AI-assisted adaptive teaching and learning research is highly interdisciplinary, bridging education, computer science, and cognitive sciences, and is increasingly shaped by international collaborations. In conclusion, this study provides an overview of the knowledge structure in AI-driven adaptive education and offers valuable insights for scholars, practitioners, and policymakers. These insights help identify future research directions, strengthen cross-border partnerships, and advance innovative pedagogical frameworks that leverage AI for inclusive and effective learning.*

Keywords: *Artificial Intelligence, Adaptive, Information Technology*

Introduction

Artificial Intelligence (AI) has emerged as a transformative force in education, revolutionizing teaching and learning through personalization, efficiency, and enhanced engagement. AI-assisted adaptive systems utilize machine learning algorithms to tailor instruction based on learners' abilities and behaviors, fostering inclusive and data-driven learning environments (Guo & Yu, 2023; Raja et al., 2024). Applications such as intelligent tutoring systems, predictive analytics, and automated grading have improved academic outcomes while reducing educators' workload (Joel et al., 2024; Ketak et al., 2024). However, challenges such as high costs, ethical concerns, and unequal access persist, requiring clear governance and professional readiness (Aravindh & Singh, 2024; Ellington, 2025).

Bibliometric analysis serves as a valuable method to map research trends, influential contributors, and global collaboration in this field (Gómez et al., 2025; García et al., 2025). This study examines the intellectual structure of AI-assisted adaptive learning, providing insights into its growth, interdisciplinary nature, and future directions in educational innovation.

Research Question

RQ1: What are the research publications of AI in Teaching and Learning up to the year of publication?

RQ2: What are the Top Ten Most Cited Authors?

RQ3: Where are the Top Ten Countries of publication most cited?

RQ4: What are popular keywords for this study?

RQ5: What is co-authorship by countries' collaboration?

Research Methodology

This study employed bibliometric analysis to systematically map research trends in AI-assisted adaptive teaching and learning. Bibliometrics involves collecting, organizing, and analyzing bibliographic data to identify influential publications, authors, and evolving research themes (Alves et al., 2021; Verbeek et al., 2002). Data were retrieved from the Scopus database using specific keywords related to artificial intelligence and adaptive learning. The dataset, limited to English peer-reviewed journal articles and conference papers from 2015 to 2025, was refined using OpenRefine. Visualization and network analyses were conducted using VOSviewer 1.6.20 to examine co-authorship patterns, keyword co-occurrence, and thematic clusters within the research domain.

Data Search Strategy

A systematic search was conducted in October 2025 using Elsevier's Scopus database to ensure comprehensive coverage of studies on AI in assistive and adaptive learning. The search performed in October 2025, utilized the advanced query: *TITLE-ABS-KEY(("Artificial intelligent") AND (assist OR adapt*)) AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "cp")) AND (LIMIT-TO(LANGUAGE, "English"))*. * was applied, limited to English-language journal articles and

conference papers published between 2010 and 2025. Books, reviews, and non-peer-reviewed materials were excluded. This search yielded 866 documents, providing a robust dataset for bibliometric analysis to examine publication trends, key authors, collaborative networks, and emerging research themes in AI-assisted adaptive education.

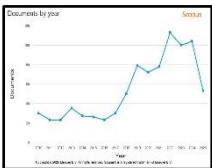
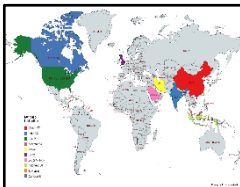
Data Analysis

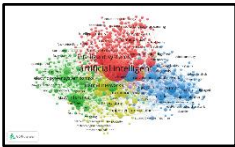
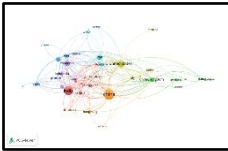
VOSviewer is a bibliometric visualization software developed by Nees Jan van Eck and Ludo Waltman at Leiden University, Netherlands (van Eck & Waltman, 2010, 2017). It enables the creation of network maps, clustering of related items, and visualization of co-authorship, co-citation, and keyword co-occurrence relationships. This study utilized VOSviewer version 1.6.20 to analyze Scopus data (2015–2025), including titles, authors, journals, citations, and keywords. The software applies the *Association Strength (AS_{ij})* normalization method to represent item relationships:

$$AS_{ij} = \frac{C_{ij}}{w_i w_j},$$

where is “proportional to the ratio between on the one hand the observed number of co-occurrences of *i* and *j* and on the other hand the expected number of co-occurrences of *i* and *j* under the assumption that co-occurrences of *i* and *j* are statistically independent” (Van Eck & Waltman, 2007).

Research Findings

Research Questions	Focus Area	Findings	Summary
RQ1	Publication Trends (2010-2025)	 Steady growth with major surge after 2017; peak in 2022 (113 papers). Slight decline in 2025 due to incomplete data or field saturation.	AI research in education has matured, reflecting post-pandemic adoption and stabilization in adaptive learning studies.
RQ2	Top Cited Authors	Ucar & Korkmaz (2020) lead with 648 citations. Other influential works include McLean & Osei-Frimpong (2019), Lv et al. (2021), and Hasan et al. (2021).	Highly cited works emphasize user trust, interaction design, and AI application diversity—from education to health and environment.
RQ3	Leading Countries	 China (207) and India (142) dominate, followed by the USA (95), Malaysia (54), Iran (47), and the UK (42).	Asian nations lead in AI learning research, driven by strong policy support and EdTech initiatives

RQ4	Popular Keywords		Major clusters: <i>AI, machine learning, intelligent systems, adaptive</i>	Research is highly interdisciplinary, integrating computer science, education, and cognitive psychology.
RQ5	Co-authorship & Collaboration		42 active countries formed 7 clusters; strongest networks between China, USA, UK, India, and Saudi Arabia	Collaboration reflects global engagement, with emerging regional partnerships enhancing cross-border knowledge exchange

Conclusion

This bibliometric study examined 866 Scopus-indexed publications to map global research trends, collaboration networks, and thematic developments in AI-assisted adaptive teaching and learning. Findings reveal a sharp increase in research activity since 2017, driven by technological integration in education. Leading contributions originate from China, the United States, India, and the United Kingdom, with growing participation from Malaysia and Saudi Arabia. Dominant themes include intelligent tutoring, adaptive systems, and machine learning. The study underscores the interdisciplinary nature of this field and its policy implications. Future research should integrate multiple databases to enhance data coverage and longitudinal insight.

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A BIBLIOMETRIC EXPLORATION OF GENERATIVE AI AND CRITICAL THINKING IN EDUCATIONAL RESEARCH

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Abstract: *Generative Artificial Intelligence (GenAI) has emerged as a transformative force in modern education. With the advent of large language models such as ChatGPT, new opportunities have arisen to enhance cognitive engagement and critical thinking among learners. However, despite rapid technological progress, a systematic understanding of how scholarly research conceptualizes and applies GenAI to foster critical thinking remains limited. This study conducts a bibliometric analysis to map global scholarship on Generative AI and critical thinking in educational research. Using Scopus as the primary database, 645 peer-reviewed documents published between 2020 and 2025 were analyzed using OpenRefine and VOSviewer. Findings reveal exponential growth in publications since 2023, driven by increased academic attention following the public release of ChatGPT. The United States and China lead in research output, while emerging contributors include the United Kingdom, Singapore, and Germany. Keyword network analysis reveals clusters centered around 'language models', 'reasoning', and 'higher-order thinking', indicating the integration of GenAI with cognitive skill development. This bibliometric exploration contributes to understanding the intellectual structure of this evolving field, emphasizing the dual role of GenAI as both a catalyst for educational innovation and a challenge for ethical, reflective practice.*

Keywords: *Generative AI, Critical Thinking, Education*

Introduction

Generative Artificial Intelligence (GenAI) represents a major paradigm shift in the digital transformation of education. Its capacity to generate text, visuals, and simulations has revolutionized instructional practices, particularly in facilitating critical thinking and higher-order cognitive engagement. Scholars such as Pavlik (2025) and Tariq (2024) highlight its potential to personalize learning and cultivate creativity, while others caution against overdependence on AI-generated outputs that may hinder analytical reasoning (El Samaty, 2025). Despite these debates, limited bibliometric evidence exists to synthesize how global research connects GenAI and critical thinking. This study aims to map and evaluate the emerging scholarship, offering insights into key contributors, publication trends, and conceptual directions.

Literature Review

Research on GenAI in education has expanded rapidly since the release of advanced large language models (LLMs). Early studies concentrated on AI's technical evolution, whereas recent investigations focus on pedagogical implications. Guo and Lee (2023) observed that ChatGPT supports reflective learning through scaffolded dialogue, enabling students to evaluate reasoning processes. Meanwhile, Gravino, Iannella, Marras, Pagliara, and Palomba (2024) emphasized the ethical dimension of AI literacy, urging educators to guide students toward responsible engagement. Existing literature converges on the view that GenAI enhances idea generation, but its success depends on structured pedagogical integration that promotes autonomy and self-regulation. A bibliometric perspective allows scholars to systematically trace these conceptual developments and assess how research aligns across regions and disciplines.

Methodology

Bibliometric analysis encompasses the organization, systematic collection, as well as examination of bibliographic data derived from scientific publications (Alves, Borges, & Nadae, 2021; Assyakur & Rosa, 2022; Verbeek, Debackere, Luwel, & Zimmermann, 2002). A bibliometric method was applied to examine peer-reviewed publications retrieved from the Scopus database between 2020 and 2025. The search string combined terms related to 'generative AI', 'large language model', 'ChatGPT', and 'critical thinking'. Only English-language journal articles were included. After cleaning and refining the dataset using OpenRefine, 645 valid records were analyzed using VOSviewer 1.6.20. The analysis focused on publication trends, authorship networks, and keyword co-occurrences to uncover the intellectual and collaborative structure of the field. This approach offers an objective mapping of research productivity, thematic focus, and emerging areas of interest in GenAI scholarship.

Findings and Discussion

The bibliometric analysis revealed exponential growth in studies linking Generative AI and critical thinking, particularly after 2023. This surge coincides with the global adoption of ChatGPT, which inspired pedagogical experimentation and academic inquiry. Highly cited works, such as Wei et al. (2022) and (Zhou et al., 2023), pioneered the 'chain-of-thought' reasoning framework that underpins AI-driven learning design. Keyword co-occurrence mapping identified clusters centered on reasoning, higher-order thinking, and language models, demonstrating GenAI's intellectual integration with cognitive education. Geographically, China and the United States dominate scholarly output, while emerging collaborations from Asia and Europe suggest expanding research engagement. Despite promising advancements, challenges persist regarding ethical use, bias mitigation, and academic integrity. Scholars emphasize the necessity for educators to employ GenAI reflectively, ensuring that technology complements rather than substitutes human criticality.

Conclusion

This study provides a bibliometric overview of research on Generative AI and critical thinking within education. Results demonstrate an accelerating scholarly focus on reasoning and higher-order cognition, reflecting GenAI's expanding role in education. By consolidating dispersed

research efforts, this paper clarifies global trends and highlights areas requiring ethical and empirical attention. Future studies should integrate multi-database analyses and mixed-method designs to deepen understanding of AI's pedagogical impact. Ultimately, this exploration contributes to shaping responsible and innovative practices in GenAI-enhanced learning environments.

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ARTIFICIAL INTELLIGENCE OF HIGHER ORDER THINKING IN SCIENCES EDUCATION: A BIBLIOMETRIC ANALYSIS

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(TNR, 10, Align Left, Capitalize Each Word)

Abstract: This study presents a bibliometric analysis of research on artificial intelligence (AI) and its role in enhancing higher-order thinking (HOT) within science education. Using data from the Scopus database (2020–2025) comprising 2,009 publications, the study examined research trends, collaboration networks, and thematic structures. Data were refined with OpenRefine, analyzed using Scopus Analyzer, and visualized through VOSviewer. Results indicate a significant rise in publications from 2019 onward, reflecting growing interest in AI-driven pedagogical innovation. China, the United States, and the United Kingdom were identified as leading contributors and highly collaborative nations. Frequently occurring keywords such as “artificial intelligence,” “students,” “machine learning,” and “higher education” highlight dominant research themes. Co-authorship and keyword co-occurrence analyses revealed eight key clusters representing interdisciplinary collaboration between AI and science education. Overall, the study provides a comprehensive overview of AI’s growing influence on higher-order thinking, emphasizing future directions for global educational research and innovation.

Keywords: *Sciences, Education, Artificial Intelligence, Higher Order Thinking*

Introduction

Artificial Intelligence (AI) has emerged as a transformative force in various sectors, including education. The integration of AI in higher education, particularly in science education, has the potential to revolutionize traditional teaching and learning practices. AI-powered tools offer personalized support, enabling students to better understand study materials, visualize complex concepts, and engage in interactive problem-solving Mnguni (2025); Stuchlikova & Weis (2024). However, the role of AI in education is multifaceted, presenting both opportunities and challenges. While AI can enhance student engagement and learning efficiency, it also raises concerns about overreliance, potential biases, and the need for critical thinking skills Stuchlikova & Weis (2024) ; Al Ka’bi (2023). This study aims to explore the impact of AI on higher-order thinking (HOT) in science education through a bibliometric analysis, providing insights into current trends, practices, and outcomes. Zhao & Fu (2025)

Literature Review

Artificial Intelligence (AI) plays a vital role in enhancing higher-order thinking (HOT) skills analysis, evaluation, and creation essential for critical thinking and problem-solving in education. AI-assisted teaching enables adaptive and personalized learning, increasing engagement and understanding (Mnguni, 2025; Herath & Mittal, 2022). However, challenges persist, including overreliance on AI, superficial explanations, and ethical concerns related to data privacy and algorithmic bias (Michel-Villarreal et al., 2023; Javaid & Haleem, 2020). The success of AI integration depends on teacher readiness, curriculum design, and contextual factors (Babu et al., 2025). Recent studies highlight AI's transformative potential in science education through real-time feedback, personalized pathways, and tools like ChatGPT that foster authentic inquiry and critical reflection (Mnguni, 2025). Ilgun Dibek et al. (2025) identify three key domains technological integration, research trends, and educational applications—demonstrating AI's power to enhance learning environments and innovation while emphasizing the need for sustainable, ethical implementation in education.

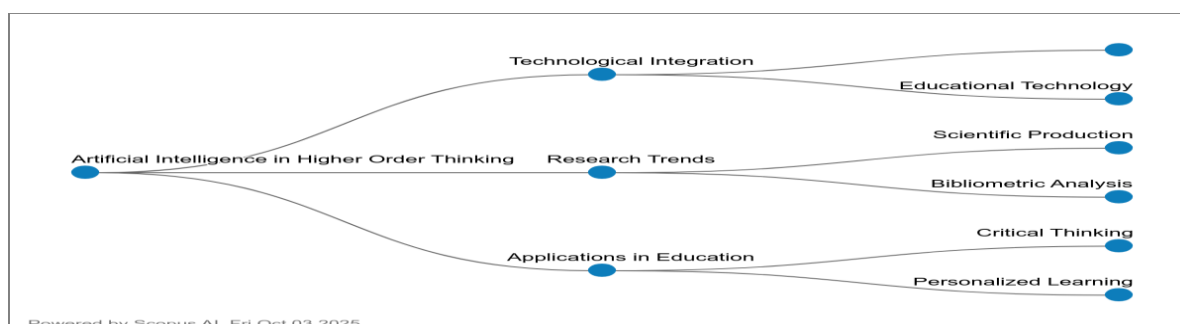


Figure 1: The Topic Branches Into Three Main Domains: Technological Integration, Research Trends, And Applications In Education

Methodology

This study utilized bibliometric analysis to systematically collect, organize, and evaluate scientific publications on artificial intelligence and higher-order thinking in science education (Passas, 2024; Gan et al., 2022). Using descriptive statistics and advanced techniques like co-citation analysis, the study identified key journals, authors, and publication trends (Agunti & Perez, 2022; Wang et al., 2024). Data were sourced from the Scopus database, ensuring academic rigor and reliability (Singh et al., 2021; Yubo et al., 2023). Only peer-reviewed journal articles from January 2020 to October 2025 were included, providing a robust and contemporary overview of research patterns and intellectual structures in this emerging educational field.

Data Analysis

VOSviewer, a bibliometric software by Nees Jan van Eck and Ludo Waltman, was used to analyze and visualize scientific literature through co-authorship, co-citation, and keyword networks (Arruda et al., 2022; Norh Hassin & Kamaludin, 2024). This study applied VOSviewer version 1.6.20 to Scopus data from 2020–2025, examining publication patterns and research structures. Using the association strength (AS_{ij}) normalization method, it

provided accurate similarity measures and network visualizations, offering comprehensive insights into research trends in AI and higher-order thinking in science education.

Data Search Strategy

The data for this study were collected using the Scopus advanced search function, recognized for its comprehensive coverage of scholarly publications. The search query TITLE-ABS-KEY (“artificial intelligence” AND (higher order OR thinking) AND (science OR education OR technology)) AND PUBYEAR > 2019 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE, “English”)) was designed to capture relevant studies from 2020 to 2025. Conducted in October 2025, the search ensured transparency and reproducibility. Only English, peer-reviewed publications within the specified period were included, resulting in 2,009 documents. This dataset forms a robust foundation for bibliometric analysis, mapping research trends, and exploring AI’s role in fostering higher-order thinking in science education.

Table 1: Summary of Research Questions and Key Findings

Research Question (RQ)	Focus / Description	Key Findings / Summary Statement
RQ1: What are the research trends in online learning studies according to the year of publication?	Examines annual publication growth from 2020–2025.	Research output shows a strong upward trend, rising from 165 publications in 2020 to 614 in 2025. The surge reflects rapid AI integration in education and increased scholarly focus on fostering higher-order thinking through digital transformation.
RQ2: What are the most cited articles?	Identifies the most influential and highly cited works.	The most cited articles (2020–2024) reflect global interest in AI’s transformative role post-COVID-19. Highly cited works—such as Bi et al. (2023) and Farrokhnia et al. (2024)—focus on generative AI (ChatGPT), academic writing, and cross-disciplinary applications in education, health, and technology.
RQ3: Where are the top 10 countries based on number of publications?	Analyzes geographic distribution of research productivity.	China leads with 578 publications, followed by the U.S. (233) and India (167). Europe and emerging nations like Malaysia and Mexico show growing contributions, with research concentrated mainly in Asia and North America due to strong policy support and academic investment.
RQ4: What are the popular keywords related to the study?	Explores keyword co-occurrence to identify core themes and emerging topics.	Dominant keywords include artificial intelligence, students, higher education, teaching, and machine learning. Emerging terms like ChatGPT and generative AI indicate growing focus on AI-driven learning and the intersection of education with advanced technologies.
RQ5: What are the relevant cooperative author groups?	Examines collaboration patterns among authors and countries.	Co-authorship analysis reveals eight international collaboration clusters. China, the U.S., the U.K., and India are key hubs, while countries like Malaysia and Saudi Arabia contribute to growing global cooperation. Collaboration reflects both thematic and institutional partnerships beyond geographic proximity.

Conclusion

This study analyzed 12,272 Scopus-indexed e-learning publications from 2020–2025, representing 0.06466% of total research (12,272 of 18,976,811). A descriptive analysis examined output by year, institution, author, and research area. Thematic mapping divided topics by centrality and density: declining themes included electronic, computer-based, and motivational studies, while niche themes such as “alcohol,” “college students,” and “depression” showed limited relevance. Central clusters featured “learning analytics,” “e-assessment,” and “MOOCs.” Motor themes emphasized “authentic” and “self-assessment,” whereas basic themes highlighted “distance learning,” “COVID,” and “online education.” “E-

assessment,” “higher education,” and “assessment” showed highest centrality, linking key e-learning research areas.

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TRENDS AND INSIGHTS IN CYBERSECURITY AWARENESS AND DIGITAL EDUCATION RESEARCH: A GLOBAL BIBLIOMETRIC OVERVIEW

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Abstract: *The increasing importance of cybersecurity in the digital era showcases the demand for enhancing cybersecurity awareness and strengthening digital education, particularly in academic and professional contexts where vulnerabilities often arise from human factors rather than purely technical weaknesses. In spite of the expanding body of literature, there remains a lack of systematic mapping to understand the trends, patterns, and global collaboration in this research domain. This research addresses the gap by performing a bibliometric analysis of publications related to cybersecurity awareness and digital education. Data were collected through Scopus advanced searching using the keywords "cybersecurity," "awareness," and "education," yielding a total of 1,107 documents. OpenRefine was employed to clean and harmonize the dataset, while Scopus Analyzer provided statistical insights into publication growth, sources, authorship, and citation structures, while the VOSviewer software was applied to generate co-authorship, co-occurrence as well as country collaboration networks. The analysis indicated a consistent increment in publications throughout the past decade, forming distinct clusters of international collaboration. These findings enrich the body of knowledge by offering a thorough overview of research progress, highlighting influential authors and institutions, and identifying gaps where future studies can integrate practical awareness frameworks into digital education systems. This analysis contributes to strengthening evidence-based strategies for integrating cybersecurity awareness into digital education globally.*

Keywords: *Cybersecurity, Awareness, Digital, Education, Literacy*

Introduction

In today's digital age, the widespread integration of technology into daily life has transformed communication, education, and commerce, while simultaneously heightening exposure to cyber threats. This reality makes cybersecurity awareness an essential aspect of digital literacy. Cybersecurity awareness entails understanding potential vulnerabilities and adopting secure digital practices, while digital education utilizes technology-based tools to facilitate effective teaching and learning. The convergence of these two fields empowers individuals to engage responsibly within the digital environment. Scholars have emphasized that human factors remain one of the primary causes of cybersecurity breaches (Alalawi et al., 2024). Similarly, studies have also shown the role of institutional policies and AI-driven learning tools in mitigating digital vulnerabilities. Innovative educational initiatives, such as AI-integrated

mobile applications (Alalawi et al., 2024), provide tailored learning through interactive lessons, scenarios, and chatbot support to enhance awareness. At the institutional level, embedding cybersecurity awareness within higher education systems strengthens organizational resilience and bridges knowledge gaps between students and staff (Bueno, 2025). Collectively, the literature demonstrates that innovative, interactive, and AI-driven educational strategies are crucial in building sustainable cybersecurity awareness, equipping individuals to navigate the digital ecosystem safely and responsibly.

Research Question

RQ1: What are the research trends in online learning studies according to the year of publication?

RQ2: What are the top 10 most cited articles?

RQ3: Which are the top 10 countries based on the number of publications?

RQ4: What are the most popular keywords related to the study?

RQ5: What are the patterns of co-authorship based on countries' collaboration?

Methodology

This study employed bibliometric methods to analyze peer-reviewed Scopus publications between 2015 and 2025. The search string included terms related to “cybersecurity”, “awareness”, and “education”. Only English-language, final-stage journal articles were included. A total of 1,107 documents formed the dataset. OpenRefine was used for data cleaning, and VOSviewer 1.6.20 generated co-authorship and keyword co-occurrence networks. Analyses examined publication trends, country productivity, and thematic clusters to map the intellectual structure of the field.

Data search strategy

To obtain strategic data for the bibliometric analysis, the Scopus advanced search function was employed due to its broad coverage of peer-reviewed publications and robust search capabilities.

Table 1: The Search String

Scopus	TITLE (("cybersecurity" OR "cyber-security" OR "cyber security") AND ("awareness" OR "literacy" OR "education")) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English"))) Access date: October 2025

Table 2: The Selection Criterion is Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2015 – 2025	< 2015

Findings and Discussion

The analysis reveals a clear evolution in research on cybersecurity awareness and digital education. Between 2015 and 2017, publications were relatively few, indicating the early stage of development in this research field. A notable increase occurred between 2018 and 2020 as global digital transformation accelerated, driven by growing cybersecurity threats and the COVID-19 pandemic's influence on online learning. From 2021 onward, publications rose sharply, peaking in 2024, signifying the maturation of the field and its growing alignment with international digital education and security policies. The subsequent slight decline in 2025 reflects consolidation as researchers shift focus toward advanced themes such as AI-based cybersecurity tools, policy evaluation, and sustainable frameworks. The most cited articles demonstrate a convergence of behavioral, educational, and policy-driven approaches. Highly influential works by Zwilling et al. (2022), Li et al. (2019), and de Bruijn & Janssen (2017) emphasize human factors, awareness, and strategic policies as key elements of cybersecurity resilience.

Topics such as gamified learning, child-centered awareness, higher education, and economic implications illustrate the multidisciplinary nature of this field. Geographically, the United States and the United Kingdom dominate publication output, while emerging contributions from Saudi Arabia, India, Malaysia, and South Africa highlight increasing global inclusivity and cross-regional collaboration. Keyword co-occurrence and co-authorship analyses further confirm the expansion of research into interconnected clusters, combining education, technology, and behavioral dimensions. Collectively, these findings indicate that cybersecurity awareness in digital education has evolved into a mature, interdisciplinary research domain that integrates global collaboration, policy innovation, and technological advancement to build safer digital learning ecosystems. These outcomes collectively demonstrate the maturity and interdisciplinary growth of cybersecurity awareness research worldwide. The visualization networks illustrate that cybersecurity and digital education have increasingly merged through policy, pedagogy, and AI-driven innovation.

Conclusion

This study provides a comprehensive overview of the evolving research landscape on cybersecurity awareness and digital education from 2015 to 2025. The findings reveal steady growth in publications, reflecting increased global recognition of cybersecurity as an integral element of digital learning ecosystems. Highly cited studies highlight behavioral, policy, and educational dimensions, while leading contributors such as the United States, the United Kingdom, and China demonstrate strong international collaboration. The keyword and co-authorship analyses further underscore the multidisciplinary and globally connected nature of this field. Overall, the study establishes that cybersecurity awareness has matured into a vital component of digital education, demanding pedagogical innovation, policy integration, and sustained cross-border cooperation. Although limited by its reliance on Scopus and English-language sources, this research lays a strong foundation for future studies to expand in scope and depth, strengthening global digital resilience through education and awareness. Future bibliometric research may explore longitudinal developments beyond 2025 to examine evolving digital education paradigms.

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NEED ANALYSIS FOR THE DEVELOPMENT OF A UIS MOBILE VIRTUAL TOUR

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Abstract: *The integration of virtual reality (VR) technology into mobile applications has created new opportunities to enhance user experiences in education and campus promotion. This study aims to evaluate user needs for the development of the UIS Mobile Virtual Tour Application, designed to provide an immersive and interactive exploration of Universiti Islam Selangor (UIS). A needs analysis was conducted using a questionnaire survey involving 184 respondents comprising students, parents, and members of the public. The findings reveal several essential requirements, including intuitive navigation, high-quality panoramic visuals, cross-device accessibility, and the integration of multimedia components such as narration, background music, and textual information. Results also demonstrate a strong demand for the application, particularly in improving access to information, enhancing user engagement, and providing comprehensive visualization of campus facilities. Guided by the Unified Theory of Acceptance and Use of Technology (UTAUT), the analysis indicates that performance expectancy recorded the highest level of agreement, while effort expectancy also showed positive responses in terms of ease of use and user-friendly interfaces. In contrast, social influence and facilitating conditions had a more moderate impact on user intention. Respondents further emphasized the importance of Nielsen's heuristic design principles, particularly system feedback, intuitive navigation, flexibility, error prevention, and accessible user support. Overall, the findings underscore that functionality, usability, and intuitive design are the key determinants of user acceptance of the Virtual Tour UIS application, providing a strong foundation for the development of an effective and user-friendly mobile VR solution.*

Keywords: *Mobile Application, Nielsen's Usability Heuristic, UTAUT Model, Virtual Reality (VR), Virtual Tour*

Introduction

The integration of Virtual Reality (VR) technology has opened new opportunities for higher education institutions to enhance user experiences in teaching, learning, and campus promotion. This study explores the development of the UIS Mobile Virtual Tour Application to provide immersive and interactive access to Universiti Islam Selangor (UIS). Guided by the UTAUT model and Nielsen's heuristic principles, a needs analysis highlights user expectation for intuitive navigation, multimedia integration, and cross-device accessibility. The findings establish a solid foundation for designing an effective and user-friendly VR solution for UIS.

Literature Review

The advancement of mobile technologies and virtual reality has introduced innovative ways for universities to showcase their campuses and engage with students, parents, and visitors. A mobile virtual tour can enable Universiti Islam Selangor (UIS) to provide accessible and interactive information about its facilities, services, and environment without requiring physical presence. To ensure the effectiveness of such an application, a need analysis is essential to identify what users truly require, including navigation support, access to relevant campus information, and engaging interactive features. This process also helps align the application with institutional objectives, available resources, and technical capabilities.

This literature review examines prior studies on mobile virtual tours in both educational and tourism contexts, with a focus on usability, accessibility, and user experience in map-based and VR applications. It further considers adoption factors such as perceived usefulness and ease of use, while highlighting best practices in interactive content design and evaluation methods. By synthesizing these insights, the review aims to outline user needs, design requirements, and potential areas for enhancement, thereby providing a strong foundation for the development of a UIS mobile virtual tour.

Virtual Reality (VR) Technology

Virtual Reality (VR) is a technology that creates three-dimensional environments where users can interact in real time through visuals, sounds, and sometimes haptic feedback, giving a strong sense of presence (Lai, 2024). The development of VR began in the 1960s with early inventions such as Morton Heilig's *Sensorama* and Ivan Sutherland's *Sword of Damocles*. Over time, VR evolved into modern devices like Oculus Rift, HTC Vive, and PlayStation VR, supported by powerful hardware, software such as Unity and Unreal Engine, and interactive tools like motion controllers and haptic systems (Chen & Lin, 2018; Mu et al., 2024; Coronado et al., 2023; Toala-Palma et al., 2020).

Today, VR is applied across many fields including education, healthcare, tourism, and cultural heritage. Studies show it helps students better understand scientific concepts (Fadil & Wahid, 2021) and can be used to promote Malay cultural heritage such as traditional houses (Yusof et al., 2017). In addition, VR supports training simulations, medical practice, and virtual tourism by offering realistic, immersive experiences. With continuous advancements like gesture control and remote sensing, VR's potential applications continue to grow, although challenges in cost, accessibility, and content development remain (Toala-Palma et al., 2020).

Virtual Tours in Education

Studies in Malaysia highlight the growing adoption of virtual tours and virtual/augmented reality (VR/AR) technologies as innovative approaches in education. Siaw (2023) introduced ViTour, a low-cost virtual tour developed at IPG Batu Lintang, which showed positive user perceptions regarding effectiveness, ease of use, and enjoyment. Similarly, Ang and Wahid (2022) developed a markerless AR campus tour application, emphasizing its interactivity compared to traditional static websites. Furthermore, Adnan and Adnan (2021) investigated the acceptance of 360-degree VR among educators and learners in Malaysian public higher



education institutions, finding generally positive perceptions despite challenges such as limited resources, tools, and technical expertise.

Other local initiatives also illustrate the impact of VR in enhancing conceptual understanding and student orientation. Abdullah et al. (2021) explored the use of GeoVR-Xplorer at Kolej Matrikulasi Kelantan and found that VR improved comprehension of abstract scientific concepts, such as molecular geometry, through exploratory and realistic visualization. Likewise, the UKM Explorer project provided an immersive virtual campus tour experience, helping prospective and new students to navigate Universiti Kebangsaan Malaysia's campus virtually, especially those unable to visit physically (Journal IMCMS, 2021). In addition, virtual tour technology has proven to be a safe and practical solution for learning during critical situations such as the COVID-19 pandemic, when physical presence at specific locations was restricted. For instance, the Asia Pacific University of Technology & Innovation (APU) in Malaysia leveraged this technology to attract international students by providing an immersive virtual experience of its campus (Rohizan et al., 2019).

Taken together, the literature indicates that virtual tours in education present significant opportunities to improve accessibility, comprehension, and overall learning experiences. By enabling remote exploration, enhancing conceptual understanding, and supporting institutional visibility, virtual tours stand out as a highly valuable tool within the modern educational landscape.

Mobile Application Development Frameworks/Models

The Mobile Application Development Life Cycle (MADLC) is a methodological framework designed specifically to ensure that mobile application development is carried out in a systematic, efficient, and user-oriented manner. This model outlines a series of well-structured phases, including planning, requirements analysis, interface and architecture design, coding, testing, deployment, and ongoing maintenance (Vithani & Kumar, 2014). Unlike conventional software development life cycles such as SDLC, MADLC is tailored to address the unique challenges of mobile applications, such as platform diversity, hardware limitations, screen size variations, operating system differences, and the need for a responsive user experience (Alshamrani & Bahattab, 2015). In the context of mobile-based virtual reality (VR) development, MADLC provides a solid foundation for integrating interactivity, 3D graphics, and sensor technologies such as gyroscopes or accelerometers to deliver an immersive experience.

Applying MADLC to the development of mobile VR applications allows the requirements analysis phase to focus on the specific needs of VR, including graphics processing capabilities, real-time performance stability, and compatibility with mobile VR devices such as head-mounted displays (HMDs) or cardboard VR viewers. During the design phase, MADLC supports the creation of user interface (UI) and user experience (UX) elements that take into account user comfort, field of view, and 360-degree interaction—key aspects of an engaging VR experience (Anthes et al., 2016). Furthermore, the testing phase within MADLC is critical to ensure consistent performance across different devices and operating systems, while also validating immersive components such as ambient sound and 3D visuals. This structured approach makes MADLC an ideal framework for developing mobile virtual reality applications, such as virtual tours, as it ensures that each stage of development is aligned with the technical demands of VR and the expectations of end users.

UTAUT Model in Interactive Technology Acceptances Studies

The Unified Theory of Acceptance and Use of Technology (UTAUT) provides a comprehensive framework for examining factors that influence user acceptance of new technologies. This model incorporates four core constructs—performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC)—together with key moderators such as age, gender, experience, and voluntariness, allowing for direct comparison with findings from prior technology adoption studies (Venkatesh et al., 2003).

In line with recent findings from virtual-tour, museum, and VR adoption studies, the model is extended with experience-specific factors including immersion, interaction, perceived enjoyment, design aesthetics, and trust, which have been shown to significantly improve explanatory power for virtual experiences (Li, 2025; Bilynets, 2024; Wen, 2023). Where the application incorporates augmented-reality or gamified features, the UTAUT2/UTAUT-3 additions of perceived enjoyment, price value, and habit are also considered, reflecting positive effects on behavioural intention in mobile AR tourism contexts (Venkatesh et al., 2012; Low, 2019).

Measurement will employ canonical UTAUT items pilot-adapted to the mobile-tour setting to maintain cross-study comparability; reliability and validity will be examined through Cronbach's α , composite reliability, and average variance extracted (AVE), followed by structural equation modelling (CB-SEM for large samples or PLS-SEM for smaller ones) as recommended in technology-acceptance research (Hair et al., 2019).

To strengthen ecological validity, the survey will be complemented with objective usability metrics such as task-completion time, navigation errors, or experimental comparisons of 360° versus guided-AR modes, an approach increasingly employed in VR acceptance studies (Pham et al., 2022). Finally, given the Islamic heritage context of the UIS campus, perceived cultural value and design aesthetics are incorporated as contextual predictors of continued usage intention, echoing digital-museum studies that highlight cultural engagement as a key determinant of adoption (Phang & Kong, 2024).

Several recent studies demonstrate that adopting UTAUT or UTAUT2 is useful when investigating acceptance of virtual tour, augmented/virtual reality, and campus-heritage/edu-tourism applications. For example, Phang and Kong (2024) applied UTAUT2 together with the theory of substitutability in *“Exploring the influence of technical and sensory factors on Malaysians’ intention to adopt virtual tours in heritage travel”*, finding that constructs like performance expectancy, hedonic motivation, habit, and perceived substitutability significantly influenced users’ intention to adopt virtual tours; interestingly, effort expectancy, social influence, and facilitating conditions were not significant in their sample.

Similarly, *“Beyond Exhibits: Exploring Museum VR Adoption through a Validated UTAUT2 Model”* (Universiti Malaysia Sarawak) confirmed the relevance of UTAUT2 in museum VR settings, extending the model with design quality and past experience as significant predictors of behavioural intention. Another context is Low, Wei Shang (2019), in their master’s thesis *User Acceptance Of Mobile Augmented Reality For Tourism By Adopting The UTAUT Model* (in Melaka, Malaysia), showing that performance expectancy, facilitating conditions, and perceived playfulness had positive effects on behavioural intention to use mobile AR for

tourism; effort expectancy was less significant given the high familiarity of users with smartphones. There is also work on *Smart Tourism Experiences: Virtual Tour on Museum / Smart Experience*, where UTAUT is used to examine acceptance of virtual tour technology among museum visitors in Jakarta, revealing that UTAUT constructs significantly influence smart experience and public acceptance of the virtual tour technology. Moreover, the large-scale study *Acceptance and Use of Virtual Learning Environment in Higher Education* across Turkey and the UK applied UTAUT and found variation in how strongly performance expectancy, effort expectancy, social influence, and facilitating conditions predict behavioural intention and use, depending on country context.

These studies offer several insights for your UIS mobile virtual tour project. First, they show that performance expectancy and hedonic motivation / perceived playfulness are often strong predictors in virtual tour / AR/VR settings — so your instrument should incorporate those constructs. Second, facilitating conditions sometimes matter and sometimes don't — depending on how mature the users are in using mobile technology; in contexts where users already have good devices and skills, facilitating conditions may show weaker effects (as in Phang & Kong 2024; Low 2019). Third, extensions like design quality, past experience, perceived substitutability (i.e. how virtual tour competes with or substitutes for physical visit), or sensory/technical factors (immersion, interactivity, multimedia richness) help increase explanatory power beyond the core UTAUT constructs. Finally, these studies indicate that moderators (such as whether usage is voluntary, prior experience, demographic factors) and context (heritage vs museum vs general tourism vs educational contexts) influence which constructs emerge as significant — so including those moderators is useful.

In sum, for UIS mobile virtual tour, adopting UTAUT2 (or UTAUT with extensions) is advantageous because (a) it has been empirically validated in 'virtual tour / AR/VR' settings in Malaysia and elsewhere; (b) it allows incorporation of both utility (usefulness) and experiential / hedonic dimensions that are especially relevant in tour-type applications; (c) it gives flexibility to include context-specific constructs (design quality, immersive/media richness, interactivity) and relevant moderators; and (d) it supports rigorous method (survey + SEM/PLS) that others have used successfully, so your findings will be comparable.

Methodology

This study employed a quantitative research design to collect and analyze numerical data, enabling the identification of patterns, relationships, and trends among respondents (Zulkifley & Sazelli, 2013). The research was conducted at Universiti Islam Selangor (UIS), Bandar Seri Putra, Kajang, Selangor, as the mobile VR application was specifically developed to showcase the campus environment, facilities, and atmosphere to various stakeholders, including students, parents, and visitors. The UIS campus also served as the main reference point for collecting panoramic images, videos, and institutional information to be integrated into the application, as well as for testing and evaluation purposes.

The population of this study consisted of potential users of the Virtual Tour UIS application, including current and prospective students, parents, and the general public. From this population, a sample of respondents was selected using a convenience sampling method, whereby participants were recruited based on accessibility and willingness to participate. This

approach was deemed appropriate as the study is exploratory and developmental in nature, with the primary aim of obtaining timely and cost-effective feedback from diverse user groups.

Data were collected using an online questionnaire designed via Google Forms, which covered respondent demographics, prior experiences with technology, expectations for the virtual tour, and preferred design features. The questionnaire was constructed based on the Unified Theory of Acceptance and Use of Technology (UTAUT) and Nielsen's usability heuristics, ensuring that both aspects of technology acceptance and interface design were addressed. The form was distributed through social media, institutional email, and direct communication, with the data collection period lasting three months. All responses were recorded automatically and exported for analysis, with confidentiality and anonymity maintained throughout the process.

The data were analyzed using SPSS software. The procedure began with data cleaning to remove incomplete or invalid responses, followed by descriptive statistical analysis to examine demographic profiles, information channels, and exposure to virtual tour applications. Mean and standard deviation values were calculated for items measured on a five-point Likert scale, allowing the researcher to identify overall user perceptions and expectations. Finally, the results were interpreted to determine patterns in user needs, with emphasis placed on items that recorded higher mean scores and strong levels of agreement, which served as the basis for the proposed design framework of the Virtual Tour UIS application.

Analysis and Result

This study involved 184 respondents, comprising 53.8% females and 46.2% males. The majority were aged between 18–25 years (52.2%) and were students or prospective students (66.3%). In terms of ICT skills, most respondents identified themselves as moderately skilled (70.7%), while mobile phones were the most commonly owned device (58.7%). Regarding purpose, 79.9% of respondents stated their interest in using a *virtual tour* application to explore the UIS campus virtually, demonstrating alignment with the target audience of the application.

Awareness of UIS was universal (100%), with social media identified as the dominant source of information (54.3%). Although more than half of the respondents had never used a *virtual tour* application (57.1%), nearly all (97.3%) expressed strong interest in the UIS Virtual Tour. This confirms the significant potential of the application as a promotional medium and a tool for virtual campus exploration

Table 1: Respondents' Demographic Profile (N=184)

Profile	Category	Frequency	Percentage (%)
Gender	Male	85	46.2
	Female	99	53.8
Age	18–25 years	96	52.2
	26–35 years	38	20.7
	41 years and above	50	27.2
Profession	Student/Prospective	122	66.3
	Parent	56	30.4
	Public	6	3.3
ICT Skills	Not skilled	28	15.2

Device Ownership	Moderately skilled	130	70.7
	Skilled	26	14.1
	Mobile phone	108	58.7
	Laptop	52	28.3
Application Purpose	Tablet	24	13.0
	Campus exploration	147	79.9
	Tourism/Interest	27	14.7
	Admission decision	10	5.4

Table 1 indicates that the majority of respondents were young students with moderate ICT skills. Mobile phones were the most dominant device, highlighting the need for the application to be developed in a mobile-friendly format.

Table 2: Awareness and Interest in Using the Application

Item	Yes (%)	No (%)
Awareness of UIS	100.0	0.0
Prior experience with virtual tour apps	42.9	57.1
Interest in UIS Virtual Tour	97.3	2.7
Main sources of information	Social media (54.3%) Official UIS platforms (44.6%), Print media (1.1%)	-

All respondents were aware of UIS, yet the experience of using *virtual tour* applications was still relatively low. Nevertheless, almost all expressed high interest in the UIS Virtual Tour, highlighting its strong potential for acceptance among users.

Table 3: Factors Influencing User Needs

Domain	Key Statements	% Strongly Agree
Performance Expectancy	Useful for campus information	66.3
	Saves time	70.7
	Enhances exploration experience	70.7
	Speeds up campus visitation	74.5
Effort Expectancy	Easy to use	53.8
	User-friendly interface	53.3
	No advanced skills required	47.3
	Enables efficient exploration	54.3
Social Influence	Recommended by peers	57.6
	Encouraged by influential individuals	44.0
	Supported by environment	47.8

	Improves personal reputation	40.8
Facilitating Conditions	Adequate technological facilities	53.3
	Basic application knowledge	33.7
	Sufficient organizational support	43.5
	Adequate technical support	39.7

Performance expectancy emerged as the strongest domain, with high agreement that the application saves time, speeds up visitation, and enhances the exploration experience. Effort expectancy also showed positive responses, although some reservations remained regarding technical skills. Social influence and facilitating conditions scored moderately, suggesting the need for stronger organizational and technical support. Overall, the findings indicate that acceptance of the UIS Virtual Tour application is high, particularly regarding its functionality and user experience. However, technical and organizational support should be strengthened to ensure optimal usability and sustained user confidence

Discussion

The findings of this study demonstrate a high level of acceptance and interest in the UIS Virtual Tour application, particularly among young users who constitute the majority of the respondents. This is consistent with prior research which has highlighted that younger generations, particularly students, are more receptive to mobile-based applications and immersive technologies such as virtual reality (VR) for educational and exploratory purposes (Radianti et al., 2020; Sharma et al., 2021). The demographic profile, with most respondents aged 18–25 and possessing moderate ICT skills, reinforces the suitability of developing a user-friendly mobile application that caters to this group.

Performance expectancy emerged as the most influential factor, where respondents strongly agreed that the application would be useful, time-saving, and able to enhance the exploration experience. This aligns with the Unified Theory of Acceptance and Use of Technology (UTAUT) model, which consistently identifies performance expectancy as a strong predictor of technology adoption (Venkatesh et al., 2003). The findings also echo those of Bower and Jong (2020), who found that VR-based applications significantly enhance user engagement and satisfaction when exploring educational environments.

Effort expectancy also received positive responses, with more than half of the respondents agreeing that the application is easy to use and features a user-friendly interface. However, some reservations were observed regarding the requirement for advanced technical skills, indicating the necessity of designing a simple and intuitive interface. This finding is consistent with the study by Alalwan et al. (2017), who argued that minimizing perceived effort is critical in increasing the adoption of mobile applications.

Social influence and facilitating conditions, on the other hand, were found to be moderate. While peer recommendations were relatively strong, encouragement from influential

individuals and perceptions of enhanced reputation were lower. Similarly, although more than half of the respondents indicated sufficient technological readiness, organizational and technical support were perceived as limited. This suggests the importance of institutional backing and continuous technical assistance to increase user confidence. Prior studies also stress the role of social and organizational support in sustaining the long-term adoption of educational technologies (Nikou & Economides, 2018; Hew & Lo, 2018).

Overall, these findings indicate that while the UIS Virtual Tour has high potential for acceptance due to its functionality and performance benefits, the success of its implementation will also depend on strengthening institutional support systems and addressing perceived technical barriers. Enhancing usability, providing adequate training resources, and integrating promotional strategies through social networks may further improve adoption rates.

Conclusion

This study highlights the strong potential of a UIS Mobile Virtual Tour application as an engaging and accessible platform for campus exploration and promotion. Through a needs analysis of 184 respondents, the findings reveal clear user expectations for an intuitive, mobile-friendly design enriched with high-quality panoramic visuals, interactive multimedia elements, and seamless cross-device functionality. Guided by the UTAUT model, performance expectancy emerged as the strongest predictor of user acceptance, underscoring the importance of usefulness and time-saving features. Effort expectancy also showed positive responses, indicating that a user-friendly interface will be key to adoption, while social influence and facilitating conditions played a more moderate role.

The results confirm that functionality, usability, and immersive design are critical determinants of user satisfaction and intention to use the application. They also emphasize the need for institutional support and robust technical infrastructure to sustain long-term engagement. By combining VR technology with user-centered design principles, this study provides a practical framework for developing an effective and innovative mobile virtual tour that can enhance UIS's visibility, improve access to information, and offer prospective students, parents, and the public a rich and interactive campus experience.

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KNOWLEDGE AND ATTITUDE TOWARDS INFERTILITY: A BIBLIOMETRIC REVIEW

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Abstract: Infertility is increasingly recognized as a global public health concern, not only for its biomedical implications but also for its psychological, social, and cultural dimensions. Understanding the knowledge and attitudes towards infertility is crucial for informing policies, reducing stigma, and enhancing patient-centered care. Despite its importance, research in this area has been scattered, necessitating a comprehensive bibliometric analysis to map trends, collaborations, and thematic developments. The present study addresses this gap by systematically examining global research output on knowledge and attitudes towards infertility. Data were collected using the Scopus database through an advanced search strategy with the keywords “knowledge,” “attitude,” and “infertility,” yielding a total of 1,035 articles. The data were then refined and harmonized using OpenRefine to ensure consistency and accuracy. Statistical and graphical analyses were conducted using the Scopus analyzer, while VOSviewer software was employed to generate network visualizations of co-authorship, co-citation, and keyword co-occurrence patterns. The findings revealed a steady increase in publication output over the past five decades, with a sharp rise after 2010, indicating growing academic attention to the subject. The United States, the United Kingdom, and Australia emerged as the leading contributors, while collaborative networks highlighted increasing involvement from developing countries such as India, Nigeria, and Iran. Keyword co-occurrence analysis identified seven major clusters, reflecting thematic emphases on assisted reproductive technologies, patient awareness, fertility preservation, psychosocial dimensions, and cultural perceptions. These results contribute to the body of knowledge by mapping the intellectual structure and global research dynamics of infertility studies. In conclusion, the study underscores the multidimensional nature of infertility research and highlights the need for strengthened interdisciplinary and international collaborations to address this complex health issue.

Keywords: Knowledge, Attitude, Infertility

Introduction

Infertility affects millions of couples globally, carrying emotional, social, and medical consequences. Despite its widespread occurrence, knowledge and awareness about infertility remain limited, leading to misconceptions and stigma. Studies have shown that knowledge

levels differ among populations, with many individuals demonstrating inadequate understanding of fertility despite holding positive attitudes. For instance, research from Mosul city reported moderate to low knowledge levels, yet most participants maintained positive attitudes (Hashim et al., 2024). Similarly, male participants in Iran displayed low health literacy about infertility, unaffected by age or education, while college students in another study showed gender differences in fertility awareness but shared significant knowledge gaps (Saifi et al., 2021; Alaei et al., 2019). These findings highlight the need for education to enhance understanding of fertility and reproductive health. Cultural and social beliefs also shape attitudes and practices related to infertility. A scoping review revealed that while both men and women had limited awareness, they were willing to adopt lifestyle changes to improve fertility (Mabitsela et al., 2025). Infertile women often showed greater knowledge due to direct healthcare experiences, yet misconceptions persisted even among them (Sharma et al., 2023). In Morocco, attitudes towards infertility treatments varied significantly by gender, with men more likely to suggest polygamy as a solution (El Adlani et al., 2021). These findings underscore that infertility awareness and attitudes are influenced not only by education but also by cultural norms, highlighting the importance of culturally sensitive and inclusive educational interventions.

Findings and Discussion

RQ1.What are the research trends on *knowledge and attitude towards infertility* according to the year of publication

The publication trend on knowledge and attitudes toward infertility shows steady growth from 1971 to 2025, with a significant rise after 2010. Early studies were limited and focused mainly on clinical aspects, but research expanded as infertility gained recognition as a global health issue and assisted reproductive technologies became more common. The sharp increase between 2015 and 2024 reflects growing awareness, reduced stigma, and the inclusion of social, psychological, and cultural perspectives alongside medical research. Improved access to global databases and bibliometric tools also contributed to this surge. The slight decline in 2025 is likely due to incomplete indexing. Overall, the findings indicate that infertility has evolved from a purely biomedical topic into a multidisciplinary field emphasizing health, culture, and society.

RQ2.What are the top 10 most cited articles?

The analysis of the most cited articles shows that research linking infertility with cancer survivorship and reproductive decision-making has the greatest influence in this field. Highly cited studies, such as those by Benedict et al. (2016), Quinn et al. (2009, 2007), and Schover et al. (2002), focus on fertility preservation and the psychosocial impact of infertility among cancer patients, highlighting the importance of integrating clinical and emotional aspects of care. Other influential works by Hodes-Wertz et al. (2013) and Bunting et al. (2013) emphasize fertility knowledge, decision-making, and women's attitudes toward reproductive technologies. Studies addressing HPV vaccine hesitancy and contraceptive barriers, such as Karafillakis et al. (2019) and Ochako et al. (2015), broaden the discussion to reproductive health behaviors and public health awareness. Overall, the citation trends reveal that impactful research on infertility often combines medical, psychosocial, and cultural perspectives, addressing issues that influence health policy and patient-centered reproductive care.

RQ3.Where are the top 10 countries based on the number of publications?

The country-wise distribution of studies on knowledge and attitudes toward infertility shows that most research comes from high-income, English-speaking countries such as the United States, the United Kingdom, Australia, and Canada, which benefit from strong academic and healthcare systems as well as ample research funding. European countries like the Netherlands and Sweden also make notable contributions. In contrast, emerging economies such as India, Nigeria, Turkey, and Iran are producing a growing body of research, driven by rising infertility rates and social awareness but limited by funding and infrastructure challenges. Overall, the findings reveal global disparities in research capacity while showing an encouraging trend of increasing contributions from developing regions, reflecting infertility's recognition as both a medical and socio-cultural issue requiring worldwide attention.

RQ4. What are the popular keywords related to the study?

The co-occurrence analysis of author keywords using VOSviewer revealed key themes and connections in research on knowledge and attitudes toward infertility. From 4,295 keywords, 978 met the criteria, forming seven major thematic clusters through full counting and a minimum occurrence threshold of five. These clusters represent main focus areas such as assisted reproductive technologies, fertility preservation, patient awareness, cultural perceptions, and psychosocial impacts. The analysis highlights how infertility research spans medical, psychological, and socio-cultural dimensions, showing both well-established and emerging topics. Overall, it provides a clear picture of how key concepts are linked, emphasizing the need for integrated, multidisciplinary approaches to advance understanding and interventions in infertility.

RQ5. What is co-authorship by countries' collaboration?

The co-authorship analysis using VOSviewer examined international collaborations in infertility research related to knowledge and attitudes. Applying a minimum of five co-authored documents, 45 countries met the criteria, forming seven clusters that represent global research networks. The analysis showed that high-income countries act as major hubs, leading research and sharing best practices, while emerging economies are increasingly contributing through regional and international partnerships. These collaboration patterns highlight the importance of global cooperation in expanding perspectives, improving research quality, and addressing infertility as a shared health and social issue. Overall, the findings emphasize that effective progress in infertility research depends on international teamwork and cross-cultural understanding.

Conclusion

This study analyzed global trends, themes, and collaborations in research on knowledge and attitudes toward infertility, revealing steady growth since the 1970s and a sharp increase after 2010. Most studies originated from high-income countries, while emerging economies are showing increasing involvement. Keyword and co-authorship analyses identified seven major thematic and collaboration clusters, highlighting infertility as a multidisciplinary issue that spans medical, psychological, and cultural dimensions. The findings underscore the importance of international and interdisciplinary collaboration to improve awareness, education, and

reproductive health services. Although limited to English-language articles from Scopus, the study provides valuable insights into global research patterns and emphasizes the need for broader and more inclusive future studies.

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METABOLOMIC SIGNATURES IN THE PROGRESSION AND TREATMENT OF SUBSTANCE USE DISORDERS: A BIBLIOMETRIC ANALYSIS

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Abstract: *Metabolomics provides a systems-level understanding of biochemical mechanisms underlying substance use disorders (SUDs). This bibliometric analysis mapped 1,214 Scopus-indexed publications (1973–2025) to evaluate global trends, key contributors, and thematic research hotspots. Data were curated using OpenRefine and analyzed via VOSviewer to visualize publication trends, keyword co-occurrence, and citation networks. Results show exponential publication growth since 2015, led by the United States, China, and Europe. Keyword clustering revealed research concentrations in biomarker discovery, neurobiological mechanisms, and personalized therapy. Despite growing activity, the field remains methodologically fragmented. Metabolomic profiling demonstrates strong potential for precision medicine and translational applications in addiction research.*

Keywords: *Metabolomic, Signature, Substance Use Disorder, Precision Medicine*

Introduction

Substance use disorders (SUDs) are chronic, relapsing conditions that impose major social and healthcare burdens worldwide (Morcuende et al., 2021). Despite existing therapies, high relapse rates and poor treatment adherence highlight the need to better understand their underlying biological mechanisms (Loganathan & Tiego, 2023). Metabolomics, the comprehensive profiling of metabolites has emerged as a powerful approach to identify biochemical alterations associated with substance dependence, progression, and treatment response (Caspani et al., 2022). Studies have revealed disruptions in energy metabolism, neurotransmitter pathways, and oxidative stress regulation, with key biomarkers such as cholic acid and L-valine proposed as diagnostic and prognostic indicators (Mamat et al., 2025). Integrating metabolomics with other omics platforms enhances insight into the neurobiological effects of chronic drug exposure and supports precision medicine development (Yang et al., 2023). However, methodological heterogeneity, limited sample sizes, and individual variability continue to restrict reproducibility and clinical translation. This study conducts a bibliometric analysis to map global research trends on metabolomic signatures in SUDs, identify key contributors, and highlight emerging themes that may guide future research and therapeutic innovation.

Methodology

Data were extracted from Scopus using Boolean queries combining metabolomic and SUD-related terms. Example of Boolean search (e.g., TITLE-ABS-KEY (("metabolomic" OR "metabolome") AND ("addiction" OR "substance use disorder"))). The dataset comprised 1,214 English-language peer-reviewed journal articles (1973–October 2025). OpenRefine was used for data cleaning, while VOSviewer (v1.6.20) performed network visualization of keywords, co-authorships, and citations. Publication year, document type, and country contributions were analyzed to identify productivity and emerging research hotspots.

Findings and Discussion

Publication Trends

Annual output rose sharply post-2015, reflecting technology-driven expansion with exponential growth following 2021. Early decades (1973–2009) yielded sparse output due to technological constraints, whereas contemporary growth aligns with precision medicine initiatives and improved metabolomic workflows.

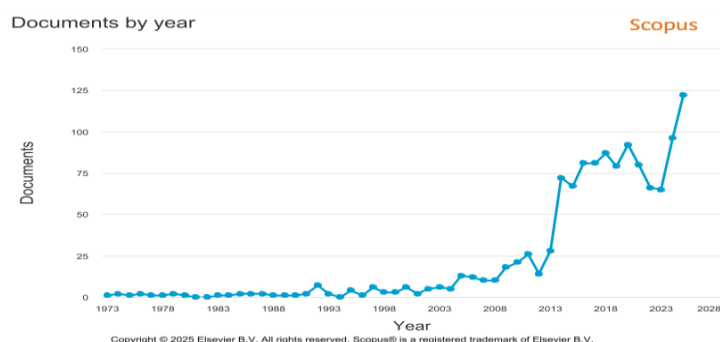


Figure 11: Number of Documents Based on Year of Publication

Top Cited Articles

Table 7. Most cited author and article

Authors (Year)	Source	Topic	Citations
Ghandi et al. (2019)	Nature	Cancer Cell Line Encyclopedia	2245
Jonklaas et al. (2014)	Thyroid	Hormone Replacement Guideline	1355
Pergolizzi et al. (2008)	Pain Practice	Opioid Management	748
Johnson et al. (2014)	J Psychopharmacol	Psilocybin in Addiction	722
Škroť et al. (2017)	Nature	Disulfiram Anticancer	657
de Sousa E Melo et al. (2017)	Nature	Stem Cells & Cancer	618

Highly cited papers span oncology, endocrinology, pharmacology, and psychiatry reflecting the interdisciplinary integration of metabolomics. Methodological innovations and biomarker-driven translational work dominate citations.

Keyword Analysis

Keyword co-occurrence mapping generated five clusters centered on metabolism, biomarker discovery, gene expression, and drug effects. The network reflects increasing alignment between preclinical and clinical metabolomics for addiction. Human studies linking metabolic signatures to behavioral and neurochemical outcomes are gaining prominence.

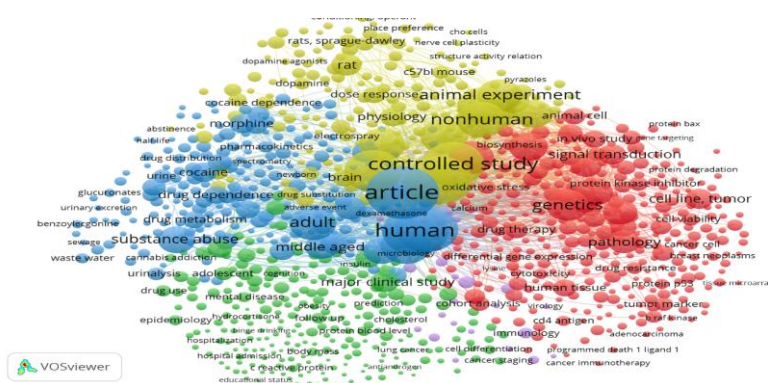


Figure 12: Network Visualization Map of Keywords' Co-Occurrence

Conclusion

This bibliometric overview underscores the accelerating influence of metabolomics in addiction research. Although publication output and thematic diversity have expanded rapidly, collaboration remains regionally clustered. Integrating metabolomics with genomics, proteomics, and neuroimaging could yield a holistic precision-medicine framework for SUDs. Future work should focus on harmonizing data sharing and fostering cross-disciplinary partnerships to translate metabolomic insights into actionable interventions.

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AI-AUGMENTED CREATIVE METACOGNITION AND BRAIN-BASED ENTREPRENEURSHIP: A BIBLIOMETRIC PERSPECTIVE FOR FUTURE BUSINESS EDUCATION

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Abstract: *The rapid transformation of education in the era of the Fifth Industrial Revolution highlights the need for human-centered and innovation-driven learning paradigms. This study examines emerging connections between design thinking, creative metacognition, and brain-based entrepreneurship learning to support future business curricula. Using a bibliometric synthesis, 1,492 Scopus-indexed documents were retrieved and refined using OpenRefine for data accuracy. Publication trends, influential authors, leading countries, and source distribution were analyzed using Scopus Analyzer, while VOSviewer was applied to visualize co-authorship networks and keyword co-occurrence. Findings indicate a steady growth in research output, with the United States, United Kingdom, and China as dominant contributors. Four thematic clusters emerged: design-driven learning innovation, neuro-cognitive creativity development, interdisciplinary education, and technology-enhanced pedagogy. These results demonstrate a global shift toward educational models that integrate brain-based learning and reflective creative thinking. The study highlights the increasing relevance of neuroscience-informed, empathy-driven, and adaptive learning frameworks for future-ready business education.*

Keywords: *Design Thinking, Creative Metacognition, Neuroscience, Future Education*

Introduction

The integration of artificial intelligence (AI) into business education is revolutionizing the way creativity and entrepreneurship are taught and practiced. AI-augmented creative metacognition leverages generative AI (GAI) and natural language processing (NLP) to enhance creative problem-solving and decision-making processes, fostering innovation and divergent thinking in students (Knibbe, Peschl, & Osiyevskyy, 2024; McNees, 2025; Q. Solteo, Jr., 2025). This technological advancement is reshaping traditional educational models by providing personalized learning experiences and real-time feedback, thus improving cognitive engagement and self-efficacy (Park, Kim, & Lee, 2025; Suvorova & Demirbilek, 2025). Moreover, brain-based entrepreneurship, which combines AI with entrepreneurial education, offers powerful tools for opportunity identification, market analysis, and business model validation, ultimately preparing students for the dynamic demands of the modern business world (Ameen, Sharma, Tarba, Rao, & Chopra, 2022; McNees, 2025; Shepherd & Majchrzak, 2022; Yu, Ramayah, & Lin, 2025). However, the ethical implications and potential over-reliance on AI highlight the need for a balanced, human-centered approach to ensure that creativity and critical thinking are not diminished (Hunt & Kurdoglu, 2025; Q. Solteo, Jr.,

2025; Rakshith & Roopa, 2025). This bibliometric perspective underscores the transformative potential of AI in future business education while advocating for responsible and strategic integration.

Research Question

RQ1: What are the global publication trends of design thinking, creative metacognitive and neuroscience in education?

RQ2: What are the most cited authors and articles?

RQ3: Where are the top ten countries based on the number of publications?

RQ4: What are the popular keywords and themes related to the study?

RQ5: What is co-authorship by countries' collaboration?

Research Methodology

This study applied a bibliometric approach to collect and analyse scholarly publication data (Alves et al., 2021; Assyakur & Rosa, 2022). Beyond basic statistics, the analysis incorporated advanced techniques such as co-citation and network mapping (Wu & Wu, 2017). The literature search was conducted iteratively with careful selection of keywords to ensure a reliable dataset (Fahimnia et al., 2015). Only high-impact, peer-reviewed journal articles indexed in SCOPUS were included, while books and lecture notes were excluded to maintain academic rigour (Gu et al., 2019; Al-Khoury et al., 2022). Publications from 2020 to October 2025 were then analysed for mapping, performance metrics, and thematic interpretation.

Data Search Strategy

The data retrieval process for this study was systematically conducted using the Scopus database, selected for its broad indexing of peer-reviewed scientific publications and strong academic credibility. The advanced search function was applied using the query: TITLE (("Design Thinking" OR "Creative Metacognition" OR "Neuroscience") AND Education) AND PUBYEAR > 2019 AND PUBYEAR < 2026, executed in October 2025 to capture the most recent research outputs. The dataset was refined according to predefined inclusion and exclusion criteria, restricting the scope to publications from 2020 to 2025 to ensure relevance to contemporary educational developments. Only peer-reviewed journal articles were included, while books, lecture notes, and conference papers were excluded to maintain methodological rigour. After refinement, a total of 875 publications remained. This dataset provides a credible foundation for bibliometric analysis, enabling the identification of research trends, collaboration patterns, and emerging thematic directions in AI-augmented creative metacognition and brain-based entrepreneurship education.

Data Analysis

VOSviewer is a bibliometric visualization tool developed by Nees Jan van Eck and Ludo Waltman at Leiden University, Netherlands (Van Eck & Waltman, 2010, 2017). The software is designed to generate network maps, identify clusters of related items, and visually display patterns in co-authorship, co-citation, and keyword co-occurrence. In this study, VOSviewer version 1.6.20 was employed to analyze Scopus data from 2015 to 2025, including information on article titles, authors, journals, citation counts, and keywords. The program utilizes the

Association Strength (AS_{ij}) normalization technique to represent the strength of relationships between items where the value is “proportional to the ratio between the observed number of co-occurrences of *i* and *j* and the expected number of co-occurrences of *i* and *j* under the assumption that the co-occurrences are statistically independent” (Van Eck & Waltman, 2007).

Research Findings

Table 1: Research Objective, Domain of Analysis, Findings, Summary

Research Objective	Domain of Analysis	Findings	Summary (Concise Interpretation)
RQ1: To examine global publication trends of design thinking, creative metacognition, and neuroscience in education.	Publication Trends (2020–2025)	Publications increased from 205 (2020) to a peak of 308 (2024), reflecting rising interest in brain-based, creativity-driven, and design-led learning. Slight decline in 2025 (285) is due to publication cycle effects. Growth aligns with Education 5.0, digital transformation, and post-pandemic pedagogical reform.	Research in this field is expanding and strengthening, driven by global shifts toward human-centered, interdisciplinary, and emotionally intelligent learning approaches.
RQ2: To identify the most cited and influential authors and articles.	Citation and Influence Analysis	Zhang et al. (2020) ranks highest (370 citations), followed by Meyer & Norman (2020) and Pande & Bharathi (2020). Influential articles converge on themes of neuroscience-informed learning, design thinking, and creative cognition.	Highly cited works form the theoretical base of current educational innovation, showing a shift toward experiential, reflective, and brain-based pedagogy in the global research agenda.
RQ3: To determine the top contributing countries by publication volume.	Geographic Research Productivity	US (421) leads, followed by UK (134), China (94), Australia (90). Other emerging contributors include India, Germany, Taiwan, Thailand, and Malaysia.	Developed nations lead due to infrastructure and funding, but global participation is broadening, showing shared movement toward SDG4 and

			Education 5.0 priorities.
RQ4: analyse popular keywords research themes.	To Keyword Co-Occurrence and Thematic Clustering	Four core clusters identified: (1) Design Thinking, (2) Neuroscience / Neuroeducation, (3) Higher Education, and (4) Experiential Learning & Innovation. Keywords indicate strong integration of cognition, creativity, motivation, mental health, and digital learning.	Education is shifting from traditional instruction to integrative, evidence-based, neuro-cognitive and creativity-centered learning ecosystems.
RQ5: examine co-authorship and international research collaboration.	To Co-Authorship and Network Mapping	US is the largest collaboration hub, linking strongly with UK, China, Spain, Brazil. Regional clusters include Malaysia, Indonesia, and India, increasingly participating in global knowledge exchange.	Global research networks are highly interconnected, promoting shared innovation, bridging knowledge capacities, and fostering collaborative development of future-ready education frameworks.

Conclusion

This bibliometric study examined global research on design thinking, creative metacognition, and neuroscience in future education using 1,492 Scopus-indexed publications. Findings show a steady rise in research output from 2020 to 2025, with the United States, United Kingdom, and China as leading contributors. Four main thematic clusters emerged: design-driven learning innovation, neuro-cognitive creativity, interdisciplinary education, and technology-enhanced pedagogy. Highly cited works highlight increasing emphasis on human-centred and brain-informed learning aligned with Education 5.0. The study underscores the value of integrating cognitive science and design approaches, while acknowledging limitations in database and language coverage.

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GLOBAL RESEARCH PATTERNS IN LISTENING ASSESSMENT: A BIBLIOMETRIC ANALYSIS (2000–2025)

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Abstract: *The growing importance of listening skills in education and language acquisition has driven increasing scholarly attention to listening assessment. However, limited bibliometric research has mapped the global research landscape in this field. This study addresses this gap by conducting a bibliometric analysis using Scopus-indexed publications on “listening assessment.” The dataset of 884 documents (2000–2025) was analyzed using Scopus Analyzer, OpenRefine, and VOSviewer to examine publication trends, key authors, prolific countries, and keyword clusters. Results revealed steady growth in listening assessment research, led by the United States, United Kingdom, and China. Thematic clusters identified include “language testing,” “listening comprehension,” and “assessment tools.” Co-authorship and collaboration networks showed expanding international cooperation, especially among English-speaking and Asian countries. These findings offer insights into the intellectual development of listening assessment research and highlight emerging areas for future exploration.*

Keywords: *Listening, Assessment, Language Testing, Bibliometric Analysis, Scopus*

Introduction

Listening assessment plays a central yet historically underexplored role in language education. Compared with reading and writing, listening involves complex cognitive processes that are difficult to observe, posing unique challenges for evaluation (Schmidt & Holzkecht, 2024). Traditional listening assessments have often lacked reliability and consistency, prompting the need for more objective and technology-supported approaches (Slamet & Mukminatien, 2024). With advancements in digital platforms and psychometric tools, contemporary studies now offer more valid and efficient means of measuring listening proficiency (Ockey, 2024). This study aims to analyze the global research landscape of listening assessment using bibliometric techniques to identify trends, key contributors, and thematic directions.

Literature Review

Listening is foundational in language acquisition (Folkerts & Matz, 2024) and integral to communication, yet educational systems have historically prioritized reading and writing (John et al., 2025). Researchers emphasize combining subjective and objective assessment tools to

capture the multidimensional nature of listening comprehension (Hidri, 2014; Slamet & Mukminatien, 2024). Emerging trends include online listening assessments and technology-enhanced testing, which improve feedback and learner engagement but also introduce technical and anxiety-related challenges (Deng et al., 2024; Tran & Ma, 2021). Studies further highlight the potential of physiological indicators, such as pupillometry, to provide insight into cognitive listening effort (Kuchinsky & Milvae, 2024). Overall, research underscores the importance of developing reliable, valid, and context-sensitive assessments that align with learners' diverse environments.

Methodology

This study employed a bibliometric approach to analyze Scopus-indexed research on listening assessment between 2000 and 2025. The search string used was:

TITLE((listening OR "listening skill" OR "listening skills" OR "listening strategy" OR "listening strategies") AND (assessment OR assessments OR test OR tests OR evaluation)) AND PUBYEAR > 1999 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE, "English")).

After screening and refinement, 884 publications were selected. Data cleaning was performed using OpenRefine, while VOSviewer (v1.6.20) generated bibliometric maps for co-authorship, keyword co-occurrence, and citation networks (van Eck & Waltman, 2010). The analysis focused on publication trends, citation impact, leading countries, and thematic clustering to reveal intellectual structures within the field.

Table 1: The Search String

Scopus	TITLE ((listening OR "listening skill" OR "listening skills" OR "listening strategy" OR "listening strategies") AND (assessment OR assessments OR test OR tests OR evaluation)) AND PUBYEAR > 1999 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English"))
Access date: October 2025	

Findings and Discussions

1. What are the trends in this study according to the year of publication?

Publication Trends: The number of publications rose steadily from 2014 to 2023, peaking at 70 papers. This trend reflects growing institutional support and cross-disciplinary interest, partly accelerated by digitalization and the post-pandemic shift to online assessment research.

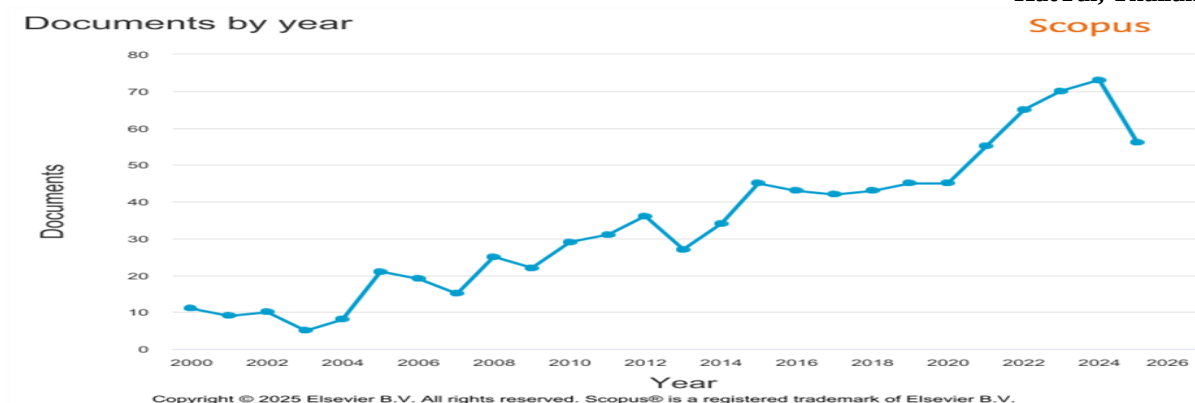


Figure 2: Number of Documents Cited by Year

2. What are the top 10 most cited articles?

Most Cited Articles: The most influential works include Cameron & Dillon (2007) on the LISN-S test and Schoeffler et al. (2018) on web-based listening assessments, showing the strong intersection of technology and language testing.

3. What are the top 10 countries based on the number of publications?

Leading Countries: The United States leads global contributions (187 publications), followed by the UK (100) and China (92). Regional participation from Japan, Australia, and Iran indicates emerging global collaboration in the field.

4. What are the popular keywords related to the study?

Keyword Analysis: Frequent keywords include “listening tests,” “speech perception,” “hearing impairment,” and “cognition,” forming eight thematic clusters. The analysis reveals interconnected research in auditory perception, cognitive psychology, and educational testing.

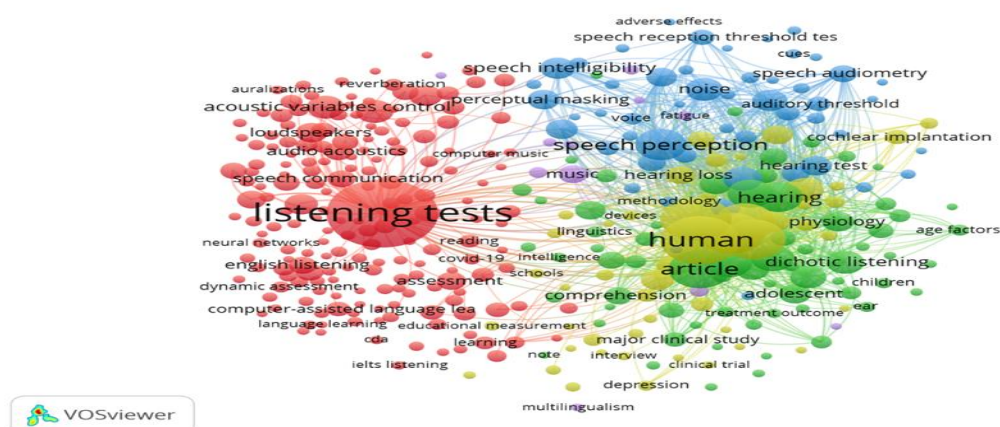


Figure 3: Network Visualization Map of Keywords' Co-occurrence

5. What is co-authorship by countries' collaboration?

Co-authorship Networks: VOSviewer mapping shows strong collaborations among English-speaking and Asian nations. The United States, United Kingdom, and Germany serve as key hubs in international research partnerships, promoting cross-institutional knowledge exchange.

Conclusion

This bibliometric study provides a structured overview of research on listening assessment from 2000 to 2025. The findings reveal a consistent increase in publication activity and collaboration, with leading contributions from the U.S., U.K., and China. Core themes include language testing, comprehension, and technological integration. The study highlights bibliometric analysis as an effective tool for mapping scholarly progress and identifying underexplored areas. Future research should incorporate multiple databases and explore qualitative insights into assessment practices to broaden understanding. Continued interdisciplinary collaboration and technological innovation are essential for advancing listening assessment research globally.

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THE ROLE OF EMOTIONAL INTELLIGENCE IN EDUCATION: A WORLDWIDE RESEARCH OVERVIEW

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Abstract: Emotional intelligence (EI) is increasingly recognised as a key factor in educational success, influencing students' academic performance, psychological well-being, and social functioning. Despite this growing relevance, EI research in education remains fragmented, making it difficult to identify global trends and core thematic directions. This study conducts a bibliometric analysis to systematically map scientific output, collaborative networks, and major research themes related to EI in educational settings. Data were retrieved from the Scopus database using a refined keyword search and filtered to 553 English-language publications. Descriptive trends were analysed using Scopus Analyzer, while VOSviewer was used to visualise co-authorship, co-citation, and keyword clustering. The results indicate a steady increase in research from 2004 to 2024, with China, the United States, the United Kingdom, and Malaysia emerging as leading contributors. Spain reported the highest citation impact. Collaboration analysis shows eight international clusters, with China and the UK serving as central nodes. Dominant themes include leadership, higher education, academic achievement, and psychological well-being. These findings offer a consolidated overview of the global research landscape on EI in education and highlight its expanding role as a framework for supporting educational development and policymaking.

Keywords: Emotional, Intelligence, Education, Psychological

Introduction

Emotional Intelligence (EI) has become a central topic in education due to its strong influence on both student and teacher performance. Defined as the ability to recognise, understand, and manage emotions, EI plays a critical role in supporting holistic development in learning environments (Rahman & Mahadi, 2024; Solih et al., 2024). Global scholarship shows a steady

rise in EI-related publications, reflecting growing awareness of its importance in academic achievement, social interaction, and psychological well-being (Yousaf et al., 2021; Brandao de Souza & Jacomuzzi, 2025; Dolev & Leshem, 2017). This study examines global research trends on EI in educational contexts, offering an overview of its evolution, key applications, and emerging directions.

Literature Review

Research on emotional intelligence (EI) in education has expanded significantly, demonstrating its importance in enhancing teaching and learning outcomes. Studies show that EI supports academic performance, emotional regulation, and social development among students (Hussainy et al., 2022; Stewart et al., 2010). In schools, EI-based programmes have improved students' self-awareness and interpersonal skills (Viñas & Blanco, 2022), while in higher education, emotionally competent teachers create more engaging and supportive classroom environments (Brandao De Souza & Jacomuzzi, 2025). EI also plays a key role in teacher development, strengthening professional relationships and classroom management (Dolev & Leshem, 2017). However, existing literature is limited by reliance on self-report data and a lack of longitudinal and cross-cultural studies. Further research is needed to deepen understanding of EI's long-term educational impact.

Research Question

- RQ1: What are the publication trends over time?
- RQ2: Which are the top 10 most cited articles?
- RQ3: Which countries contribute the most publications?
- RQ4: What are the most frequently used keywords?
- RQ5: How do countries collaborate through co-authorship?

Methodology

Bibliometrics is a systematic method for gathering, organizing, and analyzing bibliographic data from scientific publications Alves et al., (2021). Data were retrieved from the Scopus database using specific keywords related to artificial intelligence and adaptive learning. The dataset, limited to English peer-reviewed journal articles and conference papers from 1996 to 2025, was refined using OpenRefine. Visualization and network analyses were conducted using VOSviewer 1.6.20 to examine co-authorship patterns, keyword co-occurrence, and thematic clusters within the research domain.

Data Search Strategy

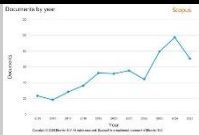
The Scopus advanced search function was used to collect publications with the query TITLE (emotional AND intelligence AND education OR psychological), limited to English-language journal articles. The search was conducted in October 2025 and covered the period 2015–2025 to ensure a contemporary focus. Only peer-reviewed and final-stage publications were included, while non-English works, conference papers, book chapters, and “In Press” items were excluded. Subject areas were limited to Environmental Science, Energy, and Social Sciences to maintain relevance to educational and psychological contexts. After applying all screening criteria, 553 articles were retained for bibliometric analysis.

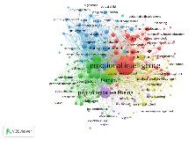
Data Analysis

This study utilized VOSviewer 1.6.20 to analyze Scopus datasets, creating network visualizations based on association strength normalization.

Research Findings

Table 1: Summary of Key Findings Based on Research Questions

Research Questions	Focus Area	Findings	Summary
RQ1	Publication Trends (2015 -2025)	 Publications were low in 2015–2017, grew steadily in 2018–2021, surged in 2023–2024, and slightly declined in 2025 due to incomplete indexing.	Overall, the trend shows steady growth, with emotional intelligence becoming a research hotspot post-2022, driven by rising focus on student well-being and socio-emotional learning.
RQ2	Top Cited Authors	Chandra (2021) leads with the highest citations, followed by Sun et al. (2019), Martínez-Monteagudo et al. (2019), Guerra-Bustamante et al. (2019), and Li et al. (2015).	Highly cited studies reflect EI's growing importance for resilience, well-being, and performance in education.
RQ3	Leading Countries	 Spain leads with 87 publications, followed by China (61), India (58), the United States (53), and the United Kingdom (45). Malaysia (29), Turkey (26), Indonesia (20), Pakistan (19), and South Africa (15).	The geographic spread shows EI's global relevance, shaped by differing institutional support, research capacity, and cultural emphasis across regions.

RQ4	Popular Keywords		Major cluster“psychological well-being,” “students,” “mental health,” “nursing education,” “academic performance,”	Keyword clustering shows EI’s multidisciplinary role, linking stress, coping, development, and achievement across psychology, education, and health.
RQ5	Co-authorship & Collaboration		34 active countries formed 8 clusters, with China, Spain, the United States, and the United Kingdom emerging as the strongest collaboration network.	Collaboration demonstrates worldwide engagement, with growing regional partnerships strengthening cross-border knowledge sharing.

Conclusion

This study examined global research trends on emotional intelligence in education, revealing a steady rise in publications from 2015 to 2025 and strong scholarly growth in recent years. Spain, China, India, the United States, and the United Kingdom lead contributions, while Malaysia and other emerging nations show increasing participation. Collaboration mapping identified eight international clusters, with China and the UK as key hubs. The findings highlight emotional intelligence as essential in supporting student well-being, teaching effectiveness, and holistic learning. Although limited to Scopus English-language data, this study offers a foundation for broader future research.

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THE IMPACT OF CORPORATE SOCIAL RESPONSIBILITY ON COMPANY BRAND REPUTATION AND PERFORMANCE: A BIBLIOMETRIC ANALYSIS

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Abstract: *This study explores the intellectual landscape and research trends on the impact of Corporate Social Responsibility (CSR) on company brand reputation and performance an area gaining increasing academic and corporate attention. Despite the global emphasis on CSR, there remains limited consolidated understanding of its influence on brand equity and firm performance across sectors and regions. To address this gap, a bibliometric analysis was conducted using 933 peer-reviewed journal articles retrieved from the Scopus database (2001–2025) through advanced search techniques focusing on “corporate social responsibility,” “brand reputation,” and “performance.” The data were analysed using Scopus Analyzer for descriptive statistics and trends, Open Refine for data cleaning, and VOS viewer for co-occurrence, co-authorship, and country collaboration mapping. Results revealed five major thematic clusters, with “corporate social responsibility,” “sustainability,” and “corporate reputation” as dominant keywords. The United States, China, and the United Kingdom emerged as leading contributors, with a sharp rise in publications after 2015. Co-authorship analysis showed increasing international collaboration between developed and emerging economies. This study enriches understanding of CSR’s strategic role in enhancing organizational outcomes and serves as a comprehensive reference for scholars and practitioners aligning CSR initiatives with branding and performance objectives.*

Keywords: *Corporate Social Responsibility, Brand Reputation, Company Performance*

Introduction

Corporate Social Responsibility (CSR) plays a vital role in modern strategic management, shaping corporate ethics, brand reputation, and performance. As stakeholders grow more conscious of sustainability, CSR has become essential for building trust and brand value. This paper examines how CSR initiatives enhance reputation, customer loyalty, and financial performance through empirical and theoretical insights.

Literature Review

The connection between Corporate Social Responsibility (CSR) and brand performance has been widely examined, with consistent evidence indicating that CSR initiatives enhance brand reputation, which subsequently strengthens brand performance. Studies across diverse industries affirm that CSR contributes to improved organizational outcomes by fostering trust, innovation, and social legitimacy. For example, Hesari et al. (2021) revealed that CSR positively affects resource commitment, green creativity, and corporate reputation as key

drivers of brand performance. Similarly, Zhang and Liu (2023) found a significant relationship between CSR, financial performance, and brand value, moderated by social capital. These findings highlight CSR's strategic importance in shaping corporate image and achieving competitive advantage. Furthermore, CSR influences consumer perceptions and product evaluations; Chernev and Blair (2015) demonstrated that even non-core CSR initiatives enhance consumer trust and loyalty by reflecting authentic corporate values. Transparent CSR reporting further amplifies this effect by strengthening reputation and credibility (Pérez-Cornejo et al., 2020).

Additionally, CSR's influence extends to innovation and financial performance. Nguyen et al. (2021) found that corporate reputation mediates the relationship between CSR and supply chain outcomes, translating social initiatives into measurable business value. In emerging markets, CSR-driven brand strategies increase loyalty and corporate performance (Meru & Kinoti, 2022). Empirical studies also show CSR investments improve financial metrics such as return on assets and market capitalization (Zhukova & Melikova, 2021), while fostering innovation (Reverte et al., 2016). Overall, CSR emerges not merely as a moral duty but as a strategic enabler and enhancing customer-based brand equity, promoting innovation, and driving sustainable corporate success.

Research Questions

- RQ1: What is the number of studies on CSR published in online learning studies according to the year of publication?
RQ2: What are the top 10 most cited articles?
RQ3: Where are the top 10 countries based on the number of publications?
RQ4: What are the popular keywords related to the study?
RQ5: What is the co-authorship by countries?

Methodology

Bibliometric analysis is a vital research method for systematically collecting and interpreting scholarly data (Alves et al., 2021). Beyond basic metrics, advanced techniques like co-citation analysis uncover intellectual foundations and research trends. This study employed a structured, keyword-driven approach using Elsevier's Scopus database, focusing on peer-reviewed journal articles (2000–2025). Only high-impact works offering strong theoretical contributions were included, while non-journal sources were excluded to ensure methodological rigor and analytical precision (Al-Khoury et al., 2022). This systematic process enhances the validity, relevance, and credibility of the bibliometric findings.

Findings

From 2001–2025, publications on CSR's impact on brand reputation and performance rose sharply from fewer than 10 annually before 2007 to over 100 by 2024 driven by post-crisis ethics focus, ESG regulations, stakeholder capitalism, and post-COVID trust rebuilding, reflecting CSR's evolution into a core strategic discipline.

The ten most cited CSR studies linking brand reputation and performance. Orlitzky et al. (2003) leads with 5,140 citations, evidencing CSR's strategic value. Subsequent works expanded

CSR's scope through financial, ethical, and stakeholder lenses, confirming its role in driving competitiveness, reputation, and sustainable business performance.

CSR research on brand reputation and performance is globally active, led by the U.S. (170) and China (157). Europe (Spain, U.K.) emphasizes sustainability and governance, while emerging economies (South Korea, India, Malaysia, Pakistan, Vietnam) integrate CSR into competitiveness, regulation, and SDGs, reflecting worldwide strategic adoption of responsible business practices.

VOS viewer co-occurrence analysis of 1,820 CSR-related keywords, identifying 210 terms across five clusters. Core themes include CSR, sustainability, reputation, and performance, with emerging topics like ESG and green marketing. The map reveals evolving, multidisciplinary CSR research linking ethics, strategy, brand and organizational performance.

The VOS viewer co-authorship analysis (Figure 1) maps international CSR research collaboration. Using full counting and a five-document threshold, 48 countries formed five clusters. The U.S. and China lead in output and collaboration, with strong ties across Anglo-American, European, and Asia-Pacific networks, reflecting globalized, cross-regional CSR scholarship.

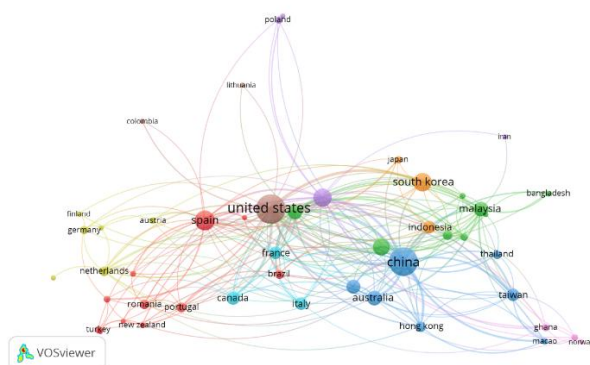


Figure 1: Network Visualization Map of Co-authorship by Countries' Collaboration

Conclusion

This study analysed 933 Scopus-indexed articles (2000–2025) to map the intellectual structure and global collaboration on CSR's impact on brand reputation and performance. Findings show rising publications since 2016, with key themes in sustainability, reputation, and stakeholder engagement. The U.S., China, and U.K. lead in output and collaboration. Keyword analysis reveals interdisciplinary integration across marketing, finance, and strategy. CSR has evolved from philanthropy to a strategic driver of brand differentiation and performance. Despite relying solely on Scopus, the study provides valuable insights for scholars, practitioners, and policymakers into CSR's growing academic and practical significance.

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MAPPING THE KNOWLEDGE LANDSCAPE OF SUBMARINE CABLE INFRASTRUCTURE: A BIBLIOMETRIC ANALYSIS

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Abstract: Submarine cable infrastructure is crucial for global telecommunications, supporting international data transfer and internet connectivity. As the demand for high-capacity and resilient networks grows, the need for a comprehensive understanding of research trends and developments in this field becomes more important. However, a systematic review of the academic literature on submarine cable infrastructure remains scarce. This bibliometric review aims to address this gap by analyzing the evolution of research on submarine cables and their technological, economic, and regulatory aspects. Data was collected from Scopus using advanced search queries with the keywords “submarine,” “cables,” “fiber,” and “fibre,” yielding a final dataset of 1,989 documents. Statistical analysis and graph generation were conducted using Scopus Analyzer, while OpenRefine was utilized for data cleaning and harmonization. VOSviewer was then employed for data visualization to identify key research clusters, co-authorship patterns, and emerging trends. The analysis reveals a significant increase in research output over the past decade, with notable contributions from leading countries, including the United States, the United Kingdom, and China. Key thematic areas include advances in cable technology, network resilience, and the economic and regulatory challenges of deploying submarine cables. This bibliometric review offers valuable insights into the structure and dynamics of the field, highlighting key areas for future research and offering a foundational reference for stakeholders in the submarine cable industry.

Keywords: Submarine, Cable Technology, Submarine Cables, Fiber, Fibre

Introduction

Submarine cables are the backbone of global communication and energy infrastructure, enabling international connectivity, high-speed internet, and offshore energy transmission. They play a crucial role in supporting economic growth, technological innovation, and sustainable energy transitions (Setianingrum et al., 2024). Driven by the surge in social media and cloud computing, global data demand continues to rise, reinforcing the importance of submarine cables in the digital economy (Aishwarya, 2020). Technological advancements such as coherent transceiver technology and smart submarine line terminal equipment (SLTE) have enhanced capacity, reliability, and costefficiency, thereby extending the operational life of cable systems (Hadaway et al., 2016). In energy applications, life cycle cost (LCC) models

highlight that electricity loss and cable failure can account for up to 30.8% and 62.0% of total costs, emphasizing the importance of robust and efficient designs for offshore energy projects (Liu et al., 2015). Emerging technologies such as Space Division Multiplexing (SDM) and Multi-Core Fiber (MCF) are expected to further improve network capacity and resilience, with 32-fiber SDM systems offering an optimal near-term design (Takahashi et al., 2020; Bolshtyansky et al., 2020). Beyond their technical function, submarine cables serve as strategic digital trade routes that underpin global data exchange and cloud computing (Aishwarya, 2020). Their deployment requires integrated models that consider cost, route optimization, and environmental impact to ensure economic efficiency and long-term network sustainability (Wang et al., 2022).

Methodology

Bibliometrics represents a systematic and quantitative approach to examining scientific literature through the collection, organization, and analysis of bibliographic data (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). Traditionally focused on identifying key journals, publication trends, and influential authors (Wu & Wu, 2017), the field has advanced to incorporate sophisticated techniques such as document co-citation analysis, enabling a deeper understanding of intellectual structures and thematic evolution. A rigorous bibliometric study demands a methodical and iterative process, including careful keyword selection, extensive literature retrieval, and detailed data evaluation to ensure reliability and validity (Fahimnia et al., 2015). In this research, priority was given to high-impact publications that significantly shape theoretical and conceptual frameworks. Scopus, acknowledged for its comprehensive academic coverage, served as the exclusive data source (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). Only peer-reviewed journal articles published between 2020 and December 2023 were included to ensure analytical precision and contemporary relevance (Gu et al., 2019).

Data Search Strategy

A comprehensive and structured search strategy was employed to retrieve relevant academic literature concerning submarine or subsea fiber optic technologies using the SCOPUS database's advanced search function. The search string applied was: TITLE-ABS-KEY ((submarine OR subsea) AND (fiber OR fibre OR fiber)) AND PUBYEAR > 1960 AND PUBYEAR < 2026, which focused on publications containing these terms within their titles, abstracts, or keywords, and published between 1961 and 2025. To ensure the quality and relevance of the data, several filters were applied. The language was limited to English (LIMIT-TO (LANGUAGE , "English")), and only peer-reviewed journal articles and conference papers were included (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")), thereby excluding books, reviews, and other non-research content. Further refinement was applied by including only those publications that were in the final stage of publication (LIMIT-TO (PUBSTAGE , "final")), excluding in-press or incomplete works. Additionally, the subject areas were limited to Engineering, Computer Science, Business Management & Accounting, and Energy (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ENER")) to maintain disciplinary relevance and ensure the inclusion of technically focused research. No specific

timeline filter was applied beyond the year range, which allowed for a broader historical context.

Data Analysis

VOSviewer, developed by Nees Jan van Eck and Ludo Waltman at Leiden University, is a widely recognized bibliometric analysis software known for its advanced visualization capabilities and methodological precision (van Eck & Waltman, 2010, 2017). It enables the exploration of co-authorship, co-citation, and keyword co-occurrence networks, translating complex bibliometric relationships into visually interpretable maps and clusters. By employing association strength (AS_{ij}) rather than traditional similarity indices such as cosine or Jaccard coefficients, VOSviewer provides a more accurate representation of inter-item relatedness, enhancing the interpretability of bibliometric visualizations (Appio et al., 2014; van Eck & Waltman, 2007, 2010). In this study, bibliometric data extracted from the Scopus database covering publications from 1961 to October 2025 were analyzed using VOSviewer version 1.6.20. Through its clustering and mapping techniques, the software facilitated the identification of intellectual structures, thematic connections, and evolving collaboration patterns, reaffirming its utility as a leading tool in bibliometric research.

Result and Discussion

This section presents the key findings derived from the bibliometric analysis of 1989 peer-reviewed journal articles on submarine cables published between 1961 and 2025. The results are organized to highlight the productivity of subject areas, the most influential articles and authors, country-level contributions, emerging thematic keywords, and international research collaborations. Using tools like Scopus Analyzer and VOSviewer, the analysis offers valuable insights into the intellectual structure, research trends, and global engagement surrounding the intersection of submarine cables and cable technology.

Table 1: Summary of Research Questions and Key Findings

Research Question (RQ)	Focus / Description	Key Findings / Summary Statement
RQ1: 1. What is the number of publications by year?	Examines annual publication growth from 1961-2025	Publication trends show slow growth from 1961–1990s, reflecting early-stage subsea research, followed by steady increases from the 2000s and a sharp surge post-2020, driven by global digital expansion, resilient infrastructure needs, and technological and collaborative advancements.
RQ2: 2. What are the top 10 most cited articles?	Identifies the most influential and highly cited works.	The citation data reveal that the most highly cited work among the listed authors is by Huang et al. (2021), with 219 citations for a paper on a silicon photonic–electronic neural network for fiber nonlinearity compensation, published in Nature Electronics
RQ3: 3. What are the top 10 countries based	Analyzes geographic distribution of	The publication data reveals that the United States leads significantly with 482 publications, nearly double that of the second-highest contributor, China (255), followed closely by Japan (238). In contrast, European countries

on the number of research publications?	productivity.	like the United Kingdom (175), France (143), Norway (60), Italy (51), and Germany (45) demonstrate moderate levels of publication
RQ4: What are the popular keywords related to the study?	Explores keyword co-occurrence to identify core themes and emerging topics.	The analysis highlights prominent keywords such as "optical fibers," "submarine cables," and "fiber optics," which had high occurrences and total link strength values, signifying central roles in the field
RQ5: 5. What is co-authorship by countries' collaboration?	Examine collaboration patterns among authors and countries.	These clusters reveal collaboration groupings, often based on geographical proximity or shared research interests. The results show that countries like the United States, the United Kingdom, and China are central to global research collaboration, indicated by their high number of documents, citations, and strong link strengths

Conclusion

This study offers a comprehensive bibliometric evaluation of submarine cable infrastructure research, examining publication trends, influential works, national contributions, keyword patterns, and collaboration networks. Analysis of nearly two thousand publications reveals a rapid expansion of the field, especially after 2020, driven by the growing global dependence on digital and energy infrastructures. The dominance of the United States, China, and Japan underscores the field's global competitiveness, while European and coastal nations provide regional expertise. Thematic clustering highlights the convergence of optical communication, sensing technologies, and offshore engineering as central areas of scholarly attention and innovation.

The study's major contribution lies in systematically mapping the intellectual and collaborative structures of submarine cable research, thereby guiding future scholarly and industrial engagement. By visualizing knowledge clusters and emerging trends, it strengthens the foundation for policy development, investment strategies, and sustainable subsea system design. Despite its limitations—such as reliance on a single database and exclusion of non-English sources—the research establishes a vital framework for future inquiry. Ultimately, submarine cable studies have matured into a strategically significant domain underpinning the global digital economy and energy transition, requiring sustained interdisciplinary investigation.

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GAMIFICATION IN FOREIGN LANGUAGE LEARNING: GLOBAL TRENDS AND RESEARCH DIRECTIONS

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Abstract: Gamification has emerged as an innovative pedagogical approach in foreign language learning, enhancing learner engagement, motivation, and learning outcomes. This study provides a global analysis of research trends and intellectual patterns in the field of gamification within language education. Data were retrieved from the Scopus database using the keywords gamification, teaching, learning, and language, resulting in 1,239 documents refined through OpenRefine. Analytical tools such as Scopus Analyzer and VOSviewer were employed to explore publication trends, keyword co-occurrence, and co-authorship networks. The findings reveal a steady growth in research output between 2015 and 2025, with a sharp rise after 2018 and a publication peak in 2024. Spain, the United States, Indonesia, and Malaysia emerged as leading contributors, reflecting both established and emerging research hubs. Keyword clustering identified dominant themes related to motivation, e-learning, language acquisition, and gamified learning environments, alongside emerging areas such as artificial intelligence and virtual reality. This study offers a comprehensive overview of the global research landscape, highlighting evolving directions and providing insights for future pedagogical innovation in language learning.

Keywords: Gamification; Foreign Language Learning; Research Trends; Educational Technology

Introduction

Gamification, defined as the integration of game mechanics into non-game contexts, has become an increasingly influential approach in foreign language learning. By embedding elements such as points, levels, and challenges into instructional design, gamification enhances learner engagement, motivation, and performance. This strategy has transformed conventional language classrooms into more interactive and student-centered environments, aligning with modern educational paradigms that emphasize experiential and active learning. Over the past decade, research has shown that gamified platforms such as Duolingo, Kahoot, and Quizlet significantly improve vocabulary retention, grammar comprehension, and learner participation (Tamayo et al., 2023; Alenazi, 2025; Ali & Abdalgane, 2022). However, findings across studies remain inconsistent due to variations in implementation methods, learner profiles, and technological infrastructure (Luo, 2023; Zhang & Hasim, 2023). Challenges such as digital literacy gaps, limited teacher readiness, and contextual constraints continue to affect the effective use of gamification in diverse educational settings (Zhou & Wei, 2024; Davardan & Taghizadeh, 2025).

Despite these challenges, gamification has emerged as a prominent research theme in applied linguistics and educational technology, attracting increasing scholarly attention worldwide. The growing body of literature reflects an expanding interest in understanding how gamified approaches foster motivation, engagement, and long-term learning outcomes. This study therefore employs a bibliometric approach to systematically analyze global research on gamification in foreign language learning. Accordingly, the following research questions guide the analysis: RQ1: What are the most frequently occurring keywords used in studies related to gamification in foreign language learning? RQ2: How do countries collaborate in the field of gamification research for foreign language learning?

Methodology

This study employed a bibliometric approach to examine the development and collaboration trends in gamification research within foreign language learning. Data were retrieved from the Scopus database, covering publications from 2015 to October 2025, using relevant keywords such as gamification, language learning, and teaching. Only peer-reviewed journal articles were included to ensure data reliability and scholarly quality. To address RQ1 and RQ2, the data were cleaned and standardized using OpenRefine, followed by analysis through Scopus Analyzer and VOSviewer. The Scopus Analyzer was used to identify the most frequently occurring keywords, while VOSviewer visualized country-level collaboration networks, revealing international research connections in the field.

Findings and Discussion

RQ1: What are the most frequently occurring keywords used in studies related to gamification in foreign language (FL) learning?

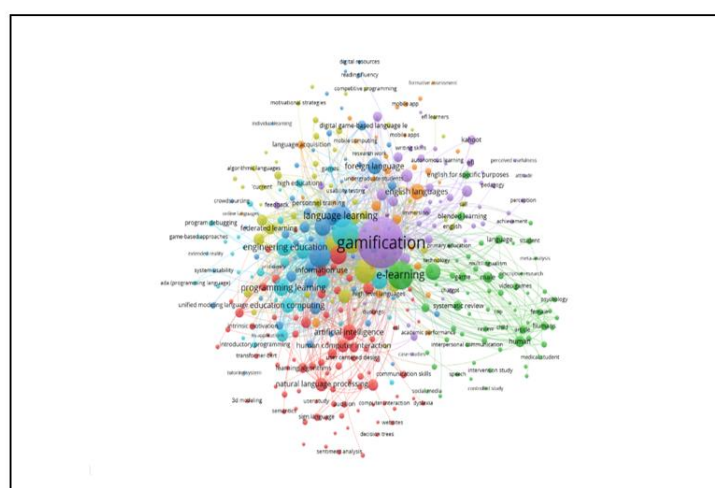


Figure 1: Keyword Co-occurrence Network in Gamification and FL Learning

The keyword co-occurrence analysis, generated through VOSviewer, explores how often author-supplied keywords appear together across publications, revealing thematic relationships and research directions in gamification studies. Using a full counting method with a minimum of five occurrences per keyword, 379 out of 2,897 keywords met the inclusion criteria, forming seven thematic clusters. The keyword “gamification” emerged as the central node with strong

associations to “motivation,” “language learning,” “students,” and “e-learning.” Additional clusters connect gamification with “artificial intelligence,” “virtual reality,” and “digital storytelling,” illustrating its interdisciplinary growth across education and technology. This visualization reflects the conceptual structure and evolving research focus, highlighting gamification’s expanding role from a motivational tool in language classrooms to a multifaceted component of digital and immersive learning ecosystems.

RQ2: How do countries collaborate in the field of gamification research for foreign language learning?

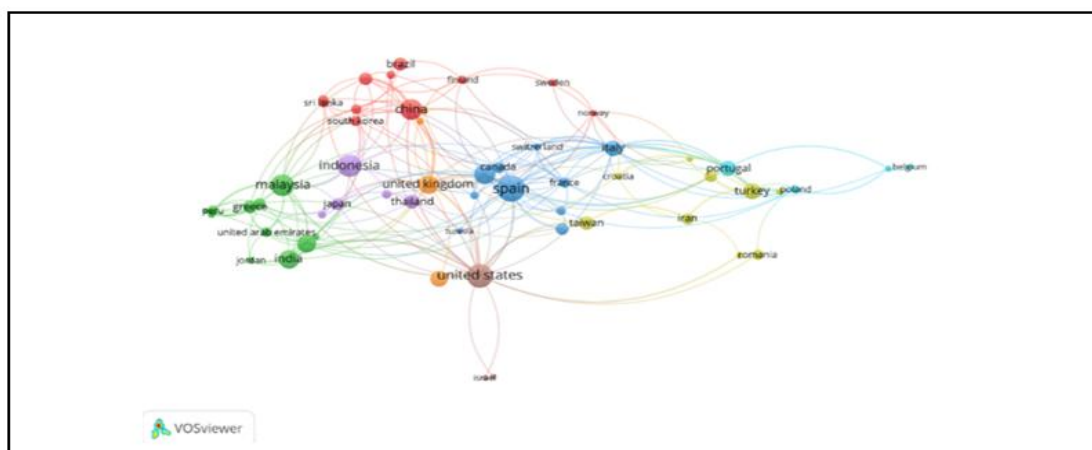


Figure 2: Co-Authorship Network by Countries in Gamification and FL Learning

The co-authorship network generated through VOSviewer illustrates international collaboration patterns in gamification research within foreign language learning. Each node represents a country, with node size reflecting publication volume and link thickness showing collaboration strength. Using a full counting method with a minimum of five publications per country, 61 countries met the inclusion criteria and formed eight clusters. The analysis reveals that Spain and the United States are central hubs with strong international linkages, while Malaysia, China, and the United Kingdom also demonstrate notable activity and growing partnerships. Emerging contributors such as Indonesia and Saudi Arabia highlight expanding research participation beyond traditional Western centers. These patterns indicate that the study of gamification in language learning has evolved into a globally connected field, where collaboration across regions contributes to the exchange of ideas, diversified perspectives, and a more inclusive understanding of educational innovation worldwide.

Conclusion

This study provides a comprehensive bibliometric overview of gamification in foreign language learning, highlighting research trends through keyword co-occurrence and international collaboration patterns. The findings reveal that “gamification,” “motivation,” and “language learning” are dominant and interconnected themes, indicating the field’s focus on engagement-driven pedagogical strategies. Emerging keywords such as “artificial intelligence,” “virtual reality,” and “digital storytelling” suggest that future research is increasingly integrating gamification with immersive and intelligent technologies. The co-authorship analysis shows that global collaboration in this field is growing, with Spain and the

United States serving as central contributors, while Malaysia, China, Indonesia, and Saudi Arabia demonstrate rising participation and influence. This expansion reflects a shift toward more diverse and inclusive research networks that enrich the discourse on gamification and language education.

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GLOBAL INSIGHTS INTO SUSTAINABLE LEADERSHIP TRENDS IN HIGHER EDUCATION

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Abstract: Sustainable leadership in higher education has gained increasing scholarly attention as universities strive to integrate institutional excellence with social and environmental accountability. To map the intellectual landscape of this growing field, this study conducts a bibliometric analysis of 1,100 publications indexed in Scopus between 2015 and 2025. Using the keywords “leadership,” “sustainable,” “higher,” and “education,” the dataset was refined through OpenRefine for consistency and analyzed using Scopus Analyzer and VOSviewer. The analysis identifies the most cited articles that have shaped the discourse on sustainable leadership, revealing influential works emphasizing innovation, resilience, and the integration of sustainability principles in academic governance. Additionally, co-authorship analysis by country highlights strong international collaboration, particularly among the United States, China, and Malaysia, reflecting the global effort to advance sustainable leadership practices in higher education. The findings offer valuable insights into key intellectual contributions and cross-national research networks that continue to drive the evolution of this interdisciplinary domain.

Keywords: Sustainable Leadership, Higher Education, Bibliometric Analysis International Collaboration

Introduction

Sustainable leadership in higher education has gained prominence as universities play a strategic role in addressing environmental, social, and economic challenges. This leadership involves implementing sustainable development initiatives that integrate teaching, research, policy, and community engagement (Filho et al., 2020; Leal Filho et al., 2025). Higher education institutions (HEIs) are uniquely positioned to advance sustainability, shaping future leaders and influencing societal transformation (Aung & Hallinger, 2022). Understanding the scholarly landscape of sustainable leadership is essential to identify influential research and global collaboration patterns. Bibliometric analysis offers a systematic approach to mapping this field by examining publication trends, citation impact, and co-authorship networks. The first research question identifies the most cited articles, revealing key contributions, frameworks, and emerging priorities in sustainable leadership. The second examines co-authorship by country, highlighting international collaboration and knowledge exchange. Together, the study clarifies the intellectual structure of sustainable leadership research, emphasizing influential works, leading contributors, and guiding future sustainability practices and partnerships in higher education.

Methodology

This study employed bibliometric analysis as a systematic approach to gather, organize, and analyze bibliographic data from scientific publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). Bibliometrics extends beyond generating descriptive statistics, such as identifying leading journals, publication years, and prolific authors (Wu & Wu, 2017), to more advanced analyses, including document co-citation mapping. Such techniques provide insights into the intellectual structure and influence of the field. Scopus was selected as the primary data source to ensure precision, consistency, and extensive coverage (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). To maintain academic quality, only peer-reviewed journal articles were included, while books, lecture notes, and other non-journal materials were excluded (Gu et al., 2019). Relevant publications from 2015 through October 2025 were systematically retrieved and organized for analysis. The bibliometric analysis specifically addressed the study's two objectives: (1) identifying the most cited articles to determine the key contributions and influential works in the domain, and (2) examining co-authorship by country to uncover patterns of international collaboration, highlighting which nations actively contribute to and shape sustainable leadership research.

Findings and Discussion

RQ1: What are the most cited articles?

Table 1: Most Cited Articles on Sustainable Leadership in Higher Education (HE)

Authors	Year	Source title	Cited by
Aftab et al., (2022)	2022	Journal of Cleaner Production	199
Borah et al. (2022)	2022	Technology in Society	201
Iqbal & Ahmad (2021)	2021	Sustainable Development	160
Iqbal et al., (2020)	2020	Journal of Cleaner Production	202
Burawat (2019)	2019	International Journal of Quality and Reliability Management	154
Li et al., (2019)	2019	Sustainability (Switzerland)	157
Hallinger & Suriyankietkaew (2018)	2018	Sustainability (Switzerland)	161
Jansson et al.(2017)	2017	Journal of Cleaner Production	231
Banker et al.(2014)	2014	Management Decision	220
Avery & Bergsteiner (2011)	2011	Strategy and Leadership	287

The analysis of the most cited articles on sustainable leadership shows that influential works span diverse contexts—from foundational studies linking leadership to organizational resilience and performance, such as Avery and Bergsteiner (2011), Banker et al. (2014), and Jansson et al. (2017), to more recent high-impact studies by Iqbal et al. (2020, 2021), Borah et al. (2022), and Aftab et al. (2022) addressing contemporary themes like environmental ethics, digital leadership, and learning organizations; together, these older and newer contributions reflect a field that is both historically grounded and dynamically evolving in response to global sustainability challenges.

RQ2: What is the co-authorship by country?

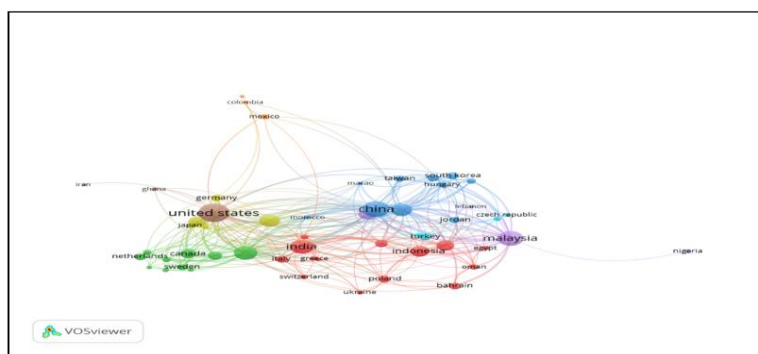


Figure 1: Co-Authorship by Country in Sustainable Leadership Research in HE

The co-authorship analysis at the country level offers important insights into the collaborative patterns that shape global research output. Using VOSviewer, countries are depicted as nodes, with connecting lines representing the frequency and strength of shared publications. The analysis shows that the United States leads in total publications (149), but its link strength (89) is comparatively lower than countries such as China (127) and Malaysia (108), suggesting that U.S. research relies less on international collaborations. In contrast, nations like Pakistan (103) and Saudi Arabia (56) exhibit high collaboration relative to their publication volume, emphasizing the role of cross-border partnerships in boosting visibility and impact. These findings indicate that research influence is driven not only by quantity but also by the scope of international collaboration. China and Malaysia emerge as central hubs facilitating regional and global partnerships, reflecting national strategies to strengthen research networks. The identification of 10 clusters among 54 qualifying countries demonstrates how global scholarship is organized into interconnected yet distinct collaborative communities. Overall, these insights underscore that international co-authorship is a key factor in citation impact, knowledge dissemination, and the development of emerging research hubs, particularly in Asia and the Middle East.

Conclusion

This study provides a bibliometric overview of sustainable leadership research in higher education, examining the most cited articles and co-authorship by country. Citation analysis shows the field is shaped by foundational works on organizational resilience, financial strategies, and consumer behavior, alongside recent studies on environmental ethics, digital leadership, and learning organizations. Co-authorship analysis highlights countries leading in publications and others acting as hubs for international collaboration. Overall, the findings emphasize that both influential research and global partnerships drive the growth and impact of sustainable leadership in higher education.

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BRIDGING ENGLISH LANGUAGE EDUCATION AND EMPLOYABILITY: A BIBLIOMETRIC REVIEW OF ENGLISH FOR OCCUPATIONAL PURPOSES (EOP)

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Abstract: *The increasing demand for employability-driven language education has underscored the need to align English for Occupational Purposes (EOP) curricula with real labor market requirements. This study employs a bibliometric approach to analyze research trends, thematic patterns, and scholarly structures in EOP-related publications, highlighting the evolving role of curriculum design in supporting workforce readiness. Data were retrieved from Scopus using the keywords “EOP,” “ESP,” “English for employment,” and “English at workplace,” yielding 880 documents published between 2020 and 2025. Data were refined using OpenRefine, and analyzed using Scopus Analyzer and VOSviewer. Findings reveal consistent growth in EOP research emphasizing employability, curriculum innovation, and workplace communication. Malaysia, the United States, and China emerged as leading contributors, demonstrating the field’s global expansion. This study concludes that EOP curriculum development must go beyond linguistic training to integrate employability skills, ensuring relevance to industry demands.*

Keywords: *EOP, ESP, Employability, Workplace Communication, English for Employment*

Introduction

In a globalized workforce, English proficiency has become a vital component of employability and career development. English for Occupational Purposes (EOP), a branch of English for Specific Purposes (ESP), is tailored to equip learners with language skills relevant to professional communication and job performance. With English serving as the lingua franca of international business and technology, aligning EOP instruction with employment demands is essential. This study explores how EOP research has evolved to meet labor market expectations by mapping publication trends, thematic directions, and the collaborative landscape of EOP scholarship.

Literature Review

Research has established that EOP enhances employability by addressing the linguistic and communicative demands of workplace environments (Kim, 2008; Delgado, 2019). EOP programs have been developed across diverse disciplines—business, engineering, and

administration—to ensure graduates possess both language proficiency and job-related competencies (Bui & Huong, 2023). However, studies show a misalignment between the EOP curriculum and workplace realities, as many programs emphasize academic English over practical communication (Kamil & Muhammad, 2021; Zainuddin et al., 2019). In developing economies, educational policies increasingly reflect the economization of English learning, where curricula are shaped by global labor markets (Ali & Hamid, 2023). In Malaysia and Saudi Arabia, for instance, the gap between English skills taught in universities and employers' expectations continues to challenge graduate readiness (Alqahtani, 2021). To bridge this gap, stakeholder feedback—particularly from employers—must inform course design to ensure EOP programs foster both linguistic and soft skills, including teamwork, adaptability, and professionalism (Sarudin et al., 2013; Abdullah et al., 2022).

Methodology

This research adopts a bibliometric analysis approach using the Scopus database to identify trends in EOP-related publications. A total of 880 documents were retrieved using advanced keyword searches, cleaned with OpenRefine, and analyzed using VOSviewer (v1.6.20) to examine publication trends, co-authorship, citation patterns, and keyword co-occurrences. The dataset focused on peer-reviewed English-language journal articles published between 2020 and 2025. Results were synthesized to answer five research questions concerning trends, citations, countries, keywords, and collaborations.

Table 1: Summary of Research Questions and Findings

Research Question	Focus	Summary of Findings
RQ1: Trends by Year	Publication and citation growth	EOP research showed steady growth from 2020–2025, peaking in 2023–2024. Increased interest was linked to post-pandemic digital education and employability-focused language training.
RQ2: Top Cited Works	Influential studies	Most cited works centered on AI integration, online learning, and digital tools (Mahapatra, 2024; Derakhshan et al., 2023). These highlight a shift toward technology-enhanced EOP instruction.
RQ3: Leading Countries	Geographic contribution	Malaysia led with 235 publications, followed by the U.S. (132) and China (95). Malaysia's strong policy on digital learning and language education explains its prominence.



RQ4: Popular Keywords Thematic mapping

Nine clusters emerged: workplace communication, employability, curriculum design, stakeholder engagement, digital learning, and EOP training effectiveness.

RQ5: Collaboration Patterns Co-authorship networks

Strong collaboration observed among Asian countries, especially Malaysia–China partnerships. Global research networks indicate increasing interdisciplinary exchange.

Discussion

The bibliometric results show a consistent increase in EOP research output from 2020 to 2025, with peaks observed in 2023 and 2024. This trend corresponds to the global emphasis on employability-focused English education following the pandemic. Foundational studies in earlier years continue to influence the field, showing sustained academic engagement. The ten most cited articles primarily explore the integration of technology and AI in ESL/EOP learning contexts (Mahapatra, 2024; Derakhshan et al., 2023), indicating a shift towards digital pedagogies and adaptive learning tools. Malaysia emerged as the top contributor with 235 publications, followed by the United States and China, underscoring Malaysia's commitment to research-driven language education. Keyword analysis revealed nine thematic clusters centring on workplace communication, employability, curriculum design, and stakeholder collaboration. Collaboration patterns indicate strong regional partnerships, particularly among Asian countries, reflecting collective efforts to align EOP with global workforce requirements. Overall, EOP has evolved beyond linguistic focus into a multidisciplinary field emphasizing technology, curriculum innovation, and employability.

Conclusion

This study provides a bibliometric overview of English for Occupational Purposes (EOP) research between 2020 and 2025. The findings highlight significant growth and diversification within the field, particularly in Malaysia, which leads global contributions. Key themes such as workplace communication, employability, and digital pedagogy underscore the transformation of EOP into a tool for professional readiness. To strengthen its impact, future EOP initiatives should enhance collaboration between academia and industry, ensuring that curricula reflect real workplace expectations and equip graduates with relevant skills.



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GLOBAL RESEARCH TRENDS ON THE APPLICATION OF WAVE EQUATION AND VIBRATION IN ACOUSTIC AND VIBRATION ENGINEERING

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Abstract: *The wave equation serves as a cornerstone in acoustic and vibration engineering, forming the foundation for modeling wave propagation, sound transmission, vibration control, and structural dynamics. Despite its wide application, global research trends on this topic have rarely been systematically analyzed using bibliometric methods. This paper presents a concise bibliometric perspective on studies related to the wave equation in acoustic and vibration engineering, using data extracted from the Scopus database. A total of 883 journal publications were identified and analyzed using Scopus Analyzer, OpenRefine, and VOSviewer. The analysis reveals consistent growth in research output over the past two decades, led primarily by China and the United States. Major research themes include computational modeling, acoustic material design, vibration mitigation, and the use of metamaterials. This study highlights global collaboration patterns and identifies core knowledge clusters, offering insights for future research development in acoustics and vibration analysis.*

Keywords: Wave Equation, Acoustic Engineering, Vibration Control, Research Trends, Vosviewer

Introduction

The wave equation, a fundamental form of partial differential equation, plays a crucial role in describing how waves propagate through various media. Initially formulated from d'Alembert's analysis of a vibrating string, the equation has become central to numerous applications in engineering and physics, particularly in acoustics and vibration studies. It enables researchers to model and predict wave behaviors with precision, making it indispensable in modern engineering design. In acoustic engineering, the wave equation supports detailed modeling of sound propagation and scattering, especially in heterogeneous or anisotropic materials. Applications range from noise prediction and control to medical ultrasound and subsurface imaging. Meanwhile, in vibration engineering, it underpins analyses of mechanical structures such as beams, plates, and strings, helping engineers predict resonance frequencies and mitigate unwanted vibrations. Advances in computational techniques, such as the Finite Difference Time Domain (FDTD) and Finite Element Method (FEM), have expanded the applicability of the wave equation. These numerical methods allow simulation of complex geometries and real-world materials, supporting the development of quiet and stable

engineering systems. In addition, the emergence of metamaterials has introduced new capabilities in controlling wave propagation, leading to innovations in vibration isolation and sound absorption. Given its interdisciplinary importance, understanding how global research on wave equations has evolved can provide valuable insights. Therefore, this bibliometric study aims to map the intellectual structure, collaboration networks, and emerging themes in this field through quantitative and visual analysis.

Methodology

Bibliometric analysis was employed to systematically examine global research activity related to the wave equation in acoustic and vibration engineering. Data were collected from the Scopus database, selected for its comprehensive coverage of peer-reviewed publications. The search was performed on 3 October 2025 using the keywords “wave”, “equation”, and “acoustic” within article titles, limited to English-language journal articles. The dataset included 883 documents published between 1951 and 2025. Publications such as conference papers, book chapters, and reviews were excluded to ensure data consistency. The retrieved data were cleaned using OpenRefine to eliminate duplicates and ensure metadata accuracy. For analysis and visualization, VOSviewer (version 1.6.20) was used to map co-authorship networks, keyword co-occurrence, and thematic clusters. This software applies a clustering algorithm that identifies relationships among bibliometric items based on co-occurrence frequencies. Unlike traditional Multidimensional Scaling (MDS), VOSviewer employs the Association Strength normalization method, providing more reliable mapping of related research entities. Through this process, the study identified publication trends, top contributing countries, most-cited papers, and keyword relationships, allowing the construction of an overview of global research dynamics in this area.

Findings and Discussion

The analysis of publications from 1951 to 2025 revealed a steady increase in research activity, especially from the early 2000s onward. During the initial decades, publications were limited to fewer than five per year, but since 2010, the number has risen significantly, reaching over sixty in 2024. This upward trend corresponds with rapid technological advancement, particularly in computational modeling and simulation, which allow more accurate analysis of complex wave phenomena. The growth also reflects the expanding role of acoustics and vibration control in various industries, including aerospace, automotive, and construction. Furthermore, the surge in research during and after the COVID-19 pandemic suggests a shift toward virtual experimentation and theoretical modeling as alternatives to laboratory-based research.

A review of citation patterns identified several highly influential works that have shaped the theoretical foundation of the field. The most cited article, by Alkhalifah (2000), introduced an acoustic wave equation for anisotropic media, providing a crucial framework for seismic and geophysical applications. Classic works such as Pratt and Worthington (1990) on inverse theory and Schamel (1973) on ion acoustic waves continue to be referenced extensively, reflecting their enduring scientific value. More recent studies, such as those by Seadawy (2014) and Liu and Sen (2009), demonstrate advancements in high-order finite-difference and numerical modeling, emphasizing greater accuracy and adaptability in wave simulation. These developments indicate that while the field remains grounded in traditional mathematical

physics, it is increasingly oriented toward computational precision and integration with emerging technologies such as machine learning and digital twin systems.

Geographically, research activity is dominated by China and the United States, which together account for nearly half of all publications in the dataset. Both countries exhibit strong institutional frameworks and sustained investment in scientific research. China's rapid rise reflects its national policy emphasis on innovation and technology leadership, while the United States continues to benefit from a well-established academic infrastructure and global collaboration networks. Other active contributors include India, Saudi Arabia, and South Korea, which have shown notable growth due to expanding research capacity in acoustics and mechanical engineering. European nations such as France and the United Kingdom also play significant roles, often forming collaborative networks that connect Asia, North America, and the Middle East. The co-authorship mapping results show that international collaboration has become a defining characteristic of this field, fostering knowledge exchange and enhancing research quality across regions.

The thematic and keyword analysis further reinforces the interdisciplinary nature of this research area. Six dominant clusters emerged from the keyword co-occurrence mapping, representing major themes such as acoustic wave propagation, computational modeling, seismology and geophysics, nonlinear and plasma wave dynamics, mathematical modeling of anisotropic media, and applications involving metamaterials and smart systems. These clusters illustrate the integration of physical theory with practical engineering innovation. The frequent appearance of keywords such as finite element method, metamaterials, numerical analysis, and vibration control suggests a shift toward simulation-based design and material optimization. Recent trends also point to an increased focus on sustainable and adaptive systems, where vibration and acoustic management are critical for developing energy-efficient and environmentally conscious technologies. Overall, the findings highlight that research on the wave equation has matured into a complex, collaborative, and technologically driven domain that continues to evolve with advancements in computational science and materials engineering.

Conclusion

This bibliometric perspective provides a comprehensive overview of global research trends on the application of the wave equation in acoustic and vibration engineering. The findings confirm a steady rise in scholarly output since the early 2000s, with China and the United States leading in publication volume and international collaboration. Influential works have laid a strong theoretical foundation, while contemporary studies focus on computational innovations, hybrid modeling, and metamaterial applications. Thematic mapping reveals an interdisciplinary field connecting physics, mathematics, and materials engineering, emphasizing sustainable and adaptive technologies. Overall, bibliometric analysis proves valuable for identifying research gaps, strengthening collaborations, and guiding future exploration of wave-based modeling in modern engineering.

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EVOLUTION OF FIRE RESISTANCE IN TIMBER STRUCTURE: A BIBLIOMETRIC ANALYSIS APPROACH

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Abstract: *The growing emphasis on sustainable and fire-resilient construction has intensified interest in the fire performance of timber structures. However, a comprehensive synthesis of global research trends in this area remains limited. This study conducts a bibliometric analysis to examine the evolution, research patterns, and collaborative networks in timber fire resistance research. Using Scopus advanced searching with defined keywords, 402 relevant publications from 2000 to 2025 were retrieved. Data were refined using OpenRefine for consistency and analysed through the Scopus Analyzer and VOSviewer to generate statistical trends and network visualisations, including co-authorship, keyword co-occurrence, and citation mapping. The results reveal a steady increase in publications, with notable growth after 2015, reflecting greater recognition of timber's role in sustainable construction and fire safety. China, Canada, and the United States emerged as leading contributors, while key themes such as fire resistance, charring rate, cross-laminated timber, and fire protection dominated the research landscape. The findings provide valuable insights into research gaps, collaboration patterns, and emerging directions supporting safer and more sustainable timber construction.*

Keywords: *Timber Structure, Charring Rate, Fire Resistance, Bibliometric Analysis*

Introduction

Fire resistance plays a vital role in ensuring the safety and stability of timber structures during fire exposure. Timber is widely used in construction due to its strength, aesthetics, and environmental advantages, but it is naturally combustible. Its performance in fire depends on factors such as the formation of a char layer, the size of the timber members, and the type of connections and protective coverings used (Džidić and Aktee, 2025; Rusinová et al., 2023).

The char layer serves as insulation, slowing heat transfer and protecting the core. The charring rate, influenced by species, density, and moisture content, is a critical parameter in determining fire resistance (Cachim & Franssen, 2010). Larger sections and higher stiffness improve performance by retaining unburned wood during exposure. Standard fire tests such as ISO 834 are used to assess this behaviour, while numerical models like Abaqus simulate and validate results (Fragiacomo et al., 2013). Recent research has advanced fire protection using retardants such as ammonium polyphosphate and tannic acid (Zhao et al., 2025). Overall, continued

experimental and analytical studies are essential to enhance the safety and reliability of timber in modern fire-resistant construction.

Methodology

This study employed bibliometric analysis to systematically collect and evaluate scientific publications on the fire resistance of timber structures, aiming to identify research trends, collaboration networks, and thematic (Alves et al., 2021; Verbeek et al., 2002). The Scopus database was selected for its broad academic coverage. Using the advanced search feature, relevant publications were identified with the following search string TITLE(("fire resistance" OR "fire performance" OR "fire behaviour") AND ("timber" OR "wood" OR "hardwood*" OR "softwood*" OR "lumber" OR "wooden" OR "bamboo*" OR "LVL" OR "CLT" OR "glulam")) AND PUBYEAR > 1999 AND PUBYEAR < 2026. This search captured studies on both natural and engineered timber, including laminated veneer lumber (LVL), cross laminated timber (CLT), and glued laminated timber (glulam). Only journal articles, conference papers, and book chapters from 2000 to 2025 were included, while books and non-English documents were excluded.

A total of 402 documents were obtained and refined using OpenRefine to eliminate duplicates and standardise author names and keywords. The cleaned dataset was analysed with VOSviewer version 1.6.19 to visualise co-authorship, keyword co-occurrence, and citation networks. This structured process ensured reliability and provided a clear understanding of global research activity in fire-safe timber construction.

Findings

The publication trend on the fire resistance of timber structures from 2000 to 2025 shows steady growth, with clear acceleration in the last decade. Fewer than ten papers were published annually before 2010, indicating limited research attention. From 2010 onwards, publication output increased notably, exceeding 20 papers per year after 2017 and reaching a peak of 50 in 2025. This growth reflects the expanding use of engineered wood products such as cross laminated timber and glulam, alongside regulatory updates and renewed interest in structural fire safety and design standards.

The ten most cited studies demonstrate the evolution of knowledge from material behaviour to advanced modelling. The leading article by Brando et al. (2012) examined fire-induced tree mortality and wood density effects, while Racher et al. (2010) analysed the thermal performance of dowelled connections. Recent works such as Mensah et al. (2023) explored fire retardant mechanisms, and Naser (2019) introduced artificial intelligence for fire prediction. Yue et al. (2017) improved fire performance through chemical modification, and Schmid et al. (2015) developed the reduced cross-section method, now widely adopted in design practice. Collectively, these studies illustrate the field's progress from fundamental fire behaviour research to innovative design and sustainable timber applications.

The bibliometric analysis revealed that China led global research on fire resistance of timber structures with 92 publications, followed by Canada (58), the United States (44), and Japan (43). European countries such as Italy, Switzerland, Sweden, and the Czech Republic also made steady contributions supported by strong academic and policy frameworks. New Zealand and

Australia produced 18 and 17 publications respectively, consistent with their national focus on sustainable timber construction. Overall, the research landscape shows a wide international spread, but concentrated leadership remains in China, Canada, and Japan, where industrial development and national policies actively support timber research.

Keyword co-occurrence analysis using VOSviewer identified seven main thematic clusters from 244 keywords (Figure 1(a)). The largest cluster focuses on “fire resistance,” “timber,” and “structural design,” reflecting strong interest in the fundamental behaviour of timber under fire exposure. Other clusters include experimental testing methods such as “flammability testing” and “cone calorimeter,” computational approaches such as “finite element method” and “numerical models,” and engineered wood applications such as “cross laminated timber” and “glulam beams.” Additional clusters highlight passive fire protection measures, structural performance, and environmental sustainability, indicating that research in this field integrates experimental, computational, and ecological perspectives.

Co-authorship analysis of 57 countries (Figure 1(b)) revealed five collaboration clusters, showing that countries with the highest publication outputs which are China, Canada, and the United States were act as central nodes in international research networks. European countries such as Italy, Sweden, and Switzerland also maintain strong collaborative links through joint projects and shared testing facilities. Meanwhile, smaller research nations like New Zealand and Australia demonstrate active partnerships that strengthen their global presence. The findings show that scientific progress in timber fire safety depends not only on national productivity but also on collaboration, which enhances knowledge exchange and promotes the development of reliable fire-resistant timber design practices worldwide.

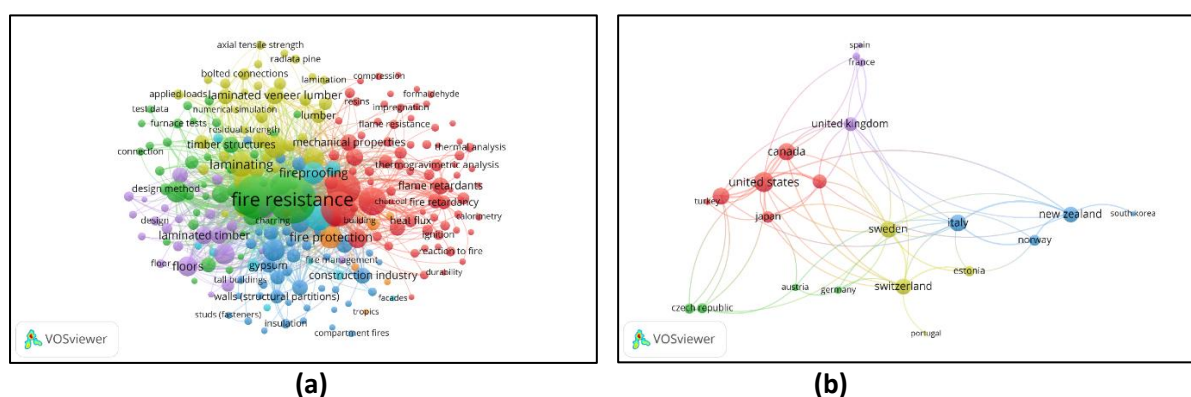


Figure 1: a) Co-Occurrence Popular Keywords, b) Co-authorship by country

Conclusions

This study examined the evolution and current state of research on the fire resistance of timber structures using bibliometric analysis. It analysed 402 publications from 2000 to 2025 to identify major trends, influential works, and global collaboration networks. Results showed a steady rise in research output, especially after 2015, reflecting the growing interest in sustainable and fire-safe timber construction. Leading contributors were from China, Canada, and the United States. Keyword mapping revealed core themes such as fire resistance, charring behaviour, structural design, and engineered timber systems. The study highlights the shift from basic combustion studies to advanced modelling and sustainable design approaches,

emphasising the importance of international collaboration in developing reliable standards for fire-resistant timber.

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GLOBAL RESEARCH TRENDS IN LANDFILL LEACHATE TREATMENT: A BIBLIOMETRIC ASSESSMENT

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Abstract: Landfill leachate remains as one of the major environmental concerns due to its complex composition which typically contains high levels of organic matter, ammoniacal nitrogen, heavy metals, and persistent pollutants that requires effective treatment. Although numerous studies have explored treatment methods, an overall framework of global research activity is still limited. This study presents a bibliometric assessment of landfill leachate treatment methods to assess the global research trends, key contributors, and emerging research themes. Data were retrieved from the Scopus database using the keywords “landfill leachate” and “leachate treatment,” producing 784 journal articles published between 2000 and 2025. The dataset was refined using OpenRefine, analyzed through the Scopus analyzer, and visualized with VOSviewer. Findings show a continuous growth in publications, with a marked increase after 2015 reflecting growing worldwide attention to leachate management. China recorded the highest number of publications, followed by Malaysia, Iran, and India. Highly cited studies focus on electrochemical oxidation, advanced oxidation, adsorption, and biological treatments, while emerging topics include electro-Fenton processes, membrane bioreactors, and integrated treatment systems. Collaboration networks reveal strong international collaboration especially between Asian and European researchers. This study provides a clear overview of global progress, research priorities, and navigate future directions in landfill leachate treatment.

Keywords: Landfill Leachate, Leachate Treatment, Bibliometric Analysis

Introduction

Landfill leachate is a byproduct produced from the decomposition of solid waste, commonly poses serious environmental and public health risks due to its complex composition and high pollutant levels. With continuous urbanization and increasing waste generation, the effective

management of landfill leachate has become a pressing global issue for sustainable waste management systems (Singh et al. 2023; Yu et al. 2022). The leachate typically contains a mixture of organic and inorganic contaminants such as heavy metals, ammonia, and emerging pollutants, which can severely impact soil, surface water, and groundwater quality if inadequately treated (Fang et al. 2021; Xiang et al. 2025). In general, leachate treatment methods can be categorized into physical, chemical, biological, and advanced processes. Physical treatments such as screening, sedimentation, and filtration serve as preliminary stage to remove suspended solids and reduce pollutant loadings on subsequent stages (Fu et al. 2022; Singh et al. 2023). Meanwhile, chemical processes including coagulation, flocculation, and oxidation are applied to neutralize, stabilize, and remove heavy metals and refractory compounds (Chelliapan et al. 2020; Ramprasad et al. 2019). Biological treatments rely on microorganisms to degrade organic matter efficiently and economically, using systems such as activated sludge, sequencing batch reactors (SBRs), and up-flow anaerobic sludge blanket (UASB) reactors (Li et al., 2007; Zhang & Surampalli, 2016). Additionally, advanced treatment processes techniques such as electrochemical oxidation, Fenton reactions, and three-dimensional electrode systems have attracted growing attention for their promising results in removing complex and persistent compounds from landfill leachate (Deng et al. 2020; Feng et al. 2020; Yu et al. 2022).

Nevertheless, challenges persist due to leachate variability influenced by landfill age and waste composition which requires a combination of physical, chemical, biological and advanced oxidation processes in employing effective leachate treatment. Therefore, understanding the research evolution and thematic focus of leachate treatment technologies is crucial. Hence, this bibliometric study aims to map the global research framework by addressing five research questions (RQ): (1) publication trends focusing on leachate treatment from year 2000 to 2025; (2) highly cited works in this research field; (3) top contributing countries; (4) dominant and emerging keywords in leachate treatment; and (5) international research collaborations.

Methodology

This study conducts a bibliometric analysis on leachate treatment technologies to identify scientific progress and intellectual structures shaping the field. Scopus was selected as the primary database, given its extensive coverage and established reliability. The dataset was restricted to peer-reviewed journal articles, excluding books, lecture notes and non-indexed materials. An advanced search strategy was employed to ensure precision and reproducibility, using the following search string; TITLE (“leachate” AND “treatment” AND (“landfill leachate treatment” OR “leachate treatment”)) AND PUBYEAR > 1999 AND PUBYEAR < 2026 AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (PUBSTAGE, “final”)). The analysis focused on publications from 2000 to October 2025, ensuring the inclusion of the most recent and relevant contributions. Non-English documents, conference papers, and review papers were excluded to ensure dataset consistency and peer-reviewed quality. The advanced search has yielded 784 final journal articles, and the retrieved dataset was further cleaned and harmonized using OpenRefine. The statistical trends were analyzed based on Scopus analyzer and research mapping were visualized using VOSviewer (v1.6.19) by employing co-authorship, citation, and keyword co-occurrence analyses.

Results and Findings

The Table 1 below summarizes the results and findings based on the developed research questions developed.

Table 8: Research Findings Based on RQs

RQ	Main Findings
RQ1: Publication Trends	Steady growth observed over the 25 years, with a sharp rise after 2015 and a peak between 2020 to 2023 (72 papers/year). Early 2000s showed < 10 papers annually. The publication trends reflect the global recognition of leachate as environmental issue and development of leachate technology growth.
RQ2: Highly Cited Articles	Among the top cited articles in leachate treatment studies are Deng & Englehardt, (2007), employing electrochemical oxidation process for leachate treatment (357 citations), followed by Tizaoui et al., (2007) using ozone and ozone/hydrogen peroxide systems (324 citations); Halim et al., (2010) comparing removal of COD and ammonia using different types of adsorbent (312 citations); Amor et al., (2015) on combined leachate treatment using coagulation/flocculation with Fenton/photo-Fenton process (298 citations) and Mohajeri et al., (2010) electro-Fenton technique for leachate treatment (275 citations). High citations indicate the relevancy of the published leachate treatment technologies.
RQ3: Top Contributing Countries	China is the top leading countries with 208 papers, followed by Malaysia (96), Iran (69), India (47), and Turkey (46). Developing countries prioritize cost-effective leachate management compared to developed nations such as US, Canada, Korea.
RQ4: Keyword Occurrences	Seven clusters were identified where the dominant terms are landfill leachate, COD, ammonia, oxidation, adsorption, membrane, bioreactor. This indicates a shift from conventional to integrated and sustainable leachate treatment methods.
RQ5: International Collaboration	42 active countries have been identified to have a good global collaboration. China and Malaysia are the major hubs (link strength: 62 and 70 respectively). Strong Asia-Europe collaboration is also notified between China-Malaysia-UK-Germany.

Conclusion

In a nutshell, this bibliometric study has systematically mapped global research on landfill leachate treatment methods from 2000 to 2025. The findings highlight a sustained growth in publications and increasing scientific collaboration, driven by environmental concerns and policy developments. China and Malaysia are among the top leading contributors, while electrochemical and advanced oxidation methods remain the most influential research directions. Emerging themes focus on hybrid systems, biological integration, and sustainable approaches addressing persistent pollutants. These findings also emphasize the importance of interdisciplinary research and cross-country collaboration in developing cost-effective and eco-sustainable leachate treatment strategies. Nevertheless, future studies should expand to include multiple databases, non-English publications, and novel pollutants such as microplastics and

pharmaceuticals to capture a broader research spectrum specifically in leachate treatment technologies.

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EXPLORING STUDENT MOTIVATION AND INTEREST IN MATHEMATICS: A BIBLIOMETRIC PERSPECTIVE

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Abstract: *This study offers a bibliometric perspective on research concerning student motivation and interest in mathematics. It aims to map the intellectual structure, research trends, and collaboration networks shaping this field. Motivation and interest play crucial roles in influencing students' mathematical learning outcomes, yet fragmented literature limits a holistic understanding. Using bibliometric techniques, 993 Scopus-indexed publications were analyzed through a systematic process involving Scopus Analyzer, OpenRefine, and VOSviewer. The data provided statistical and visual insights into publication trends, citation patterns, and co-authorship networks. Results indicate a consistent increase in research productivity, particularly over the last five years, highlighting growing attention toward motivational factors in mathematics education. Highly cited works emphasize active learning, student engagement, and technology integration. Co-occurrence mapping revealed six thematic clusters, including learning systems, problem-solving, mathematics anxiety, technology enhanced learning, and psychological constructs such as self-efficacy and metacognition. The United States, China, and Indonesia emerged as key contributors in international collaborations. Overall, this study provides an evidence-based overview of global research dynamics, supporting educators and policymakers in promoting student centered and innovative mathematics learning.*

Keywords: Mathematics, Students, Motivation

Introduction

Understanding student motivation and interest in mathematics is vital for improving learning outcomes and fostering positive attitudes. Research shows that factors such as technology use, collaborative learning, mindset, and inclusivity significantly influence motivation. For instance, technology integration and collaboration improved achievement among senior high school students in Kumasi, though motivation alone did not (Boadu & Boateng, 2024). A growth mindset also enhanced students' mathematics utility values, while inclusivity benefited girls and older adolescents in informal STEM settings (Ozturk et al., 2024). During COVID-19, female and public-school students in Indonesia showed greater interest (Marchy et al., 2023). Moreover, teacher enthusiasm affected engagement both positively and negatively depending on context (Carmichael et al., 2017).

Methodology

Bibliometrics provides a systematic method for collecting and analyzing bibliographic data from scientific publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). Beyond basic statistical indicators such as publication sources (Wu & Wu, 2017), advanced approaches like document co-citation analysis reveal intellectual structures and research networks. Effective reviews require iterative keyword selection, systematic searching, and in depth analysis to ensure reliability (Fahimnia et al., 2015). This study emphasizes high impact publications to capture key theoretical developments. Scopus was chosen for its comprehensive peer-reviewed coverage (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). Only journal articles were included, excluding non-scholarly materials (Gu et al., 2019). Publications from 2015 to October 2025, retrieved exclusively from Scopus, formed the dataset for analysis.

Data Search Strategy

To obtain strategic data for this study, an advanced search was conducted in the Scopus database in October 2025, utilizing its extensive coverage of peer-reviewed publications and robust search capabilities for the bibliometric analysis.

Table 1: The Search String

Scopus	TITLE (("mathematics" OR "mathematic" OR "math") AND ("motivation" OR "interest" OR "learning") AND student) AND PUBYEAR > 2019 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Mathematics") OR LIMIT-TO (EXACTKEYWORD , "Mathematics Learning") OR LIMIT-TO (EXACTKEYWORD , "Mathematics Education") OR LIMIT-TO (EXACTKEYWORD , "Teaching") OR LIMIT-TO (EXACTKEYWORD , "Motivation") OR LIMIT-TO (EXACTKEYWORD , "Learning Mathematics"))

Access Date: October 2025

Source: (Scopus AI, Fri Oct 03 2025)

Table 2: The Selection Criterion Is Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2015 – 2025	< 2015

Source: (Scopus AI, Fri Oct 03 2025)

Findings and Discussion

The publication trend from 2015 to 2025 shows a steady rise, peaking in 2020–2021, likely driven by the COVID-19 pandemic, which spurred interest in digital learning and mathematics motivation research. Output later declined as research normalized post-pandemic, but publication levels remained higher than pre-2018, indicating lasting academic engagement. The most cited articles emphasize technology-enhanced and active learning, with Theobald et al. (2020) leading with 926 citations, followed by Lai & Hwang (2016) and Sun et al. (2018), showing strong focus on equity, flipped classrooms, and self-regulated learning. These works reflect a shift toward inclusive, digital, and evidence-based teaching approaches.

Indonesia leads global publications (345), surpassing the United States (147), reflecting strong national initiatives and open-access journal networks. Other contributors include China, Australia, and Malaysia, highlighting Asia-Pacific's growing research prominence. Keyword analysis reveals clusters centered on “students,” “mathematics learning,” and “educational technology,” indicating an interdisciplinary emphasis on motivation, digital pedagogy, and problem solving. Co-authorship mapping shows active global collaboration, dominated by the United States, China, and Indonesia, with Europe and Asia forming strong research clusters that enhance visibility, knowledge exchange, and international impact (Scopus, 2025).

Conclusion

This study presents a comprehensive bibliometric analysis of 993 Scopus-indexed publications focusing on student motivation and interest in mathematics. The findings reveal significant global trends shaped by digital transformation and the growing adoption of learner centered pedagogy. Research activity peaked during the COVID-19 years, emphasizing technology enhanced, active, flipped, and self-regulated learning as dominant themes in mathematics education. Keyword and co-authorship analyses identified strong global collaboration, with the United States, China, and Indonesia emerging as leading contributors, supported by increasing participation from Asia-Pacific and European countries. These patterns highlight the globalization of mathematics education research and the expanding role of developing nations in shaping scholarly discourse. The study contributes by synthesizing key developments that connect technology, motivation, and engagement, offering implications for educators and policymakers in promoting sustained interest in mathematics. Although limited to Scopus and English-language publications, it underscores bibliometric mapping as a powerful tool for understanding evolving trends and guiding future innovations in mathematics education research.

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MAPPING GLOBAL RESEARCH ON PROFESSIONAL LEARNING COMMUNITIES AND TEACHER PROFESSIONALISM: A BIBLIOMETRIC ANALYSIS

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Abstract: *This study presents a comprehensive bibliometric analysis of research on Professional Learning Communities (PLCs) and teacher professionalism within global education. The primary objective is to identify the intellectual structure, publication trends, and collaboration networks shaping this field. Data were extracted from the Scopus database using keywords related to PLCs and teacher development, yielding 473 documents. A systematic four-stage bibliometric process was conducted, involving Scopus Analyzer for trend analysis, OpenRefine for data harmonization, and VOSviewer for visualization of co-authorship and keyword co-occurrence networks. The findings indicate a notable rise in publications after 2015, led by research contributions from the United States, China, Australia, and the United Kingdom. Eight thematic clusters emerged, reflecting core focuses on teacher collaboration, professional identity, instructional leadership, and student achievement. The co-authorship patterns reveal strong international collaboration and theoretical convergence across diverse educational contexts. Overall, the study concludes that PLC research has evolved into a global movement emphasizing professional growth, collaborative learning, and pedagogical innovation. The results provide a synthesized understanding of PLC scholarship, highlight emerging research gaps, and offer valuable insights for future empirical and comparative investigations into professional development and educational improvement.*

Keywords: *Professional Learning Communities (PLCs); Teacher Professionalism; Teacher Collaboration*

Introduction

Professional Learning Communities (PLCs) have become a crucial framework in global education aimed at improving teacher professionalism and enhancing student learning outcomes. As collaborative networks, PLCs enable educators to engage in reflective dialogue, exchange pedagogical insights, and collectively refine teaching practices to promote continuous professional growth Guerra et al., (2024); Nguyen et al., (2024). The model's widespread adoption across educational systems demonstrates its adaptability in addressing diverse instructional challenges and promoting teacher learning in various contexts Bonsen & Rolff, (2006); Chen & Zhang, (2024)). Empirical evidence shows that PLCs cultivate trust, encourage innovation, and strengthen collegial relationships that are essential to effective teaching Chen & Zhang, (2024); Nguyen et al., (2024)). Beyond individual teacher development, PLCs also influence institutional improvement and student achievement, as

shown in the United States and China, where leadership and community bonding sustain successful PLCs Bensen & Rolff,(2006); (Hu et al., 2022). Nevertheless, research gaps remain regarding their role in pre-service teacher education and digital transformation challenges, particularly following the COVID-19 era.

Research Question

RQ1: What are the research trends in these studies according to the year of publication?

RQ2: What are the most highly cited articles in this field?

RQ3: Where are the top 10 countries based on the number of publications?

RQ4: What are the popular keywords related to the study?

RQ5: What is the co-authorship by countries' collaboration?

Methodology

Bibliometrics is a systematic method for gathering, organizing, and analyzing bibliographic data from scientific publications Alves et al., (2021). Data were retrieved from the Scopus database using specific keywords related to artificial intelligence and adaptive learning. The dataset, limited to English peer-reviewed journal articles and conference papers from 1996 to 2025, was refined using OpenRefine. Visualization and network analyses were conducted using VOSviewer 1.6.20 to examine co-authorship patterns, keyword co-occurrence, and thematic clusters within the research domain.

Data Search Strategy

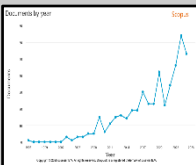
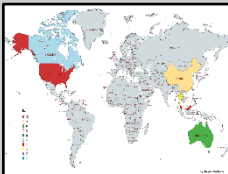
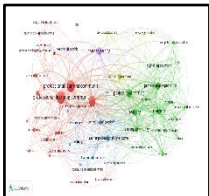
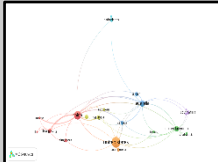
A systematic search was conducted in October 2025 using Elsevier's Scopus database to ensure comprehensive coverage of studies on professional learning communities and teacher professionalism. The search performed in October 2025, utilized the advanced query: TITLE ((Professional Learning Community OR collaborative learning community) AND (Teacher OR educator)) AND (LIMIT-TO (LANGUAGE , "English")) AND (EXCLUDE (AFFILCOUNTRY , "Israel")) was applied, limited to English-language journal articles and conference papers published between 1996 and 2025. Books, reviews, and non-peer-reviewed materials were excluded. This search yielded 473 documents, providing a robust dataset for bibliometric analysis to examine publication trends, key authors, collaborative networks, and emerging research themes in professional learning communities and teacher professionalism.

Data Analysis

This study utilized VOSviewer 1.6.20 to analyze Scopus datasets, creating network visualizations based on association strength normalization.

Research Findings

Table 1: Summary of Key Findings Based on Research Questions

Research Questions	Focus Area	Findings	Summary
RQ1	Publication Trends (1996 -2025)	 Steady growth with major surge after 2008; peak in 2023 (65 papers). Slight decline after 2023 due to incompleteness for 2025 in Scopus	Global PLC research steadily increased, driven by policy reforms and digital collaboration worldwide.
RQ2	Top Cited Authors	Admiraal et al., (2021) lead with 158 citations. Other influential works include Zheng et al. (2019), Lantz-Andersson et al., (2018), and Williams et al. (2012)	Highly cited studies reflect PLCs' global rise, innovation, and impact.
RQ3	Leading Countries	 United States (123) China (74) and Australia (44) followed by the United Kingdom (33), Canada (26), Iran (47), and the UK (42).	Developed countries prevail, characterized by advanced educational research ecosystems, solid teacher development policies, and significant research investment.
RQ4	Popular Keywords	 Major cluster“Professional Learning Community,” “Teacher Education,” “Teacher learning,” and “e- learning”	PLCs drive innovation, reflection, and reform for sustainable educational and systemic improvement.
RQ5	Co-authorship & Collaboration	 58 active countries formed 5 clusters; strongest networks between China, USA, Australia and United Kingdom.	Collaboration demonstrates worldwide engagement, with growing regional partnerships strengthening cross-border knowledge sharing.

Conclusion

This bibliometric analysis mapped global research trends, intellectual structures, and collaboration networks on Professional Learning Communities (PLCs) and teacher professionalism from 1996 to 2025. Results revealed growing scholarly attention, with major contributions from the United States, China, Australia, and the United Kingdom, alongside emerging input from Southeast Asia. Thematic clusters emphasized teacher collaboration, instructional leadership, digital learning, and professional identity. The study highlights PLCs' pivotal role in enhancing teacher competency and educational reform while acknowledging limitations linked to database and language scope. Future research should expand data sources and examine evolving PLC practices in digital and hybrid environments.

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BIBLIOMETRIC STUDY ON YOUTH RESILIENCE IN CLIMATE DISASTERS

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Abstract: *Climate disasters increasingly impact young people, necessitating better understanding of youth resilience during environmental crises. Despite recognition of youth as both vulnerable populations and capable agents in disaster risk reduction, systematic research mapping remains limited. This bibliometric analysis addresses this gap using Scopus database records through four methodological stages: collecting 665 documents (2005-2025) with keywords "youth," "resilience," and "disaster"; analyzing trends via Scopus Analyzer; cleaning data through OpenRefine; and generating visualizations using VOSviewer. Findings demonstrate steady publication growth peaking in 2025, with the United States, United Kingdom, and Australia dominating research output. Developing nations like Indonesia, Bangladesh, and Malaysia showed modest but increasing contributions. Keyword analysis identified six thematic clusters encompassing mental health, community resilience, disaster preparedness, and coping mechanisms. International collaboration networks centered predominantly around developed countries. This study synthesizes fragmented research, identifies influential works, maps global collaboration patterns, and highlights future research directions, providing essential guidance for researchers, policymakers, and practitioners advancing youth-centered resilience strategies in climate disaster contexts.*

Keywords: *Youth, Resilience, Disasters, Climate-Related*

Introduction

Climate change intensifies natural disasters such as floods, droughts, and wildfires, severely affecting young people's mental and physical health. While developmentally vulnerable, youth demonstrate remarkable resilience and adaptive capacity. Identifying factors that strengthen youth resilience during climate crises is essential for designing effective policies and interventions that support future generations.

Literature Review

Climate-related disasters significantly impact youth mental health, causing anxiety, depression, and PTSD (Akpan et al., 2025; Boyd et al., 2024; Lai et al., 2024). African youth face intensified mental health challenges from flooding and drought (Akpan et al., 2025), while Australian adolescents exposed to fires and floods experience profound helplessness,



especially those with pre-existing vulnerabilities (Boyd et al., 2024). These findings highlight the critical need for specialized mental health support in disaster-prone areas. Rather than passive victims, youth are increasingly recognized as vital contributors to disaster resilience (Zahri, Md Ali, Matsuura, et al., 2025). Through climate mitigation and preparedness programs, young people actively reduce community vulnerabilities (Pickering et al., 2022; Reckner et al., 2024; Seddighi et al., 2020). The Youth Advocacy for Resilience to Disasters (YARDs) program exemplifies how youth develop green infrastructure solutions addressing climate risks while gaining essential skills (Reckner et al., 2024).

Youth resilience emerges from interconnected social, individual, and environmental factors, including self-efficacy, self-esteem, social support, and community engagement (Ahmad et al., 2022; McDonald-Harker, Drolet, Sehgal, et al., 2021; Niu et al., 2021). Studies on Canada's 2013 Alberta floods confirm the importance of peer and caregiver support (McDonald-Harker, Drolet, & Sehgal, 2021). Innovative educational approaches incorporating virtual reality, digital games, and online platforms enhance disaster preparedness among youth (Zahri, Md Ali, Rambat, et al., 2025; Seddighi et al., 2020). Social media strengthens community support and collective action (Börner, 2023; Napawan et al., 2023), underscoring the need for holistic strategies that address psychological, educational, community, and individual dimensions.

Research Questions

RQ1: What are the research trends in these studies according to the year of publication?

RQ2: What are the top 10 most cited articles?

RQ3: Where are the top 10 countries based on the number of publications?

RQ4: What are the popular keywords related to the study?

RQ5: What is the co-authorship by countries' collaboration?

Methodology

Bibliometrics systematically analyzes scholarly publications using statistical measures and advanced methodologies like co-citation analysis (Alves et al., 2021). This study employed SCOPUS for data collection, focusing exclusively on peer-reviewed journal articles from 2005-2025 to ensure precision and quality (Al-Khoury et al., 2022).

Data Search Strategy

A structured Scopus search combined youth-related terms, resilience, and disaster keywords, limited to English academic publications from 2005-2025. Studies on terrorism, violence, and COVID-19 were excluded. After applying inclusion criteria, 665 relevant publications were identified, forming a focused dataset on climate-related disaster resilience.

Data Analysis

This study utilized VOSviewer 1.6.19 to analyze Scopus datasets, creating network visualizations based on association strength normalization.

Findings

Research on youth resilience in climate disasters increased significantly from 2005-2025, peaking near 90 publications in 2025, driven by global frameworks, climate activism, and recognition of youth vulnerability and agency. Masten (2014) leads citations with 1,086, establishing foundational resilience theory. Highly cited works from 2005-2019 provide essential frameworks for measurement, development, and mental health outcomes, shaping contemporary youth resilience research globally. The United States dominates with 250 publications, followed by the UK and Australia, reflecting robust research infrastructure. Asia's countries such as India, Indonesia, and Japan show growing contributions reflects their exposure to frequent climate-related disasters. VOSviewer co-occurrence analysis of 478 keywords (from 3,853) generated six clusters, revealing multidisciplinary research on adolescents, resilience, mental health, and holistic approaches to youth disaster resilience and community support. VOSviewer analysis of 32 countries revealed seven collaboration clusters. The UK, US, Sweden, and Australia dominate as research hubs, while developing nations like Indonesia and Bangladesh show limited collaboration despite high disaster vulnerability.

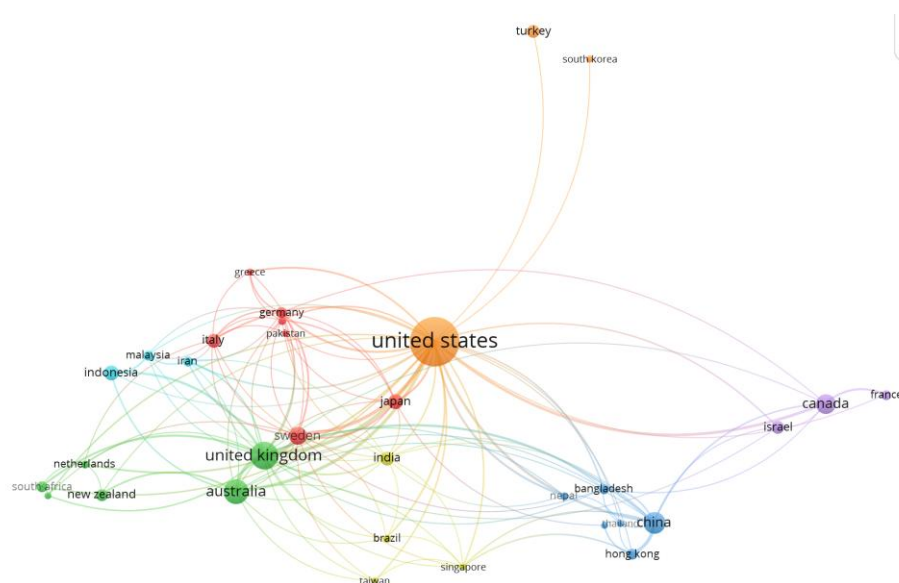


Figure 1: Co-authorship by countries' collaboration by VOSviewer

Conclusion

This bibliometric analysis examined youth resilience in climate disasters, revealing steady research growth from 2005-2025, with the UK, US, and Australia leading. Six thematic clusters emerged, highlighting mental health and community resilience; however, limitations include reliance on a single database and the predominance of English-only publications.

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BIBLIOMETRIC INSIGHTS INTO BOARD DIVERSITY AND FIRM PERFORMANCE: PATTERNS, NETWORKS, AND EMERGING DIRECTIONS

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Abstract: *The growing awareness of corporate governance reforms has received growing scholarly attention in exploring the relationship between board diversity and firm performance. The intellectual structure and knowledge development within this area remain fragmented, calling for a systematic bibliometric investigation. The data for this analysis was collected using Scopus advanced, yielding a final dataset of 318 documents, processed using OpenRefine. Bibliometric indicators, citation patterns, and productivity measures were generated using the Scopus Analyzer, while VOSviewer was applied to map co-citation, co-authorship, as well as keyword co-occurrence networks, enabling the visualization of research clusters, collaborations, and emerging themes. The findings highlight a constant increase in publications over the last decade, with notable contributions from developed economies such as the United Kingdom, the United States, and China, alongside growing interest from emerging markets. Highly cited articles predominantly focus on gender diversity, governance mechanisms, and their direct and indirect effects on firm performance. Keyword analysis revealed critical research hotspots, including “corporate governance,” “board gender diversity,” “financial performance,” “CSR,” and “sustainable development,” which form the foundation of this scholarly discourse.*

Keywords: Board Diversity, Firm Performance

Introduction

The relationship between board diversity as well as firm performance has garnered substantial focus in recent years, indicating broader societal shifts towards inclusivity and equity in corporate governance. Board diversity encompasses various dimensions, including age, gender, education, tenure, as well as nationality, each potentially influencing firm performance in distinct ways. Understanding the intellectual structure and emerging trends in this area is crucial for academics, practitioners, and policymakers aiming to optimize corporate governance frameworks.

Literature Review

Research on board diversity and firm performance demonstrates mixed results especially variation in gender, age and educational backgrounds among executives have shown to positively influence firm performance (Hernández-Atienza et al., 2024). However, the effects are not universally positive. In the Japanese firm's context, board gender diversity has been found to negatively influence firm performance, particularly in smaller firms and those with higher leverage (Wang et al., 2024). Similarly, in the UK gender and age diversity in SMEs were associated with lower firm performance (Shehata et al., 2017).

Firms with greater corporate transparency benefit more from board diversity, while those with less transparent information environments may experience adverse effects (Upadhyay, 2014). The mediating role of factors such as firm reputation and innovation partially explains the positive connection between board racial diversity as well as firm performance (Miller & Del Carmen Triana, 2009). In India, board demographic diversity positively influences standalone firms' performance but negatively affects group-affiliated firms (Aggarwal et al., 2019; Naghavi et al., 2021). Emerging trends in the literature highlight the importance of multiple dimensions of diversity and the incorporation of environmental, social, and governance (ESG) aspects, with evidence suggesting that ESG performance can mediate this relationship (Fayyaz et al., 2023; Nguyen et al., 2023).

Research Question

RQ1: What are the research trends in board diversity and firm performance studies over the years of publication?

RQ2: Which are the most cited articles in the field of board diversity and firm performance?

RQ3: Which countries are the top 10 contributors in terms of the number of publications on board diversity and firm performance?

RQ4: What are the most frequently used keywords in the field of board diversity and firm performance?

RQ5: What are the emerging and popular keywords that indicate future research directions in board diversity and firm performance?

Methodology

A bibliometric analysis allows researchers to systematically gather, organize, and analyze bibliographic information from scientific literature (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). An advanced search strategy using Scopus database was employed using the following Boolean string: TITLE-ABS-KEY ("Board Diversity" OR "Ethnicity" OR "Age" OR "Tenure" OR "Educatio" OR "Nationality" AND "Performance") AND (LIMIT-TO (LANGUAGE, "English")) The search was executed on October 3, 2025. This process yielded a final dataset of 318 documents, including journal articles, reviews, and conference proceedings. Data were exported in a standardized CSV format, including fields such as title, authors, affiliations, publication year, journal name, keywords, abstracts, and EID. Data cleaning was performed using OpenRefine, to ensure consistency and accuracy (Ahmi, 2023). Performance analysis and network visualization was conducted using VOSviewer version 1.6.19, enabling the generation of co-authorship, co-citation, and keyword co-occurrence networks, covering the period from 2020 to October 2025 (van Eck & Waltman, 2010, 2017).

Findings

The current study aims to examine the trends in the domain of Board Diversity by addressing five key research questions. The publication trend (**RQ1**) from 2020 to 2025 indicates a steady increase in scholarly attention toward firm performance and board diversity, with publications rising from 33 in 2020 to a peak of 78 in 2025. While the growth was modest between 2020 (33), 2021 (32), and 2022 (40), a sharp upward trend was observed in 2023 (58), followed by high outputs in 2024 (77) and 2025 (78). The significant growth in publications driven by regulatory reforms promoting gender diversity and post-COVID-19 focus on sustainability, and the expansion of ESG reporting, making board diversity a critical area of research. The most cited works (**RQ2**) in the field of board diversity and firm performance underscore the growing academic interest. Among the top contributions, M.H. Shakil (2021) stands out with 346 citations for his work on ESG performance and financial risk. Similarly, S. Brahma et al. (2021) with 279 citations and N.S. Orazalin & M. Baidautov (2020) with 277 citations, provides strong empirical evidence from the UK and CSR contexts. Other influential studies, such as those by Cordeiro et al. (2020) (209 citations) and Fernández & Tejerina-Gaite (2020) (201 citations), reinforce the importance of board composition in shaping environmental and financial performance. The high citation counts of these works aligns with global regulatory reforms and investor expectations emphasizing diversity, sustainability, and accountability. The distribution of publications on firm performance and board diversity (**RQ3**) highlights Malaysia and the United Kingdom as the leading contributors, with 37 publications each, followed closely by the United States (32) and China (27), dominating the research landscape. Australia, Spain, and Italy also demonstrate substantial engagement, each contributing between 23–25 studies, while emerging economies such as India (21), Saudi Arabia (18), and Egypt (13) show growing but comparatively lower levels of scholarly output. The overall pattern indicates that both developed and developing nations are actively engaging with the diversity performance debate, though the intensity of research activity varies depending on the maturity of governance frameworks, availability of data, and institutional emphasis on inclusivity.

Co-occurrence analysis of author keywords (**RQ4**) using VOSviewer allows researchers to determine connections by examining how often keywords emerge together within published studies. The findings highlight how diversity and governance issues have become central to explaining variations in corporate and financial performance. Emerging terms such as innovation, family firms, and developing countries further illustrate expanding directions of inquiry. The analysis contributes to the literature by reinforcing well-established connections between governance and performance while highlighting evolving intersections with sustainability, gender equality, and global perspectives, offering future researchers a roadmap of both mature and underexplored areas.

Co-authorship analysis by countries (**RQ5**) in VOSviewer examines how often authors from different countries collaborate and allows researchers to identify international research networks and global knowledge-sharing patterns. The findings show that the United Kingdom, Malaysia, the United States, China, as well as Italy are among the most active contributors, with the UK and Malaysia leading in both publication numbers and co-authorship links. This indicates their central role in driving collaborative research in the field. The clustering highlights regional research ecosystems, such as Middle Eastern countries (Saudi Arabia, Egypt, Kuwait, UAE) forming collaborative groups, while European countries (Italy, Spain, France, Netherlands) represent another.

Conclusion

The study aims to examine the intellectual structure, influential contributions, and emerging themes in the literature on board diversity and firm performance through a bibliometric approach. The findings revealed a clear upward trend in publications between 2020 and 2025, reflecting the increasing global prominence of board diversity. Highly cited studies have established strong connections between board composition, corporate governance, and sustainability, with emphasis on gender diversity. The analysis highlighted the dominance of countries such as Malaysia, the United Kingdom, the United States, and China, while showing the rising participation of developing economies. Keyword mapping confirmed that “corporate governance,” “board gender diversity,” “financial performance,” and “sustainability” are central research themes, while “innovation,” “family firms,” and “developing countries” indicate new directions. Although the research offers an extensive mapping of the field, it is constrained to the Scopus database and publications in English, which may exclude relevant contributions. Future research could expand the dataset, apply longitudinal comparisons, or explore the mediating and moderating mechanisms that link board diversity with firm performance.

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BIBLIOMETRIC ANALYSIS OF MATHEMATICS INTEGRATION IN STEM EDUCATION (2015-2025)

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Abstract: *The integration of mathematics within STEM education has gained increasing scholarly attention due to its vital role in fostering interdisciplinary problem-solving and global competitiveness. Despite this importance, limited studies have systematically mapped research patterns and collaboration networks in this field. This study addresses the gap through a bibliometric analysis of 776 Scopus-indexed articles published between 2015 and 2025, retrieved using the keywords “mathematics,” “education,” and “STEM.” Data were refined with OpenRefine for consistency and analyzed using Scopus tools and VOSviewer to explore publication trends, citation impact, and collaboration networks. Results indicate a steady rise in research output, peaking in 2024–2025, with the United States, Indonesia, and Germany as leading contributors. Highly cited works focus on problem-solving, interdisciplinary integration, and digital innovation in mathematics education. Keyword analysis highlights dominant themes such as “mathematics education,” “STEM education,” and “teacher education,” alongside emerging areas like “computational thinking,” “artificial intelligence,” and “sustainability.” Co-authorship mapping reveals strong international collaboration between developed and emerging economies. Overall, the study offers a comprehensive overview of the intellectual structure, thematic evolution, and global research collaboration in mathematics-focused STEM education, providing valuable insights for educators, policymakers, and future researchers.*

Keywords: *Mathematics, Education, STEM*

Introduction

Mathematics plays a foundational role in Science, Technology, Engineering, and Mathematics (STEM) education by nurturing analytical thinking, logical reasoning, and problem-solving skills essential for the 21st-century workforce. As a unifying discipline, mathematics enables students to comprehend scientific and technological concepts and to apply them effectively in real-world problem-solving contexts. Recent years have seen increased research attention toward the integration of mathematics within STEM curricula, particularly regarding technology use, teacher competency, and interdisciplinary pedagogical approaches. However, few studies have comprehensively mapped global trends and intellectual structures in this domain. This paper addresses this gap by employing a bibliometric approach to identify key research patterns and collaborative networks in the field.

Research Questions

RQ1: What are the research trends in these studies according to the year of publication?

RQ2: What are the top 10 most cited articles?

RQ3: Where are the top 10 countries based on the number of publications?

RQ4: What are the popular keywords related to the study?

RQ5: What is co-authorship by countries' collaboration?

Methodology

This study employed a bibliometric approach to systematically collect, organize, and analyze scholarly publications on the integration of mathematics in STEM education. Bibliometrics enables quantitative assessment of research development, intellectual structures, and collaboration patterns across disciplines (Alves et al., 2021; Verbeek et al., 2002). Data were retrieved from the Scopus database using the keywords “mathematics,” “education,” and “STEM,” covering the publication period from 2015 to 2025. After applying inclusion criteria (English-language journal articles in the field of Mathematics), 776 publications were identified, providing a comprehensive dataset for subsequent analysis. The data were cleaned using OpenRefine, and analyzed using VOSviewer software (version 1.6.20) developed by Van Eck and Waltman (2010). The software visualizes co-authorship networks, keyword co-occurrences, and thematic clusters, revealing key research trends and collaboration patterns. VOSviewer's mapping and clustering techniques offered an interpretable representation of how topics and authors are interlinked within the field. The analytical framework combined quantitative measures of publication output and citation counts with qualitative interpretation of keyword networks. This dual approach enabled a structured overview of the intellectual landscape, identifying dominant themes, emerging topics, and leading contributors in mathematics-focused STEM education research.

Findings and Discussion

From 2015 to 2025, research on mathematics in STEM education showed a steady upward trend, from 26 publications in 2015 to a peak of 110 in 2024 - indicating growing global interest in the field. The increase, particularly between 2019 and 2024, was driven by digital transformation during the COVID-19 pandemic and global reforms emphasizing STEM learning. The slight decline in 2025 suggests field stabilization as research themes mature.

The most influential works, led by Verschaffel et al. (2020) and Maass et al. (2019), emphasize problem-solving and interdisciplinary approaches in mathematics education. Journals such as *ZDM* and *International Journal of Science and Mathematics Education* serve as key publication outlets. Highly cited studies highlight digital integration, teacher cognition, and contextualized learning, reflecting the field's shift toward innovation and inclusivity in STEM pedagogy.

The United States dominates publication output (160 articles), followed by Indonesia (62) and Germany (59). Active contributions from Spain, the United Kingdom, and emerging countries like South Africa indicate expanding global participation. The pattern reflects strong research infrastructures in developed nations and growing investment in STEM education in developing regions, promoting a more diverse and collaborative research landscape.

Keyword analysis identified 1,574 terms forming eight thematic clusters, with “mathematics education,” “teacher education,” and “computational thinking” as dominant themes. These clusters reveal the field’s focus on technology integration, sustainability, and interdisciplinary innovation, aligning mathematics education with contemporary challenges such as digital literacy and global problem-solving.

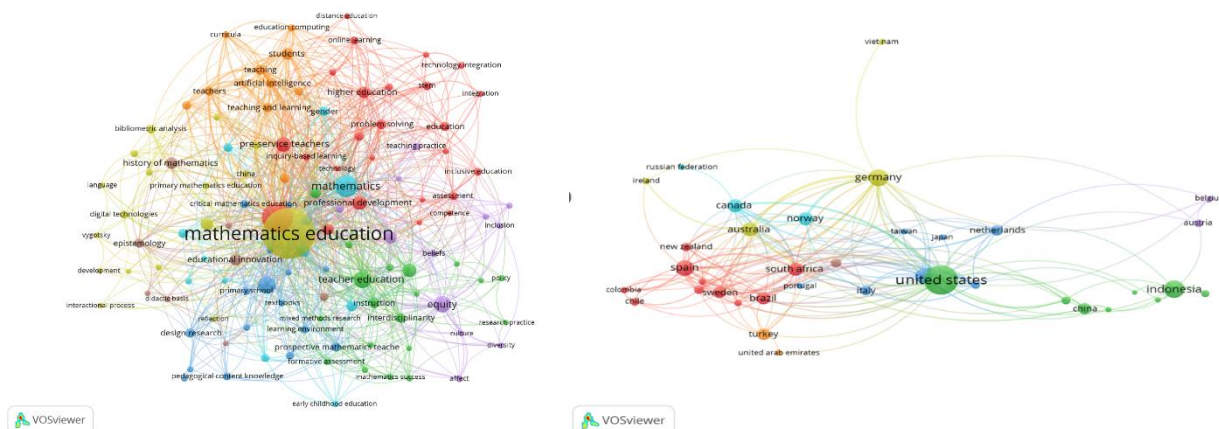


Figure 1 & 2: Network Visualization Map Of Keywords' Co-Occurrence and Co-Authorship By Countries

Source: (Scopus, Fri Oct 03 2025)

Co-authorship mapping across 88 countries (39 meeting inclusion criteria) shows robust international collaboration led by the United States, Germany, and Indonesia. Eight clusters illustrate regional and cross-continental partnerships, reflecting the importance of collaboration in enhancing research visibility and innovation. This global engagement strengthens collective capacity in advancing mathematics-oriented STEM education.

Conclusion

This bibliometric analysis highlights mathematics as a cornerstone of STEM education research, with growing global participation and diversification of themes. The findings demonstrate increased scholarly attention to digitalization, teacher education, and interdisciplinary pedagogy. The dominance of the United States and emerging contributions from Indonesia and Germany suggest both leadership and inclusivity in global collaboration. Future research should expand data sources beyond Scopus, explore thematic evolution over longer periods, and consider qualitative insights from educational practice. Ultimately, strengthening mathematics integration in STEM is essential to fostering innovative, sustainable, and equitable education systems.

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GLOBAL TRENDS IN GAME-BASED ENGLISH LANGUAGE LEARNING: A BIBLIOMETRIC OVERVIEW

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Abstract: *Game-Based Learning (GBL) has gained increasing attention in English language education as an effective way to enhance motivation, engagement and proficiency. However, comprehensive analyses of global research in this area remain limited. This study provides a bibliometric overview of research on GBL in English language learning, focusing on publication trends, influential studies, key contributors and thematic developments. Data were retrieved from the Scopus database using the keywords “Game-Based Learning” and “English Language Learning,” yielding 445 documents published between 2005 and 2025. The dataset was refined using OpenRefine and analyzed with Scopus Analyzer and VOSviewer to examine publication patterns, co-authorship networks, and keyword co-occurrence. Results show a consistent growth of publications with a marked rise after 2020. Taiwan, China, and Malaysia emerged as leading contributors, supported by strong institutional investment in digital pedagogy. Keyword mapping identified recurring themes in pedagogy, motivation, technology integration and vocabulary acquisition. Overall, this study highlights GBL’s increasing prominence in English language education and provides a valuable reference for future research directions.*

Keywords: *Game-Based Learning, English Language Learning*

Introduction

Game-based learning (GBL) integrates game elements into instruction to promote engagement and improve learning outcomes. In English language education, it enhances learners’ motivation, participation and overall proficiency, aligning with recent shifts toward technology-enhanced and learner-centred teaching (Hwang et al., 2017; Rajendran et al., 2025). The growing use of mobile and online platforms has transformed GBL from an experimental tool into a widely adopted classroom practice. Despite its increasing popularity, research on this topic remains scattered across regions and disciplines. This study therefore employs bibliometric analysis to map global trends, identify influential publications and examine thematic developments in GBL for English language learning. The analysis clarifies how GBL research has evolved and highlights emerging directions for pedagogical innovation.

Literature Review

Studies consistently report that GBL improves learners’ academic performance, particularly in vocabulary and grammar mastery. A Baamboozle-based intervention in India showed marked gains in vocabulary, grammar, and learner motivation (Rajendran et al., 2025), while Ukrainian

learners of Italian achieved higher vocabulary retention through game-based activities (Frolli et al., 2023). Similarly, a contextual gaming approach improved EFL students' grammar accuracy in Taiwan (Lin et al., 2020).

Nevertheless, GBL's effectiveness depends on thoughtful design, teacher support, and curricular alignment. Poor scaffolding or negative perceptions among non-gamers can limit its success (Ray & Ilangoan, 2024). Research also highlights the role of digital platforms and mobile learning in sustaining engagement and identity in language learning (Thanyawatpokin & Vollmer, 2022).

Overall, the literature confirms that game-based and gamified learning environments can increase motivation, participation, and proficiency, but their impact relies on context-sensitive implementation. These findings provide the foundation for this bibliometric analysis, which examines global research trends and emerging directions in GBL for English language education.

Research Aims and Questions

The main aim of this study is to provide a comprehensive overview of global research on Game-Based Learning (GBL) in English language education using bibliometric methods. By analyzing data from the Scopus database, this study seeks to identify research trends, influential authors and publications, major contributing countries, and key thematic areas. Through this approach, the study offers insights into the intellectual structure and evolving directions of GBL as a pedagogical innovation in language learning (Fahimnia et al., 2015; Wu & Wu, 2017).

To achieve this aim, the study addresses the following research questions:

RQ1 – What are the publication trends in game-based English language learning research?

RQ 2 – What are the most cited articles?

RQ3 – Where are the top 10 countries based on the number of publications?

RQ4 – What are the author keywords related to the study?

RQ5 – What is the co-authorship by countries' collaboration?

Methodology

This study employed a bibliometric analysis to examine global trends, influential works, and thematic patterns in game-based English language learning. Bibliometric analysis systematically identifies patterns in publication output, co-authorship, and conceptual development within a field (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). Data were retrieved from the Scopus database in October 2025 using the search string:

TITLE-ABS-KEY(("Game-Based Learning" OR GBL) AND ENGLISH AND (LANGUAGE OR learning)). Scopus was selected for its wide coverage of peer-reviewed research (Al-Khoury et al., 2022; di Stefano et al., 2010). To maintain quality, the search was limited to English-language, peer-reviewed journal articles, conference papers and reviews at the final publication stage while books, in-press items and non-English works were excluded (Gu et al., 2019). The final dataset of 445 documents was cleaned and standardized using OpenRefine. Descriptive statistics and publication patterns were generated through Scopus Analyzer and

network visualizations were produced using VOSviewer (version 1.6.20) (Van Eck & Waltman, 2010, 2017). This combination of quantitative and visual analysis enabled a comprehensive understanding of publication trends, co-authorship networks and keyword relationships within the field.

Findings and Discussion

Publication Trends

Analysis of studies published between 2005 and 2025 reveals a consistent upward trend in research on game-based English language learning, with rapid growth after 2020. Early work in this area was limited, but publication activity expanded significantly in the 2010s alongside the rise of digital and mobile-assisted learning (Hwang et al., 2017; Chen & Hsu, 2020). The surge in 2024 reflects the momentum of post-pandemic digital transformation and educators' growing interest in interactive technology-supported instruction.

Most Cited Studies

The most influential publications appeared in *Computers and Education* and *Computer Assisted Language Learning*. Liu and Chu (2010) recorded the highest number of citations by demonstrating how ubiquitous games enhance English listening and speaking proficiency. Hwang et al. (2017) explored the role of problem-based gaming in improving performance, and Reinders and Wattana (2015) examined affective engagement and willingness to communicate in digital environments. Collectively, these studies established GBL as a credible and motivating approach to language learning. Recent research by Lin, Ganapathy, and Manjet (2018) further emphasized the pedagogical value of classroom gamification tools such as *Kahoot!* in improving learner engagement.

Contribution Countries

The analysis identified Taiwan, China, and Malaysia as leading contributors, followed by the United States, United Kingdom, and Indonesia. Taiwan's dominance stems from sustained investment in technology-enhanced pedagogy, whereas Malaysia's increasing output reflects national educational reforms that promote innovation in English language teaching (Rajendran et al., 2025; Ray & Ilangoan, 2024). Collectively, Asian countries account for the majority of publications showing a strong regional commitment to digital language learning initiatives.

Keyword and Thematic Analysis

Keyword co-occurrence mapping using VOSviewer revealed five major clusters representing pedagogy, learner motivation, technology integration, vocabulary and grammar acquisition, and affective dimensions. High-frequency terms such as game-based learning, gamification and digital learning illustrate the field's multidisciplinary nature across education, linguistics and psychology. The increasing appearance of virtual reality and mobile learning suggests a shift toward immersive technology-rich environments (Yang et al., 2020; Hwang et al., 2016).

International Collaboration

Co-authorship analysis shows strong research networks among scholars in Taiwan, China and Malaysia, with additional methodological contributions from Western institutions (Van Eck & Waltman, 2017). These partnerships reflect Asia's expanding leadership in digital pedagogy and its growing integration into global research communities.

Conclusion

This bibliometric analysis provides a global overview of research on game-based English language learning from 2005 to 2025. Drawing on 445 Scopus-indexed publications, the study identified key contributors, influential works, and major thematic areas that define the field. The results show a steady rise in scholarly attention, with notable growth after 2020, reflecting the widespread adoption of digital tools in education. Taiwan, China and Malaysia emerged as the most productive countries, underscoring Asia's growing investment in technology-enhanced language learning. Highly cited studies emphasize the pedagogical benefits of digital games in improving learners' motivation, vocabulary, grammar and communicative skills (Liu & Chu, 2010; Hwang et al., 2017; Chen & Hsu, 2020). Although limited to the Scopus database and English-language publications, this study provides valuable insights into the intellectual development of the field. The findings reaffirm GBL's potential as a transformative and engaging approach in English language education and encourage future research that integrates cross-database analyses and classroom-based evaluations to deepen understanding of its pedagogical impact.

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KNOWLEDGE MAPPING OF RESEARCH TRENDS ON STUDENTS' CHALLENGES AND DIFFICULTIES IN LEARNING MATHEMATICS

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Abstract: *This bibliometric study explores research on students' challenges in learning mathematics to map the academic landscape in this field. Using Scopus advanced search with keywords such as "mathematics," "learning," "challenges," and "difficulties," 798 articles were analyzed. Data cleaning was done using OpenRefine, while Scopus Analyzer and VOSviewer examined publication trends, keyword co-occurrence, and collaboration networks. The findings reveal growing research on learning difficulties, teaching strategies, and digital interventions. This study highlights global efforts to address mathematics learning barriers and underscores the need for targeted, interdisciplinary approaches to improve teaching effectiveness and enhance students' understanding in mathematics education.*

Keywords: *Mathematics, Learning, Challenges, Difficulties, Education*

Introduction

Understanding the challenges and difficulties students face in learning mathematics is essential for educators, researchers, and policymakers. Despite mathematics being a fundamental subject with wide applications, many students continue to struggle across educational levels due to cognitive, emotional, linguistic, and instructional factors.

Literature Review

Cognitive difficulties often arise from challenges in understanding abstract concepts, linking ideas, and applying procedures accurately. A lack of foundational knowledge can create cumulative learning gaps, making advanced topics such as algebra and geometry difficult to master (Bryant et al., 2014; Suharna et al., 2018). Cognitive aspects like memory, intellectual ability, and metacognitive strategies also influence mathematical learning (Harskamp, 2014). Emotional factors, particularly mathematics anxiety, significantly affect students' confidence and motivation. Feelings of fear and tension toward mathematics can result from negative experiences and societal expectations (Arevee & Vintere, 2023; Karagiannakis & Cooreman, 2014). Supportive teaching and positive classroom environments can help reduce anxiety and improve performance (Verdeflor et al., 2024). Linguistic challenges are evident in multilingual contexts, where the specialized language of mathematics can hinder comprehension. Limited proficiency in the language of instruction often causes difficulties in understanding terms and

problem statements (Planas et al., 2025). Integrating language support and visual aids helps bridge this gap (Heong et al., 2024). Finally, instructional quality plays a crucial role. Traditional rote-based methods may fail to foster conceptual understanding, whereas innovative approaches such as gamification, digital tools, and inquiry-based learning can enhance engagement and comprehension (Albeshree et al., 2022; Singh et al., 2025).

Research Question

RQ1: What are the research trends in these studies based on the year of publication?

RQ2: What are the top 10 most cited articles in the field?

RQ3: Which are the top 10 countries based on the number of publications?

RQ4: What are the most frequently used keywords related to the study?

RQ5: How are countries collaborating based on co-authorship in this research area?

Methodology

Bibliometrics involves the systematic collection and analysis of bibliographic data from scientific literature (Alves et al., 2021; Verbeek et al., 2002). Modern bibliometric methods go beyond basic metrics to include advanced techniques such as co-citation analysis, revealing intellectual structures within research domains (Wu & Wu, 2017). This study followed a structured process involving keyword selection, targeted searches, and analytical review (Fahimnia et al., 2015). Data were obtained from Elsevier's Scopus database (2010–October 2025), focusing on peer-reviewed journal articles to ensure reliability and academic integrity (Gu et al., 2019). High-impact publications were prioritized to identify key theoretical and conceptual developments.

Data Search Strategy

To ensure precise and relevant literature selection, data were collected from the **Scopus** database using its advanced search feature. The Boolean query TITLE (mathematics AND learning AND (challenges OR difficulties OR education)) AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE, "English")) was executed in October 2025. The search focused on English-language publications from 2010 to 2025, retrieving 798 relevant articles. Non-English and pre-2010 works were excluded. This structured and targeted approach ensured a high-quality dataset, providing a robust foundation for subsequent bibliometric analysis.

Data Analysis

VOSviewer, developed by van Eck and Waltman at Leiden University (2010, 2017), is a leading software for bibliometric mapping and visualization. It enables researchers to analyze co-authorship, co-citation, and keyword co-occurrence networks through clear and interpretable visual maps. In this study, bibliometric data from Scopus (2010–October 2025) were processed using VOSviewer version 1.6.20. The software's Visualization of Similarities (VOS) technique, based on association strength normalization, provides a refined representation of relationships among research items. This approach enhances the accuracy and interpretability of co-occurrence maps, offering deeper insights into research structures and thematic patterns.

Findings and Discussion

From 2010 to 2025, research on students' challenges in learning mathematics showed steady growth, especially after 2018, peaking in 2024. This increase was driven by global education reforms, the impact of the COVID-19 pandemic, and a rising emphasis on STEM and remote learning. Highly cited studies focus on technology-enhanced, blended, and AI-supported learning, reflecting post-pandemic shifts toward digital and student-centered approaches. Indonesia leads with 179 publications, followed by the United States (122), while Malaysia, Spain, and Australia each contribute 30–40. Indonesia's dominance reflects education reforms and strong research incentives, while broader participation from countries like Malaysia and South Africa shows growing global concern over mathematics learning challenges. Keyword co-occurrence analysis using VOSviewer identified 161 keywords forming six clusters, with "mathematics education," "students," and "learning difficulties" as central terms. Emerging clusters on "e-learning," "AI," and "gamification" highlight rising interest in technology-driven approaches. Co-authorship analysis of 42 active countries revealed eight clusters of collaboration, showing regional and thematic research networks. The United States, Indonesia, and Germany demonstrated the strongest link strengths, emphasizing their significant roles in shaping international research collaboration in mathematics education.

Conclusion

This study used bibliometric analysis to examine global research on students' challenges in learning mathematics, identifying trends, key contributors, and collaboration patterns. Findings show rapid publication growth after 2015, led by Indonesia and the U.S., with major themes in digital learning, pedagogy, and technology integration. Emerging interests include AI and gamification. The study highlights global collaboration, practical implications for innovative teaching, and the need for inclusive, cross-cultural approaches to enhance mathematics education worldwide.

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MAPPING THE RESEARCH TRENDS ON EXPORT BARRIERS IN AGRO-FOOD SMES

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Abstract: *The growing significance of Small and Medium-sized Enterprises (SMEs) in the agro-food sector underscores the need to understand export barriers that hinder their global competitiveness. Despite their key role in employment and food security, agro-food SMEs face persistent internal and external constraints limiting export performance. Using a bibliometric approach, this study systematically analyses 1,217 Scopus-indexed documents (2010–2025) refined with OpenRefine and visualized via VOSviewer. Results reveal increasing scholarly attention since 2015, dominated by the United States, China, and the United Kingdom, and highlight themes such as financial, institutional, and managerial barriers grounded in RBV, IBV, and Network perspectives.*

Keywords: *Export Barrier, Internal Barriers, External Barriers, Agro-Food Smes*

Introduction

The internationalisation of Small and Medium-sized Enterprises (SMEs) in the agro-food sector is essential for promoting economic growth, employment, and competitiveness, yet these firms face numerous internal and external barriers that restrict their global expansion. Internal barriers such as financial limitations and weak managerial capabilities reduce export readiness, while external challenges, including regulatory hurdles, market access constraints, and procedural inefficiencies, further impede international operations (Forte & Salomé Moreira, 2018; Sannegadu et al., 2024). Agro-food SMEs also struggle with strict international quality and safety standards that are particularly demanding in developing economies with limited capital and expertise (Dhewanto et al., 2021). High compliance costs, certification expenses, and administrative burdens like documentation and payment delays discourage export participation (Ismail et al., 2013; Trade Barriers That US Small and Medium-Sized Enterprises Perceive as Affecting Exports to the European Union, 2014). Therefore, government interventions such as post-crisis assistance, export promotion programmes, and adaptive policy frameworks are vital for equipping SMEs with financial support, knowledge, and tools to engage in foreign markets (Breckova, 2018; Sharma et al., 2024; Tan et al., 2018). Additionally, collaborative networks and technological innovation enhance export capacity through knowledge sharing, resource pooling, and digital platforms that improve market access (Serrano et al., 2016; Vlachos & Gutnik, 2016), underscoring the need for holistic strategies integrating policy, training, innovation, and cross-border collaboration for export growth.

Research Question

RQ1: What are the research trends in online learning based on the year of publication?
RQ2: What are the most highly cited articles in this field?
RQ3: Where are the top ten countries contributing the most publications?
RQ4: What are the most frequently used keywords related to online learning studies?
RQ5: What are the patterns of co-authorship and country-level collaboration in this research domain?

Methodology

Bibliometric analysis is a systematic method for collecting, organizing, and critically examining bibliographic data from scientific sources (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). It goes beyond descriptive statistics by using advanced techniques such as co-citation and network analysis to uncover intellectual structures and knowledge evolution (Wu & Wu, 2017). Following Fahimnia et al. (2015), this study adopted a rigorous and iterative review process using Scopus as the primary, reliable database (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017), focusing solely on peer-reviewed journal articles from 2010 to December 2025 (Gu et al., 2019).

Finding and Discussion

Table 1: Export Barriers in Agro-Food SMEs (2010–2025)

Section	Focus Area	Key Findings	Highlights / Interpretation
5.1 Publication Trends (2010–2025)	Annual research output	Research on export barriers in agro-food SMEs shows a steady upward trajectory from 2010 (54 publications) to 2025 (85, partial year). Growth phases include: 2010–2014 (emergent interest), 2015–2019 (expansion), and 2020–2025 (consolidation and diversification).	The peak in 2024 (94 papers) is linked to post-pandemic recovery, sustainability, and digital trade. The dip in 2018 reflects funding or thematic shifts. Overall, the trend signals maturity and policy relevance shaped by global trade and SME resilience.
5.2 Most Cited Articles	Top ten influential studies	Manova (2013) - 636 Ellis (2011) - 414 Feenstra et al. (2014) - 388 Hummels & Schaur (2013) - 316 Minetti & Zhu (2011) - 314 Casey & O'Toole (2014) - 294 Manova et al. (2015) - 287 Bellone et al. (2010) - 250 Kahiya (2018) - 236 Fabbri & Menichini (2010) - 220	Two dominant strands emerge: (1) financial constraints that restrict SME exports; (2) institutional and network barriers affecting market entry. These studies shaped discourse on trade finance, SME competitiveness, and policy formulation.
5.3 Country	Top publishing nations	United States (259), China (204),	Developed nations dominate due to greater research funding and

Contributions	United Kingdom (100), Germany (77) Australia (57) Italy (43) Canada (41) France (40)	infrastructure, while emerging economies show growing engagement tied to agro-food trade integration. The uneven output mirrors global trade capacity and institutional maturity.
5.4 Keyword Co-Occurrence	Core research themes Emerging contributors: India (46) Malaysia (15) Vietnam (15) Brazil (17). From 4,104 author keywords, 391 met the occurrence threshold (≥ 5), forming six clusters around international trade, export barriers, financial constraints, sustainability, SMEs, and supply chains.	Thematic evolution extends from classical trade-finance issues toward digitalization, green trade, and SME resilience. Keywords such as China, commerce, and environmental protection highlight global and policy-oriented scholarship.
5.5 Co-Authorship and Collaboration	International research networks Of 101 countries, 43 met the inclusion threshold (≥ 5 papers), generating eight clusters. Major hubs include the United States, China, Germany, and the United Kingdom, indicating dense scholarly linkages and high citation strength.	Collaboration remains concentrated among advanced economies (North-North). Limited but rising South-South linkages present opportunities to enhance inclusivity, research diffusion, and transnational innovation.

Conclusion

This study explores the intellectual and thematic evolution of research on export barriers in agro-food SMEs through a bibliometric lens. By analysing publication trends, citation patterns, keyword co-occurrences, and global collaborations, it traced how scholarly attention has matured over time. Findings revealed a steady rise in publications since 2010, especially after 2015, highlighting growing awareness of export challenges. Finance-related constraints, institutional barriers, and relational networks were key themes, while sustainability and digitalisation emerged as new areas. Advanced economies such as the United States, China, and Europe dominated outputs, though emerging markets are expanding. The study consolidates fragmented insights into a systematic view of temporal, thematic, and geographic trends. It urges policymakers to address barriers while fostering innovation and digital adoption to strengthen SME competitiveness. Despite relying on a single database, it establishes a foundation for broader comparative research and underscores the importance of digital technologies and supply-chain innovations in advancing SME export performance.

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A DECADE OF WORKPLACE DEVIANCE RESEARCH: A BIBLIOMETRIC ANALYSIS (2015-2025)

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Abstract: *This bibliometric study maps the trends in workplace deviance research and consolidates a diffuse literature that spans misconduct, incivility, and withdrawal. A Scopus advanced search using “workplace deviance” and “counterproductive work behaviour” retrieved 1,624 peer reviewed records from 2015 to 2025. Descriptive indicators were generated with Scopus Analyzer, records were cleaned in OpenRefine, and VOSviewer was used for keyword co-occurrence and country level co authorship networks. Output increased steadily from 2015, accelerated after 2020, and peaked in 2024, with 2025 showing strong partial year activity. The United States and China lead by volume, followed by Pakistan, India, the United Kingdom, Canada, Germany, Australia, Malaysia, and the Netherlands. Thematic anchors include counterproductive work behaviour, organisational justice, leadership styles, abusive supervision, knowledge hiding, cyberloafing, psychological contract breach, and crisis related contexts. Collaboration networks show dense hubs in North America and Asia with strengthening ties across South and Southeast Asia. Findings inform efforts to foster ethical climate, fair procedures, leadership capability, and norms for digital conduct, while prioritising knowledge hiding as a target for replication and intervention.*

Keywords: *Workplace Deviance, Counterproductive Work Behaviour, Human Resource Development, Bibliometric Analysis*

Introduction

Workplace deviance comprises voluntary acts that violate important organisational norms and erode the wellbeing of organisations and their members. It spans misconduct, incivility, and withdrawal, and is associated with financial and reputational losses that concern managers and policy makers across sectors (Bennett & Marasi, 2016; Malik et al., 2021). Prior studies link deviance to individual and contextual antecedents that include attitudes, justice perceptions, and leadership. However, findings are dispersed across outlets and subtopics, which limits cumulative theorising and the translation of evidence into practice. Distinctions between organisational and interpersonal deviance remain central, with justice and affect relating to both forms, and with demographic position shaping these links (Aquino et al., 2004; Hsieh et al., 2004).

Social Exchange Theory (SET) is one of the main frameworks used to explain workplace deviance. It posits that employees respond to perceived imbalance in exchanges with the organisation or its agents, which can trigger negative reciprocity, while high quality exchanges and prosocial norms can buffer such responses (Abas et al., 2025; Abbasi et al., 2022). From a development perspective, Human Resource Development (HRD) offers levers to reduce deviance by strengthening capability, ethical climate, and fairness perceptions through training, appraisal, and reward systems that support positive exchange relationships (Aguinis & Kraiger, 2009; Colquitt et al., 2001). Despite rapid growth in publications and widening collaboration, synthesis of the field's intellectual anchors, thematic structure, and collaborative networks remains incomplete. This motivates a systematic map of the domain.

Research Objectives

This study presents a bibliometric analysis of workplace deviance scholarship from 2015 to 2025. The objectives are to consolidate dispersed evidence, identify stable anchors and emergent fronts, and provide a navigational map for theory building and evidence informed practice. We combine performance indicators with science mapping to profile output dynamics, influential contributions, thematic clusters, and international collaboration. These objectives are operationalised through the following research questions:

RQ1. How has research on workplace deviance publication trends changed over time?

RQ2. Which are the ten most cited articles, and what themes do they cover?

RQ3. Which countries are the top ten contributors by publication count?

RQ4. Which keywords occur most often, and what main themes do they indicate?

RQ5. How are countries collaborating on this topic based on co-authorship networks?

Methodology

This study applies bibliometrics as the systematic collection, organisation, and analysis of publication metadata to describe performance and map knowledge structures (Alves et al., 2021; Assyakur & Rosa, 2022). Following good practice, the workflow combined a transparent search strategy, explicit screening rules, and reproducible analytics (Fahimnia et al., 2015). Scopus was selected for its broad coverage and citation rich records that support evaluative and mapping tasks (Di Stefano et al., 2010; Khiste & Paithankar, 2017). Using the advanced search, we queried titles, abstracts, and author keywords for variants of workplace deviant and counterproductive work behaviour, limited the language to English, restricted the publication stage to final, and set the window from 2015 to 2025. Data were exported in October 2025 with fields for authors, affiliations, source title, year, document type, citations, and author keywords. Only peer reviewed journal articles were retained, while books, chapters, and in press items were excluded, yielding 1,624 records.

Records were harmonised in OpenRefine to normalise author names, institutions, countries, and keyword variants, and to remove residual duplicates. Scopus Analyzer was used in the study. VOSviewer version 1.6.20 was used to construct co authorship by country, co citation, and keyword co-occurrence networks, and to derive cluster structures and density views (van Eck & Waltman, 2010, 2017). This pipeline provides a transparent and replicable basis to

profile performance patterns and to visualise the intellectual, thematic, and collaborative structure of workplace deviance scholarship.

Findings and Discussion

The main findings and discussion are summarised in Table 1.

Table 1: Summary of Main Findings and Discussion

Research Questions	Main Findings and Discussion
1. How has research on workplace deviance publication trends changed over time?	Workplace deviance research expanded from 71 publications in 2015 to 237 in 2024, a more than threefold rise, with sustained volumes between 2020 and 2023 (171–186 per year) and a strong partial year in 2025 (134 to October). This trajectory signals maturation from a formative phase (2015–2018) to an established, dynamic domain in the early 2020s. The post-2020 acceleration aligns with pandemic-era shifts—remote work, organisational restructuring, and heightened stress—that altered supervision and social dynamics, prompting intensified inquiry into counterproductive behaviours in virtual and hybrid contexts. Growing recognition of the costs to productivity, retention, and culture further increased the topic’s practical salience and scholarly attention. The 2024 peak suggests continuing priority as organisations navigate evolving work paradigms, technological disruption, and shifting employee expectations.
2. Which are the ten most cited articles, and what themes do they cover?	The ten most cited articles focus on negative workplace phenomena and their psychological mechanisms, with citations ranging from 261 to 653. Schilpzand et al. (2016) on workplace incivility leads with 653 citations, followed by Tepper et al. (2017) on abusive supervision with 530, signalling a field centred on destructive dynamics. Eight items appear between 2015 and 2019, indicating temporal clustering in the mid to late 2010s. Core venues include the Journal of Organizational Behavior and the Annual Review of Organizational Psychology and Organizational Behavior. The large gap between the top two and the remainder suggests that broad, integrative reviews and meta-analyses shape the agenda more than single study empirics. Themes emphasise incivility, abusive supervision and moral disengagement, with knowledge hiding rising in prominence. Notably, Yam et al. (2017) show citizenship behaviour can foster deviance via psychological entitlement.
3. Which countries are the top ten contributors by publication count?	Workplace deviance research is concentrated in Western and Asian systems, led by the United States (515 documents) and China (282), followed by Pakistan (113), India (94), and Malaysia (63), with Canada, the United Kingdom, Germany, Australia, and the Netherlands also prominent. This pattern reflects strong research infrastructure, funding, and organisational behaviour traditions in English-speaking and Western contexts, while China’s share signals rapid social-science

- expansion alongside economic development and organisational modernisation. The rise of Pakistan, India, and Malaysia indicates growing attention to workplace challenges in emerging economies, including rapid organisational change, retention pressures, and governance concerns. Broader participation from Germany, Australia, and the Netherlands underscores global relevance across varied contexts. Yet Western dominance suggests agendas may still lean toward Anglo-American paradigms, reinforcing the need for comparative, culturally grounded studies and more inclusive collaboration.
4. Which keywords occur most often, and what main themes do they indicate? A keyword co-occurrence analysis processed 2,620 terms, of which 441 met a minimum of five occurrences, yielding nine thematic clusters. The landscape is anchored by counterproductive work behaviour (665 occurrences; total link strength 3,652), organisational citizenship behaviour (518; 3,230) and workplace deviance (444; 3,114), indicating a discourse organised around paired prosocial and antisocial behaviours. Frequent tags such as human, female, male, article and questionnaire point to a predominantly quantitative, survey-based tradition. Conceptual depth is evident in psychological contract breach, conservation of resources theory and social exchange theory, with leadership constructs including abusive supervision and ethical leadership prominent. Contemporary themes such as COVID 19, knowledge hiding, cyberloafing and remote work show responsiveness to changing contexts. Country terms for China, Pakistan, India, Iran and Egypt, and dark trait keywords, signal both global breadth and continuing interest in individual differences.
5. How are countries collaborating on this topic based on co-authorship networks? A country level co authorship analysis covered 88 nations and retained 49 with at least five documents, yielding nine collaboration clusters and a broadly international network. The United States is the central hub (514 documents; 16,176 citations; total link strength 259), followed by China (279; 188) and Pakistan (113; 111), indicating substantial output and extensive cross border partnerships. Western systems show high connectivity, including the United Kingdom (104), Canada (83) and France (79), while Asian participation is strong, with Malaysia at 55. India records 94 documents but a modest link strength of 30, suggesting more domestically bounded collaboration and scope to deepen international ties. Emerging contributors such as Saudi Arabia and the United Arab Emirates, and isolated cases like Trinidad and Tobago (six documents; zero link strength), point to uneven integration. The field is global yet would benefit from wider inclusion of underrepresented regions.

Conclusion

This review indicates that workplace deviance scholarship has matured into an integrated, globally networked field. The map serves as a foundation for positioning new studies, standardising terminology, and linking micro, meso, and macro mechanisms, while highlighting uneven collaboration and regional under representation that future work should

address through cross cultural designs and inclusive partnerships. For Human Resource Development, the evidence supports prioritising capability building for ethical decision making, strengthening knowledge sharing norms, and setting clear expectations for responsible conduct in hybrid and remote contexts. Curricula and practitioner guidance should incorporate cross cultural evidence to reflect varied institutional settings and ensure transferability. Looking ahead, cumulative progress depends on widening evidence bases beyond a single index and language, employing stronger causal designs and cross level models, and integrating behavioural trace and multi-source data for technology mediated behaviours. Pairing bibliometric mapping with meta-analytic estimation can turn structural insights into quantitative guidance for practice and policy.

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EXPLORING GLOBAL PATTERNS OF AI RESEARCH IN LANGUAGE LEARNING

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Abstract: *This study explores global research patterns on Artificial Intelligence (AI) in language learning through a bibliometric analysis. Using data retrieved from the Scopus database (1984–October 2025), this study identifies publication trends and leading countries contributing to the field. A total of 653 documents were analyzed using VOSviewer 1.6.20 to generate bibliometric maps and visualize research development. Results reveal that publications on AI in language learning have grown rapidly, especially after 2020, reflecting increasing global attention and technological integration in education. China, the United States, and the United Kingdom lead in research output and collaboration networks, indicating strong institutional engagement and international partnerships. The findings highlight AI as a maturing research domain in language education, driven by technological innovation and global academic collaboration.*

Keywords: *Artificial Intelligence, Language Learning, Bibliometric Analysis, Research Trends, Global Collaboration*

Introduction

Artificial Intelligence (AI) has become a transformative force in education, particularly in language learning. AI-driven tools such as chatbots, intelligent tutoring systems, and adaptive platforms enhance the personalization and interactivity of learning environments (Király, 2024; Tashpolatovna et al., 2025). These technologies provide real-time feedback, promote learner autonomy, and support differentiated instruction based on individual proficiency levels (Janku, 2025; Qassrawi & Al Karasneh, 2025). The growing availability of AI applications reflects a global shift toward integrating data-driven tools in pedagogy. In recent years, research in AI and language learning has accelerated, highlighting its impact on engagement, assessment, and instructional design (Akinsemolu & Onyeaka, 2025).

However, despite the growing literature, comprehensive analyses capturing worldwide trends and country-level contributions remain limited. This study addresses this gap through a bibliometric mapping of global research on AI in language learning, offering an overview of publication trends and identifying the most active countries in the field. This study is guided by the following research questions:

RQ1: What are the publication trends in global research on Artificial Intelligence in language learning over the years?

RQ2: Which countries contribute the most publications and demonstrate the highest research productivity on Artificial Intelligence in language learning?

Methodology

This study adopts a bibliometric approach to systematically examine research trends and geographical distribution of studies on AI in language learning. Bibliometrics provides a structured method for collecting, organizing, and analyzing bibliographic data from scholarly sources (Verbeek et al., 2002). Data were collected from the Scopus database, covering the period from 1984 to October 2025. Only peer-reviewed journal articles were included to ensure quality and consistency (Gu et al., 2019). The data were exported in PlainText format, containing information such as publication year, author, country, citation count, and keywords. VOSviewer software version 1.6.20 (Van Eck & Waltman, 2010) was used to generate network visualizations, cluster analyses, and bibliometric maps. The software's association strength normalization technique allows related items to be placed closer in visual space, illustrating their intellectual proximity (Appio et al., 2014). This enabled the identification of key trends, collaboration networks, and the most active research countries.

Findings and Discussion

Publication Trends (RQ1)

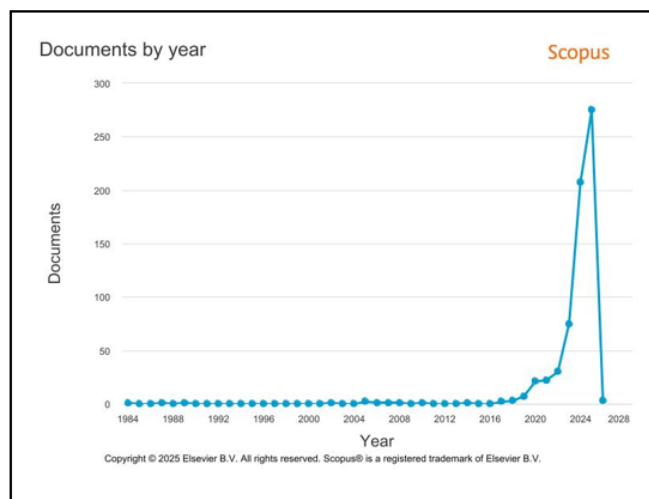


Figure 1: Trend of Research in Artificial Intelligence in Language Learning by Year

Figure 1 illustrates the growth of research on AI in language learning from 1984 to 2025. For more than three decades (1984–2017), publication output remained low, reflecting limited awareness and technological maturity. A noticeable rise began in 2018, leading to 30 publications by 2022, followed by a sharp surge between 2023 and 2025, peaking at 275 publications. This rapid increase reflects global enthusiasm for integrating AI into education, accelerated by advances in generative AI technologies such as ChatGPT. The data indicate that the field has transitioned from an emerging niche to a mainstream research area characterized by multidisciplinary interest and institutional support.

Country Contributions (RQ2)

Figure 2 summarizes the top contributing countries in AI and language learning research. China leads in total publications, followed by the United States and the United Kingdom, indicating strong academic investment and cross-border collaboration. Asian countries such as Japan and South Korea also show notable growth, while European nations contribute through partnerships and policy-driven research initiatives. The increasing collaboration between East Asian and Western institutions highlights AI in language education as a global research frontier shaped by shared technological and pedagogical goals. These patterns underscore the internationalization of research and the role of AI in bridging educational innovation worldwide.

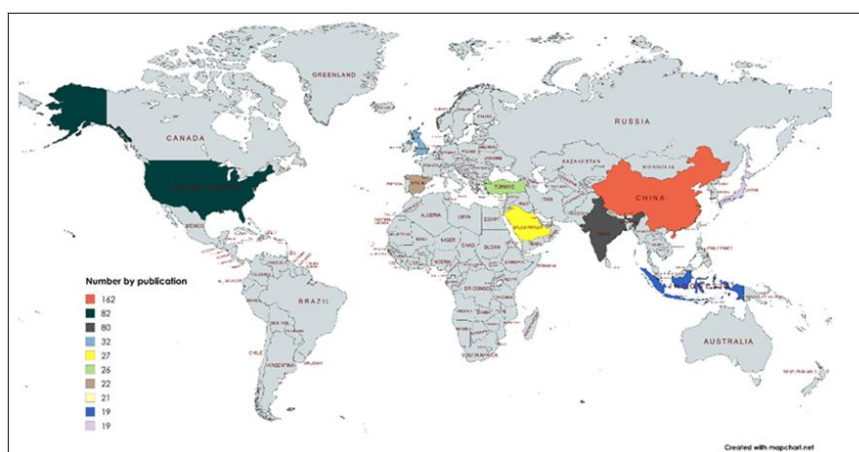


Figure 2: Country Mapping Based on the Number of Publications

Conclusion

This bibliometric study provides an overview of the global research landscape on AI in language learning, focusing on publication trends and country contributions. Results indicate a sharp rise in research output since 2020, demonstrating heightened scholarly interest and expanding academic networks. The dominance of China, the United States, and the United Kingdom reflects strong institutional support and international collaboration. Future research should explore emerging subfields such as generative AI, personalized learning systems, and multimodal language interaction. Overall, the findings confirm that AI has evolved into a central focus of educational innovation and global academic inquiry.

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TRENDS IN TECHNOLOGY-DRIVEN MATHEMATICS LEARNING: A BIBLIOMETRIC STUDY

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Abstract: *The rapid integration of digital tools and emerging technologies has reshaped mathematics education, driving scholarly interest in techniques that enhance teaching and learning. Despite growing research, a systematic review of publication trends, key works, and collaboration patterns remains essential. This study addresses that gap through a bibliometric analysis of 1,248 documents retrieved from Scopus using targeted keywords. Data were refined with OpenRefine and analyzed using Scopus Analyzer and VOSviewer to visualize trends, co-authorship networks, country collaborations, citation patterns, and keyword clusters. Results show consistent growth in publications from 2015 to 2025, with peaks during the COVID-19 pandemic, reflecting increased reliance on digital learning. The United States, Indonesia, China, and Malaysia were leading contributors, while highly cited works emphasized equity in STEM, digital innovation, and project-based learning. Keyword mapping revealed interdisciplinary clusters around mathematics education, e-learning, educational technology, and STEM integration. This research offers valuable insights into global collaboration and evolving themes, guiding educators, researchers, and policymakers in advancing technology-enhanced mathematics education*

Keywords: *Teaching, Learning, Mathematics, Technology, Digital*

Introduction

Technology has transformed mathematics education by enhancing engagement, improving outcomes, and supporting diverse learners. Innovative digital tools enable interactive learning and instant feedback, deepening understanding. Accelerated by COVID-19, these methods now support remote and hybrid teaching. This study examines their effectiveness, challenges, and implementation factors.

Literature Review

Technology integration in mathematics education has steadily grown, offering tools that enhance understanding, engagement, and performance. Formative assessments, graphing calculators, presentation software, and web-based instruction help students identify learning gaps and foster interactive learning environments (Shé et al., 2024; Raines & Clark, 2011). Project-based learning and blended approaches further support academic achievement and

reduce math anxiety (Janardhanan & Charles, 2024). Digital platforms like Moodle and GeoGebra provide flexible, personalized experiences, while assistive technologies such as mobile learning and gamification improve student attitudes and accessibility (Alessio et al., 2019; Reddy et al., 2021).

Despite these benefits, challenges persist. A major concern is the lack of a comprehensive framework that aligns pedagogical goals with technological implementation (Ní Shé et al., 2023). Research gaps also exist between commonly studied tools and those proven to optimize learning outcomes (Bray & Tangney, 2017). This study identifies three core areas—evaluation, pedagogy, and digital tools—as essential for effective integration. Structured assessment strategies, collaborative teaching methods, and inclusive technologies must work in synergy to create equitable and sustainable learning environments. Addressing these challenges through empirical research and strategic planning can help educators fully leverage technology's potential in mathematics education.

Research Questions

1. What are the longitudinal publication trends in technology-enhanced mathematics education research across the years of study?
2. Which articles represent the most highly cited contributions within this research domain?
3. Which countries are the leading contributors in terms of the top publication outputs?
4. What are the most frequently occurring author keywords that reflect the thematic focus of this field?
5. How are patterns of international collaboration reflected through co-authorship networks among countries?

Methodology

Bibliometrics is a structured approach to collecting, organizing, and analyzing bibliographic data from scientific publications. It goes beyond basic statistics by using advanced methods like co-citation and network analysis to explore a field's intellectual and thematic development. This study followed a rigorous review process involving careful keyword selection, database searches, and analytical synthesis to ensure reliability. High-impact publications were prioritized for their insights into theoretical foundations. Scopus was chosen as the primary data source due to its comprehensive coverage, and only peer-reviewed journal articles from 2015 to September 2025 were included, excluding books and conference materials to maintain academic rigor.

Findings

From 2015 to 2025, research on technology-enhanced mathematics learning grew steadily, peaking in 2024. The rise, especially after 2017, was driven by digital adoption and the COVID-19 pandemic, reflecting increased academic interest in tech-based education.

Citation analysis reveals that the most influential articles in technology-enhanced mathematics education often address broader STEM and equity issues. Theobald et al. (2020) and Stoet & Geary (2018) lead with 926 and 702 citations, respectively, focusing on inclusivity and gender

gaps. Han et al. (2015) (334 citations) highlights project-based learning's impact on diverse learners. Hillmayr et al. (2020) (274 citations) and Borba et al. (2016) (189 citations) focus more narrowly on educational technology. Studies linking math education to social and interdisciplinary concerns tend to achieve wider academic impact.

The United States and Indonesia are leading contributors, supported by infrastructure and digital reforms. Other countries like China, Malaysia, and the UK show steady engagement. This global participation reflects a shared goal: enhancing math education through technology, whether for competitiveness or access.

Keyword analysis using VOSviewer identified eight clusters, with core terms like mathematics education and e-learning linking diverse themes. The field spans pedagogy, STEM, and digital tools, shaped by trends like gamification and AI.

Co-authorship analysis revealed 55 active countries forming eight clusters. The U.S. leads in output and citations, followed by the UK, Indonesia, and China. Indonesia's rising role and contributions from the global south highlight growing international collaboration in digital mathematics education.

Conclusion

This bibliometric study explores the evolution of technology-enhanced mathematics education by analyzing publication trends, influential works, global contributors, keyword patterns, and collaborations from 2015 to 2025. It reveals steady growth, especially during the COVID-19 pandemic, and highlights the impact of studies addressing broader STEM and equity issues. The United States and Indonesia lead in output, with other nations also contributing significantly. Keyword mapping shows interdisciplinary themes around e-learning and digital innovation. The study offers insights for advancing digital practices, despite limitations like reliance on Scopus and exclusion of non-English sources.

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ANALISIS KEPERLUAN TAKSONOMI KOGNITIF ISLAM

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Hafizhah Zulkifli²

Abstrak: Galakan berfikir dalam pasca moden ini amat diperlukan dalam meningkatkan pemikiran kritis dalam kalangan pelajar. Amalan di sekolah melaksanakan Kemahiran berfikir adalah berdasarkan Taksonomi Bloom sebagai panduan. Begitu juga dengan mata Pelajaran Pendidikan Islam yang menggunakan Taksonomi Bloom di dalam kelas. Namun begitu, terdapat beberapa kekangan untuk guru-guru Pendidikan Islam menggunakan taksonomi Bloom dalam pengajaran mereka. Justeru, objektif kajian ini adalah untuk memahami keperluan membangunkan taksonomi kognitif Islam dan elemen yang sesuai dimasukkan dalam taksonomi kognitif Islam. Metodologi kajian adalah menggunakan kaedah kualitatif dengan 4 orang informan. Instrumen yang digunakan adalah protokol temubual dan data dianalisis menggunakan perisian NVivo 14. Diharapkan kajian ini dapat membantu guru-guru Pendidikan Islam dalam meningkatkan kualiti pengajaran Kemahiran Berfikir kritis dalam kalangan pelajar.

Kata Kunci: Kemahiran Berfikir Kritis, Taksonomi Bloom, Taksonomi Kognitif Islam, Pendidikan Islam, Pengajaran, Pelajar

Pengenalan

Analisis keperluan adalah suatu analisis yang dijalankan bagi mengenal pasti masalah atau sesuatu isu yang berlaku dalam persekitaran. Dalam melaksanakan analisis ini, beberapa model boleh diadaptasi dalam memberikan panduan bagaimana proses ini dapat dijalankan dengan baik. Model McArdle (1998) antara salah satu model analisis keperluan yang biasa digunakan oleh kajian terdahulu dalam proses ini yang menggariskan beberapa prosedur dan aktiviti yang tertentu.

Taksonomi Kognitif Islam difokuskan dalam bab ini adalah berdasarkan kepada keperluan yang dikenal pasti melalui temu bual separa berstruktur yang dijalankan. Adapun tujuan temu bual ini dijalankan adalah untuk mengenal pasti cabaran yang dihadapi dalam pengajaran Pendidikan Islam faktor-faktor yang menyebabkan pembangunan domain kognitif Islam dan antara elemen yang perlu dimasukkan dalam Taksonomi Kognitif Islam.

Model Analisis Keperluan

Model McArdle

Analisis keperluan adalah proses menjalankan beberapa siri aktiviti untuk mengenal pasti masalah atau isu lain dalam persekitaran kerja dan menentukan sama ada penambahbaikan adalah tindakan yang tepat dilakukan (McArdle, 1998). Pada umumnya analisis keperluan adalah fasa pertama dalam siri langkah yang dilaksanakan untuk menggalakkan perubahan efektif kerana analisis keperluan menentukan jurang antara situasi semasa, kemahuan organisasi dan pencapaian individu (McArdle, 1998).

Model analisis keperluan yang dibangunkan oleh McArdle (1998) menggariskan empat prosedur iaitu pengawasan (*surveillance*), penyiasatan (*investigation*), analisis (*analysis*) dan laporan (*report*). Bagi setiap fasa terdapat aktiviti spesifik yang digariskan seperti berikut:

- a. Pengawasan (*surveillance*)
Pengawasan adalah proses bagi menentukan situasi semasa dan mengenal pasti perubahan dengan mengamati situasi dengan teliti, terutamanya untuk melihat apakah prestasi berkaitan masalah muncul.
- b. Penyiasatan (*investigation*)
Langkah seterusnya adalah Mengumpul data untuk menentukan sama ada latihan adalah tindakan yang sesuai. Data-data ini juga akan menyediakan asas kepada pembinaan program latihan yang efektif.
- c. Analisis (*analysis*)
Menjalankan penilaian yang memberikan pemahaman yang jelas mengenai masalah dengan teliti untuk memastikan kualiti bukti dan sumber data. Tiga jenis analisis yang mungkin dilakukan iaitu berkaitan dengan objektif, organisasi dan spesifikasi tugas.
- d. Laporan (*report*)
Terdapat dua jenis laporan iaitu laporan reka bentuk latihan dan laporan akhir. Laporan reka bentuk latihan mengandungi rumusan hasil penyiasatan dan penganalisan data, membuat cadangan dan mengesyorkan bahan yang perlu digunakan oleh pengurus latihan pada setiap fasa projek. Laporan akhir pula mengandungi pengenalanpastian jurang prestasi dan apa yang perlu diubah, bagaimana perubahan boleh dilakukan dan bagaimana perubahan ini sesuai dengan tujuan organisasi.

Sorotan Kajian Analisis Keperluan

Antara kajian yang menggunakan pendekatan penyelidikan reka bentuk dan Pembangunan (PRP) adalah seperti kajian oleh Maznah Salleh, Mohd Zahuri Khairani, Yakup Mohd Rafee (2023) yang bertujuan mengenal pasti keperluan pembangunan aplikasi ApSeL dalam konteks Seni Lukisan di sekolah menengah. Pendekatan kuantitatif digunakan melalui soal selidik yang diberikan kepada 184 guru Pendidikan Seni Visual yang mengajar Tingkatan 3 di 180 sekolah menengah di Kedah. Data yang dianalisis menggunakan SPSS versi 26.0 menunjukkan interpretasi yang tinggi terhadap keperluan aplikasi ini, mencerminkan sokongan terhadap pembelajaran digital. Hasil kajian memberikan pemahaman yang kuat mengenai potensi pengintegrasian teknologi dalam pembelajaran Seni Visual di sekolah menengah. Analisis soal selidik menunjukkan konsensus tinggi di kalangan guru-guru PSV, menegaskan keperluan yang signifikan untuk membangunkan aplikasi seni lukisan dalam pengajaran dan pembelajaran di sekolah menengah.

Manakala kajian yang dilakukan oleh Zurina Mustaffa, Zaharah Hussin, & Abdul Muhsien Sulaiman (2022) adalah bertujuan mengenal pasti tahap pengetahuan Pedagogi Berbeza dan menentukan keperluan pembangunan model Pedagogi Berbeza dalam kalangan 361 guru sekolah rendah di Zon Selatan. Data diperolehi melalui soal selidik 21 item dan dianalisis menggunakan SPSS untuk statistik deskriptif. Hasil menunjukkan tahap pengetahuan guru berada pada tahap sederhana (purata min 2.82), sementara keperluan pembangunan model Pedagogi Berbeza tinggi (purata min 4.12). Keputusan menekankan keperluan mendesak membangunkan model ini sebagai respons terhadap kurangnya pengetahuan guru, sesuai untuk penanganan kepelbagaian murid di bilik darjah.

Bagi kajian yang dilakukan oleh Syarina Ramli (2021), Fasa analisis keperluan dan pembangunan model ini menggunakan kaedah *Fuzzy Delphi Method* (FDM) melibatkan 14 pakar terdiri dari tenaga pengajar TVET berpengalaman, agensi kerajaan, dan sektor swasta dalam teknologi hijau, serta wakil kementerian yang terlibat dalam penyusunan kurikulum TVET dan kurikulum di Institut Pendidikan Guru (IPG). Implikasi kajian ini menyorot bahawa hasil daripada indicator dan model pembangunan kompetensi kemahiran hijau industri 4.0 dapat memberikan panduan kepada IPG dalam menentukan elemen kompetensi kemahiran hijau industri 4.0. Ini akan memperbaiki kurikulum sedia ada di IPG, sekaligus membangunkan kompetensi kemahiran hijau industri 4.0 guru pelatih, sejajar dengan kehendak industri semasa dan objektif pembangunan lestari.

Kajian analisis keperluan yang dilakukan oleh Mohamad Ikram Zakaria (2021) telah melibatkan kajian tinjauan yang melibatkan 250 orang guru matematik sekolah rendah, dipilih secara persampelan rawak mudah. Data dikumpulkan melalui soal selidik dengan tujuan mengenal pasti keperluan untuk pembangunan model pengajaran M-PBM. Kaji selidik ini dilaksanakan untuk mendapatkan maklumat berkaitan jenis peranti mudah alih yang dimiliki, kemahiran penggunaan peranti mudah alih, kaedah pengajaran penyelesaian masalah yang digunakan oleh guru, serta penerimaan guru terhadap pelaksanaan M-pembelajaran. Dapatan dari fasa pertama kajian menunjukkan bahawa guru-guru memiliki tahap persepsi yang tinggi terhadap kaedah pengajaran penyelesaian masalah, pelaksanaan M-pembelajaran, dan juga mendukung cadangan aktiviti pengajaran M-PBM. Faktor-faktor seperti kreativiti, kesediaan guru untuk menjalankan M-pembelajaran, dan pandangan guru terhadap cadangan aktiviti pengajaran M-PBM telah dikenal pasti sebagai aspek-aspek penting yang perlu dipertimbangkan dalam pembangunan model tersebut. Oleh itu, fasa ini menggambarkan bahawa terdapat keperluan yang nyata untuk membangunkan model pengajaran M-PBM.

Seterusnya kajian Radha T. Gandhi, Mohd. Ridzwan Che Rus dan Suriani Mohamed (2020) adalah tentang pembangunan Model pemikiran Inventif Pelajar Mata pelajaran Reka Cipta. Kajian ini menggunakan pendekatan DDR yang dipelopori oleh Richey dan Klein (2007). Tujuan kajian adalah untuk mengenal pasti keperluan dan pemetaan model kajian iaitu model pemikiran inventif. Kaedah yang digunakan adalah temu bual separa struktur dengan menggunakan instrumen protokol temu bual yang melibatkan tujuh orang pakar.

Bagi kajian Muhammad Nidzam Yaakob, Syed Khalid Syed Idrus, Ahmad Sobri Shuib, Mohd Khairul Nuzul Hassan (2020) dalam pembangunan model kurikulum M-pembelajaran kursus teknologi dalam PdP di IPG. Fasa pertama kajian iaitu fasa analisis keperluan adalah bertujuan mengenal pasti keperluan m-Pembelajaran bagi Kursus Teknologi Dalam Pengajaran dan Pembelajaran di IPG. Pengkaji memilih pendekatan soal selidik dan temu bual, yang dijalankan terhadap pelajar dan pensyarah yang terlibat dalam Kursus Teknologi Dalam Pengajaran Dan Pembelajaran. Hasil keseluruhan fasa pertama menunjukkan bahawa nilai minimum bagi komponen utama model adalah yang tertinggi (min=4.510), manakala nilai minimum terendah adalah tujuan menggunakan m-Pembelajaran (min=3.715). Dapatan ini menyimpulkan bahawa terdapat keperluan yang nyata untuk membangunkan model m-Pembelajaran bagi Kursus Teknologi dalam Pengajaran dan Pembelajaran.

Manakala kajian, Muhamad Nasir Mohamad Salleh, Zaharah Hussin dan Mohd Faisal Mohamed (2020) bagi membangunkan model pengajaran taranum al-Quran, pengkaji melaksanakan fasa satu iaitu analisis keperluan untuk mengenal pasti keperluan

membangunkan model tersebut. Mereka memilih pendekatan secara kaedah campuran berbentuk '*sequential exploratory*' dalam fasa analisis keperluan. Pendekatan secara kaedah ini melibatkan dua data analisis keperluan iaitu secara kualitatif dan secara kuantitatif. Temu bual separa struktur telah dilaksanakan terhadap dua orang pensyarah PPI IPT-A yang terdiri daripada seorang tenaga pengajar utama taranum dan seorang penyelaras program SMPI PQ. Manakala secara kuantitatif, Pengkaji telah menggunakan kaedah borang soal selidik kepada 59 orang guru pelatih PQ yang telah selesai mengambil kursus *taranum*. Hasil kajian ini mendapati satu keperluan membangunkan model pengajaran taranum al-Quran agar menjadi panduan kepada pengajaran pensyarah taranum khususnya di IPT.

Bagi Kajian yang dilakukan oleh Nik Narimah Nik Abdullah, Nurfaradilla Mohamad Nasri, Muhammad Helmi Norman dan Juritah Misman (2020) bertujuan mengenal pasti keperluan membangunkan model kurikulum identiti korporat silang budaya bagi Program Seni Reka Grafik di Institusi Pengajian Tinggi. Analisis keperluan melibatkan temu bual separa berstruktur dengan 12 peserta kajian, terdiri daripada pensyarah Program Seni Reka Grafik di institusi tempatan dan dua pereka grafik berpengalaman dalam sektor awam. Tiga tema utama dikenal pasti, iaitu rekaan bercirikan identiti budaya tempatan, kurikulum berdasarkan silang budaya, dan pengajaran serta pembelajaran berpusatkan pelajar. Majoriti peserta kajian mencadangkan pembangunan model kurikulum identiti korporat silang budaya untuk program tersebut. Hasil analisis keperluan digunakan untuk membentuk matlamat dan tujuan kursus, kandungan, aktiviti pembelajaran, dan penilaian, menekankan keperluan untuk model reka bentuk kurikulum yang mencerminkan identiti korporat silang budaya dalam Program Seni Reka Grafik.

Seterusnya kajian pembangunan model pembelajaran autentik untuk program kejuruteraan di Politeknik Malaysia oleh Mohd Norulhisham Abdul Rashid (2020) menggunakan pendekatan borang soal selidik sebagai instrumen di fasa analisis keperluan bertujuan untuk mengenal pasti keperluan bagi membangunkan model sebagai garis panduan kepada para pensyarah di politeknik. Seramai 180 orang pensyarah Politeknik terlibat dalam fasa ini. Perisian IBM SPSS Statistic 20 digunakan bagi analisis data. Hasil dapatan kajian di fasa analisis keperluan model menunjukkan keperluan kajian untuk diteruskan apabila nilai min keseluruhan bagi sembilan elemen pembelajaran autentik yang dikaji berada pada skor 2.87 daripada 5.00.

Metodologi

Kajian ini menggunakan pendekatan kualitatif dengan reka bentuk kajian kes untuk memahami fenomena yang berlaku secara semula jadi (Strauss & Corbin, 1998). Reka bentuk ini bertepatan dengan persoalan kajian untuk meneroka cabaran yang dihadapi oleh guru dalam melaksanakan kurikulum dan penilaian dokumen standard, serta keperluan untuk membina taksonomi dalam pendidikan Islam. Teknik persampelan bertujuan digunakan dalam memilih peserta kajian untuk memastikan data yang dikumpul adalah kaya dan cukup mendalam untuk menjelaskan fenomena yang dikaji. Antara kriteria yang ditetapkan ialah peserta kajian terdiri daripada guru cemerlang pendidikan Islam yang berkhidmat di sekolah menengah dan mempunyai pengalaman mengajar menggunakan Kurikulum Bersepadu Sekolah Menengah dan Kurikulum Standard Sekolah Menengah. Oleh itu, pemilihan peserta kajian ini dimulakan dengan merujuk kepada individu yang mempunyai kuasa untuk mendapatkan maklumat berkenaan peserta yang memenuhi kriteria tersebut. Empat orang guru telah dipilih untuk kajian ini. Butiran maklumat peserta kajian adalah seperti Jadual 5.1 di bawah.

Jadual 1: Maklumat Peserta

Informan	Pengalaman Mengajar	Pendidikan Tertinggi
1	32 tahun	Ijazah (Universiti Kebangsaan Malaysia)
2	20 tahun	Ijazah (Universiti Yarmouk, Jordan)
3	29 tahun	Ijazah (Universiti Kebangsaan Malaysia)
4	31 tahun	Ijazah (Universiti Malaya)

Kajian ini menggunakan temu bual separa berstruktur dan analisis dokumen untuk pengumpulan data. Instrumen protokol temu bual berstruktur dibina sebagai panduan kepada pengkaji dalam mendapatkan dapatan kajian. Untuk memastikan pembangunan protokol temu bual yang berkualiti, Castillo-Montoya (2016) mencadangkan kaedah rangka kerja temu bual yang dikenali sebagai *Interview Protocol Refinement* (IPR). Terdapat empat fasa utama, dan objektif dalam setiap fasa diperincikan dalam Jadual 5.2 di bawah.

Jadual 2: Fasa *Interview Protocol Refinement Framework*

Fasa	Keterangan	Tujuan
1	Memastikan soalan temu bual sepadan dengan soalan kajian.	Membina matriks pemetaan soalan temu bual untuk diselaraskan dengan soalan kajian.
2	Mereka bentuk soalan temu bual dalam perbualan berasaskan pertanyaan.	Membentuk soalan temu bual menggunakan 4W 1H.
3	Menerima maklum balas daripada protokol temuduga.	Menyemak kesahihan soalan temu bual.
4	Menjalankan penyelidikan pra lapangan.	Memastikan persoalan kajian dapat difahami oleh peserta.

Selepas temu bual dijalankan dengan peserta kajian, transkripsi sesi telah dibuat dan dianalisis menggunakan analisis tematik seperti yang disarankan oleh Glaser (1978). Analisis data tematik ini membantu aplikasi NVIVO 14 sebagai alat untuk menyusun data secara sistematik dan teratur. Proses analisis dimulakan dengan peringkat pengkodan terbuka dan diteruskan dengan pembinaan kategori dengan menggunakan pendekatan analisis tematik yang disarankan oleh Merriam (1994) untuk menjawab persoalan kajian iaitu:

- Menamakan kategori
- Menentukan bilangan kategori
- Memikirkan sistem untuk meletakkan data ke dalam kategori.

Bagi meningkatkan kredibiliti dan ketekalan data kajian, proses semakan ahli telah digunakan, bermakna setiap peserta kajian diberi peluang untuk mengesahkan transkrip temu bual dan dapatan awal data kajian yang dibuat oleh pengkaji. Peserta kajian berhak mengubah suai dan menolak sekiranya tidak bersetuju atau terdapat ketidakselarasan antara transkrip dan dapatan awal kajian. Setelah penambahbaikan dilakukan, peserta kajian menandatangani borang pengesahan yang disediakan.

Seterusnya, proses semakan rakan sebaya juga dijalankan bagi mengesahkan hasil dapatan data, bermula dari awal proses analisis, contohnya, open coding dengan semakan awal dibuat oleh pakar yang dilantik sehingga semakan akhir selepas tema dibentuk. . Ia bertujuan untuk memastikan tema dapat menjawab persoalan kajian. Dan akhirnya, proses triangulasi dijalankan iaitu triangulasi daripada sumber kaedah pengumpulan data (temu bual dan analisis dokumen) bagi mengukuhkan dapatan kajian.

Dapatan

Penemuan terutamanya dibahagikan kepada tiga bahagian. Bahagian A memfokuskan kepada cabaran yang dihadapi oleh guru dalam menjalankan sesi pengajaran dan pembelajaran dalam pendidikan Islam. Bahagian B membincangkan sebab untuk membangunkan domain kognitif Islam, dan Bahagian C menangani elemen yang diperlukan untuk dimasukkan ke dalam domain kognitif Islam.

Cabaran Pengajaran dan Pembelajaran Pendidikan Islam

Terdapat tujuh cabaran dalam pengajaran dan pembelajaran pendidikan Islam, contohnya, kekurangan adab (nilai) dalam melaksanakan Taksonomi Bloom Taksonomi Bloom tidak sesuai dengan budaya Islam, Taksonomi Bloom tidak setara dengan Standard dan Pentaksiran Dokumen Kurikulum, kekurangan dalam memahami kandungan pelajaran, kekangan masa, kekurangan kemahiran pertimbangan profesional, dan kekurangan penilaian berterusan.

Kekurangan Adab (nilai) dalam Taksonomi Bloom

Kesemua informan bersetuju bahawa Taksonomi Bloom tidak tertumpu kepada adab atau akhlak (nilai) dalam domain kognitif. Dalam pendidikan Islam, nilai merupakan bahagian penting dalam kehidupan yang aman dan harmoni. Walau bagaimanapun, apabila melaksanakan pengajaran dengan Taksonomi Bloom, terdapat nilai yang hilang. Untuk pencapaian akademik, Taksonomi Bloom mencapai objektif pembelajaran. Ungkapan para peserta adalah seperti berikut:

“Taksonomi Bloom tidak menekankan kepentingan perwatakan yang baik dalam kehidupan. Pendidikan Islam perlu dilaksanakan dengan cara ilmu dapat diamalkan dalam kehidupan, bukan sekadar memahaminya. Inilah yang membezakan Taksonomi Bloom dengan pendidikan Islam.”

Taksonomi Bloom Tidak Sesuai untuk Budaya Islam

Informan 1, 3, dan 5 mendakwa bahawa Taksonomi Bloom tidak dapat memenuhi budaya budaya Islam kerana, dalam Islam, kita percaya kepada dunia dan akhirat, dan kita juga memerlukan rohani dan bukannya kognitif. Mereka memetik seperti berikut:

“Taksonomi Bloom tidak sesuai digunakan kerana hasil pendidikan Islam adalah berbeza. Islam menitikberatkan kedua-dua aspek dunia dan akhirat. Kami tidak mahu melahirkan pelajar yang hanya boleh cemerlang dalam akademik. Kami mengajar pendidikan Islam bukan sahaja untuk mereka lulus peperiksaan tetapi juga untuk memupuk iman dalam kehidupan mereka.”

Taksonomi Bloom Tidak Setara dengan Dokumen Standard Kurikulum dan Pentaksiran

Menurut informan 2 dan 5, mereka merasakan Standard dan Pentaksiran Dokumen Kurikulum tidak selari dengan Taksonomi Bloom. Oleh itu, mereka berasa sukar untuk mengajar kerana tidak dapat mencapai objektif pembelajaran. Petikan itu berbunyi seperti berikut:

"...pelajar boleh capai band 6. Bolehkah pelajar berlatih? Bolehkah pelajar itu hidup dengan apa yang kita ajar? Tetapi Bloom tidak mempunyai unsur-unsur penghargaan, tetapi dalam Dokumen Kurikulum Standard dan Pentaksiran kita wujud. Ini bermakna tiada persamaan antara Bloom dan Dokumen Kurikulum Standard dan Pentaksiran".

Kekurangan Memahami Isi Pelajaran

Dalam cabaran kekurangan memahami isi pelajaran terdapat dua kategori iaitu pertama kekurangan dari sudut dokumen standard kurikulum dan pentaksiran dan kedua adalah buku teks.

Dokumen Standard Kurikulum dan Pentaksiran

Informan 1, 3, dan 4 bersetuju bahawa terdapat kekurangan dalam memahami isi pelajaran. Kandungan pelajaran termasuk kurikulum, dokumen standard pentaksiran, dan buku teks. Penulis membuat kesimpulan bahawa dokumen terdahulu yang dipanggil sekolah menengah kurikulum bersepadu mempunyai banyak maklumat, manakala yang kedua, iaitu dokumen standard kurikulum dan penilaian, hanya memberikan maklumat asas. Sebagai contoh, informan 4 mengatakan bahawa:

"Ia berbeza dengan dokumen standard kurikulum dan penilaian; kandungannya berbeza. Seperti kurikulum bersepadu di sekolah menengah ini, terdapat banyak maklumat dan mendalam. Pembelajaran pelajar berbeza-beza. Apabila ia menjadi dokumen standard kurikulum dan pentaksiran, tajuk itu kelihatan seperti asas dan data sahaja. Contohnya, topik muamalat, kurikulum bersepadu sekolah menengah lebih mendalam dalam memberi maklumat, tetapi dokumen standard kurikulum dan pentaksiran pelajar hanya perlu mengetahui pengertian muamalat dan ciri-cirinya".

Ia berbeza dengan informan 2 dan 4 yang bersetuju bahawa dokumen standard kurikulum dan pentaksiran lebih mudah dan sesuai pada masa kini, seperti yang katanya dalam petikan.

"Yang baharu itu bagus. Kerana ianya ringkas tetapi padat....jika pelajar ingin butiran lanjut tentang topik tersebut, mereka boleh google atau mereka akan mempelajarinya daripada pakar. Sebagai contoh, mereka boleh mempelajarinya apabila mereka memasuki universiti dan menyertai kursus".

Seterusnya, informan menyatakan bahawa, terdapat masalah yang serius apabila guru tidak memahami dokumen standard kurikulum dan pentaksiran dan beberapa guru tidak memahami perkara itu sambil memetik:

“Sesetengah guru pendidikan Islam masih tidak memahami objektif yang telah digariskan dalam dokumen standard kurikulum dan pentaksiran. Jika kita benar-benar mengikut apa yang telah digariskan dalam dokumen standard kurikulum dan pentaksiran, sudah pasti kita dapat membina generasi yang telah diterangkan dalam dokumen standard kurikulum dan pentaksiran. Tetapi malangnya, masih terdapat sebilangan guru yang tidak membaca dokumen standard kurikulum dan pentaksiran dengan teliti”.

Buku Teks

Mengenai sukatan pelajaran buku teks yang sedang digunakan oleh guru, informan 1, 3, dan 5 menyatakan sukatan pelajaran buku teks Sekolah Menengah Kurikulum Bersepadu jauh lebih ringkas dengan penerangan yang ringkas berbanding kurikulum sebelum ini iaitu Kurikulum Bersepadu Sekolah Menengah. Ini menjadi cabaran kepada guru pendidikan Islam kerana mereka perlu berusaha lebih untuk mencari lebih banyak maklumat berkaitan topik yang ingin diajar. Sebagai contoh, informan 5 menyatakan bahawa:

“Pada pendapat saya, sukatan pelajaran buku teks daripada Kurikulum Bersepadu Sekolah Menengah sebelum ini lebih diterangkan dan mempunyai lebih banyak maklumat berkaitan topik tersebut. Tetapi dokumen standard kurikulum dan pentaksiran semasa menyukarkan guru kerana kami perlu meneroka secara bebas lebih lanjut tentang sukatan pelajaran melalui kod QR yang disediakan dalam buku teks untuk setiap topik.”

Seterusnya, terdapat juga masalah daripada buku teks terutamanya dalam tulisan Jawi. Tulisan Jawi merupakan adaptasi daripada huruf Arab dan beberapa murid tidak dapat menguasai Jawi. Ini dinyatakan dalam petikan berikut:

“Masalah buku teks ialah tidak semua pelajar memahami Jawi. Jadi kena ada tulisan rumi (huruf abjad). Kerana kebiasaannya, pelajar tidak akan menggunakan buku teks. Mereka akan menggunakan modul oleh guru mereka. Inilah sebab akhirnya Jawi tidak wujud. Kita sepatutnya membuat buku untuk dibaca oleh pelajar dan bukannya buku teks”.

Kekangan Masa

Seterusnya ialah tema kekangan masa. Kesemua informan dalam hal ini, bersetuju untuk mengalami kekangan masa dalam pengajaran pendidikan Islam. Informan 2 menegaskan guru terikat dengan pelbagai perkara selain daripada mengajar pendidikan Islam khususnya bagi Penilaian Asas Fardhu Ain (ibadah kepada Allah). Informan 2 menjelaskan:

“Apabila hendak membuat penilaian asas Fardhu Ain, ada pelbagai kerja yang perlu dilakukan seperti guru perlu membawa pelajar bertanding nasyid, mengaji al-Quran dan tahfiz al-Quran. Malah, kami dibebani mengajar 40 pelajar di dalam bilik darjah dan tidak cukup masa untuk menumpukan perhatian”.

Informan 1 menambah bahawa,

“Guru pendidikan Islam dibebani dengan pelbagai tanggungjawab selain mengajar. Terdapat begitu banyak pertandingan yang pelajar perlu dilatih dan disertai. Guru hanya diberi masa satu jam untuk mengajar dan menjalankan penilaian kelas. Adalah mustahil untuk menilai semua pelajar dalam masa yang singkat.”

Informan 1 juga menyatakan bahawa guru perlu memastikan sukatan pelajaran dirangkumi dalam tempoh yang diperuntukkan. Ini adalah satu cabaran kerana ia menyukarkan penilaian untuk dijalankan dengan betul, memandangkan masa untuk merangkumi semua topik dalam sukatan pelajaran.

Kekurangan Kemahiran Penghakiman Profesional

Seterusnya, cabaran timbul apabila informan tidak dapat memberikan markah penilaian akhir dengan adil, dan informan juga berasa teragak-agak untuk memberikan markah. Menurut beberapa informan, mereka sukar untuk memberikan markah yang baik, seperti dalam kenyataan berikut:

“... Di sini timbul perasaan pilih kasih. Bagi pelajar yang baik dengan guru, kita bagi markah tinggi. Sedangkan perkara itu tidak dibenarkan, maka pentadbir kata pelajar mesti lulus. Tak boleh jadi begini. Contohnya, dalam menghafaz al-Quran, jika pelajar tidak menghafaz, dia perlu diberi markah sifar iaitu untuk band 1”.

Kekurangan Penilaian Berterusan

Cabaran terakhir ialah kekurangan penilaian berterusan. Informan bimbang apa yang dipelajari di sekolah tidak diamalkan oleh pelajar di rumah, dan tiada pemantauan daripada ibu bapa mereka. Ini dijelaskan dalam temu bual.

“Guru bukan hanya mahu meniru dan memberi kerja rumah serta latihan. Kerja rumah mesti berubah. Kerja rumah mesti dibuat. Adakah solat itu dilakukan lima waktu sehari? Kemudian minta ibu bapa tandakan dan minta tandatangan ibu bapa atau sesiapa sahaja di rumah. Yang telah anda laksanakan. Tetapi kadang-kadang ibu bapa tidak mementulkannya kerana halangan bekerja”.

“Cuma kita tak boleh judge dekat rumah. Di sekolah, kita tahu bahawa dia telah berubah. Sebagai contoh, dahulu ada pelajar yang nakal, tetapi selepas mengajar pendidikan Islam, ia berubah. Tetapi di rumah, kita tidak tahu. Peranan ibu bapa hendaklah selari”.

Faktor Pembangunan Domain Kognitif Islam

Lima informan daripada temu bual itu ditanya sama ada taksonomi kognitif baharu untuk pendidikan Islam perlu dibangunkan. Empat daripada informan menyatakan bahawa ia perlu berdasarkan alasan mereka, yang akan dijelaskan dalam bahagian ini. Sementara itu, seorang pemberi maklumat menyatakan bahawa tidak perlu berbuat demikian, atas alasannya sendiri.

Informan 1 merupakan salah seorang informan yang bersetuju perlu ada taksonomi kognitif baharu bagi pendidikan Islam yang menggantikan Taksonomi Bloom. Informan 1 menyatakan, *“Saya bersetuju mesti ada taksonomi baharu yang boleh menilai secara holistik kerana pendidikan Islam tidak pernah boleh dinilai dengan hanya menggunakan Taksonomi Bloom Taksonomi pendidikan Islam baharu mesti merangkumi penilaian semua aspek kognitif, afektif dan psikomotor*

Informan 2 menyatakan persetujuannya dengan membangunkan taksonomi kognitif baharu untuk pendidikan Islam. Beliau menyatakan perkara ini penting kerana Taksonomi Bloom tidak memasukkan aspek keimanan atau jiwa (ruh) di dalamnya, sedangkan dalam Islam, ini merupakan komponen besar yang perlu diambil kira oleh seseorang manusia.

Informan 3 bersetuju dengan pembangunan taksonomi kognitif baharu untuk pendidikan Islam kerana kekurangan aspek moral dalam penilaian Taksonomi Bloom Informan 3 menyatakan, *“Taksonomi Bloom tidak memberi penekanan kepada nilai moral dan penilaian. Pendidikan Islam sepatutnya menekankan bagaimana pelajar boleh mengaplikasi dan mengamalkannya secara konsisten sebagai satu kebiasaan dalam kehidupan seharian mereka. Taksonomi Bloom sukar diaplikasikan dalam pendidikan Islam kerana kekurangan aspek ini. Taksonomi kognitif Bloom hanya mementingkan pelajar menguasai ilmu, tetapi pendidikan Islam menekankan penggunaan pengetahuan secara praktikal dalam kehidupan.”* Informan 4 juga tidak bersetuju dengan Taksonomi Bloom kerana, pada pendapatnya, tahap tertinggi aspek kognitif yang boleh dicapai oleh seseorang ialah penciptaan, dan ini tidak terpakai dalam pendidikan Islam. Sebagai contoh, informan 4 memberi contoh: *“Mustahil tahap penciptaan diterapkan dalam aspek ritual Islam seperti haji kerana aspek ritual tidak boleh dicipta tetapi mesti diikuti dan dipatuhi. Islam mempunyai tahap yang tersendiri dan tahap tertinggi aspek kognitif yang perlu dikembangkan.”*

Sementara itu, Informan 5 memberi perspektif berbeza mengenai keperluan membangunkan taksonomi kognitif untuk pendidikan Islam. Informan 5 tidak bersetuju bahawa perlu ada taksonomi kognitif baharu untuk pendidikan Islam. Informan 5 menyatakan bahawa, *“Kita tidak perlu bersusah payah membangunkan taksonomi kognitif baharu. Pada pendapat saya, kita cuma tidak faham secara mendalam apa yang terkandung dalam Dokumen Standard Kurikulum dan Pentaksiran untuk Kurikulum Bersepadu Sekolah Menengah. Walau apa pun cabaran yang dihadapi oleh guru, Dokumen Standard Kurikulum dan Pentaksiran sudah cukup untuk membimbing mereka dalam pengajaran pendidikan Islam. Mereka hanya perlu memahami dan membaca kandungannya.”*

Elemen yang Perlu dimasukkan dalam Taksonomi Kognitif Islam

Elemen-elemen yang disarankan oleh informan kajian semasa adalah untuk dimasukkan ke dalam pembangunan taksonomi kognitif baharu untuk pendidikan Islam. Elemen-elemen ini dicadangkan berdasarkan prinsip Islam bagaimana aspek kognitif perlu dikembangkan untuk pelajar mencapai hasil pendidikan Islam. Elemen-elemen tersebut adalah internalisasi, analisis, kesyukuran, pembiasaan, keikhlasan, pelaksanaan, konsistensi, dan refleksi.

Menginternalisasi

Daripada lima temu bual yang dijalankan bersama informan, kesemua mereka mencadangkan elemen internalisasi sebagai sebahagian daripada taksonomi kognitif baharu pendidikan Islam. Informan 2 menyifatkan penghayatan sebagai “pelajar memahami pengetahuan, mengaplikasikan pengetahuan dengan penuh kesedaran sendiri, dan mempunyai penghayatan yang baik terhadap amalan yang diajar di dalam kelas.” Informan 4 mengatakan bahawa pelajar perlu memahami dan menghayati pengetahuan yang diajar sehingga mereka dapat menghargai hubungan rapat mereka dengan Tuhan.

Analisis

Analisis ialah elemen yang sudah ada dalam taksonomi kognitif Bloom. Bagaimanapun, informan 1 dan 5 mengatakan bahawa elemen ini juga perlu dimasukkan dalam taksonomi kognitif pendidikan Islam. Sebagai contoh, informan 1 berkata, *"Apabila seseorang boleh mencapai tahap analisis kognitif, mereka boleh melihat setiap situasi yang mereka hadapi dengan cara yang positif."*

Bersyukur

Unsur kesyukuran dicadangkan sebagai taksonomi kognitif tertinggi oleh informan 1. Informan 1 menyatakan bahawa *"Bersyukur ialah tahap tertinggi dalam taksonomi kognitif yang boleh dicapai oleh seseorang dalam pendidikan Islam. Kami mahu membina generasi pelajar yang boleh menjadi hamba Allah yang bersyukur."*

Kebiasaan

Elemen ini telah dinyatakan oleh dua orang informan, masing-masing informan 1 dan 2. Kedua-dua informan menyatakan bahawa kebolehan seseorang untuk menjadikan ilmu sebagai tabiat dianggap berada pada tahap kognitif yang tinggi. Informan 1 mendefinisikan pelaziman sebagai *"Kebiasaan ialah sebarang tindakan yang dilakukan sebagai rutin harian dan boleh dikongsi dan disebarkan kepada orang lain."* Manakala Informan 2 pula mentakrifkannya sebagai *"pebiasaan yang mencapai tahap seseorang itu boleh dicontohi oleh orang lain di sekelilingnya."* Daripada kedua-dua input tersebut, pelaziman memerlukan seseorang untuk menjadikan ilmu sebagai tindakan yang dilakukan sebagai rutin harian dan boleh dicontohi oleh orang sekeliling kita.

Keikhlasan

Keikhlasan juga merupakan salah satu elemen yang dianggap mempunyai tahap kognitif yang tinggi dalam membina taksonomi kognitif bagi pendidikan Islam, menurut dua orang informan. Informan 2 malah menyatakan bahawa unsur ini lebih tinggi tahap kognitifnya daripada pelaziman. Informan 2 menyifatkan keikhlasan sebagai elemen dari aspek kognitif, seperti yang dinyatakan, *"Ikhlas adalah titik di mana seseorang tidak perlu dipaksa untuk melakukan ibadah."* Sementara itu, informan 4 menyifatkannya sebagai, *"Kami mahu para pelajar menzhahirkan ilmu itu menjadi tabiat praktikal dalam kehidupan yang dilakukan dengan ikhlas kerana Tuhan."*

Melaksanakan

Implementasi merupakan elemen yang disarankan oleh tiga orang informan dalam membangunkan taksonomi kognitif untuk pendidikan Islam. Penekanan kepada elemen ini adalah yang membezakan prinsip Islam daripada Taksonomi Bloom. Ini kerana matlamat Pendidikan Islam, menurut informan 3, adalah untuk dilaksanakan dan diamalkan dalam kehidupan, bukan hanya untuk peperiksaan. Informan 3 menekankan perkara ini sebagai alasan untuk memberi tumpuan kepada pelaksanaan ilmu dalam kehidupan pelajar sebagai penilaian prestasi. Informan 4 menyatakan bahawa pelaksanaan boleh dinilai terutama dalam topik-topik berkenaan ibadah kepada Allah, contohnya solat lima waktu, puasa, bersedekah, dan membaca al-Quran

Konsisten

Konsisten disarankan oleh dua orang informan sebagai elemen dalam membina taksonomi kognitif untuk pendidikan Islam. Menurut informan 4, pelajar perlu menzahirkan nilai yang dipelajari dalam kehidupan seharian secara konsisten dan bersopan santun. Manakala informan 3 pula menganggap elemen ini merupakan tahap kognitif yang tinggi untuk dicapai oleh pelajar. Ini kerana, menurut informan 3, pendidikan Islam bukan sahaja mahu membentuk pelajar yang hanya memahami Islam tetapi juga mereka yang boleh mengamalkan Islam secara konsisten.

Merenung

Elemen ini telah dinyatakan oleh seorang informan sahaja iaitu informan 3. Informan menyatakan bahawa *“Muhasabah adalah penting kepada pelajar kerana kita tidak mahu pelajar hanya menghafal fakta tentang topik, tetapi kita mahu topik yang telah diajar. untuk menjadi pengajaran dalam hidup, dan ini boleh dicapai melalui refleksi saya yang menggalakkan.”*

Kesimpulan

Model McArdle (1998) antara salah satu model analisis keperluan yang menggariskan empat prosedur iaitu pengawasan (*surveillance*), penyiasatan (*investigation*), analisis (*analysis*) dan laporan (*report*). Bagi setiap fasa yang berikut pula terdapat aktivitinya yang tertentu yang perlu dipatuhi bagi membolehkan data yang diperolehi adalah bermakna. Analisis keperluan yang dijalankan adalah melibatkan sesi temu bual separa berstruktur bersama empat orang informan yang dipilih secara persampelan bertujuan untuk meneroka tentang keperluan kepada taksonomi kognitif Islam.

Antara dapatan yang diperolehi boleh dibahagiakan kepada tiga bahagian iaitu Bahagian A memfokuskan kepada cabaran yang dihadapi oleh guru dalam menjalankan sesi pengajaran dan pembelajaran dalam pendidikan Islam. Antara cabaran yang dihadapi ialah kekurangan adab (nilai) dalam Taksonomi Bloom, Taksonomi Bloom tidak sesuai dengan budaya Islam dan tidak setara dengan isi Dokumen Standard Kurikulum dan Pentaksiran (DSKP). kekurangan memahami isi pelajaran, kekurangan masa, kekurangan kemahiran penghakiman personal dan kekurangan penilaian berterusan.



Bahagian B membincangkan faktor untuk membangunkan domain kognitif Islam. Majoriti informan menyatakan akan keperluan pembangunan ini untuk pemahaman dan kegunaan yang lebih berkesan untuk guru-guru. Bahagian C mendapati beberapa elemen yang diperlukan untuk dimasukkan ke dalam domain kognitif Islam. Antaranya ialah menginternalisasi, analisis, bersyukur, kebiasaan, melaksanakan, konsisten dan merenung. Daripada cabaran, faktor dan elemen yang diperlukan ini diharapkan dapat memberi gambaran atau senario aplikasi taksonomi Bloom dalam sistem pendidikan di Malaysia.

TAFSIR PSIKOSPIRITUAL TERHADAP SURAH AD-DUHA DAN TERAPI UNTUK KELESUAN EMOSI: SATU ANALISIS KRITIKAL

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Abstrak: Artikel ini mengkaji Surah ad-Duha dari perspektif tafsir psikospiritual dan potensinya sebagai terapi kelesuan emosi. Dalam konteks cabaran psikologi moden, terutama dalam kalangan individu yang mengalami tekanan jiwa, kemurungan ringan, dan kehilangan motivasi hidup, pendekatan al-Qur'an sebagai sumber penyembuhan rohani dan emosi semakin relevan. Surah ad-Duha diturunkan kepada Nabi Muhammad SAW pada saat baginda berasa sedih dan resah, menjadikannya satu rujukan penting dalam memahami sokongan Ilahi terhadap kesedihan manusia. Kajian ini menggunakan pendekatan tafsir tematik dan analisis psikospiritual berdasarkan pendekatan ulama klasik dan kontemporari. Hasil kajian mendapati bahawa Surah ad-Duha mengandungi prinsip keseimbangan emosi, harapan, dan pemulihan spiritual yang boleh diaplikasikan dalam bentuk intervensi terapi.

Kata Kunci: Surah Ad-Duha, Tafsir Psikospiritual, Kelesuan Emosi, Terapi Al-Qur'an, Pemulihan Rohani

Pengenalan

Kelesuan emosi (emotional exhaustion) merupakan satu fenomena yang semakin kerap berlaku dalam kalangan masyarakat moden. Ia merujuk kepada keadaan keletihan psikologi dan emosi yang berpunca daripada tekanan hidup yang berpanjangan, konflik dalaman, beban kerja yang berlebihan, dan kehilangan tujuan hidup (Maslach, Schaufeli, & Leiter, 2001; Shirom, 2003). Individu yang mengalami kelesuan emosi sering menunjukkan simptom seperti hilang motivasi, rasa tidak berdaya, perasaan sunyi yang mendalam, mudah berputus asa, dan mengalami kekosongan spiritual. Dalam konteks ini, fenomena ini bukan sahaja mempengaruhi keupayaan seseorang untuk berfungsi secara sosial dan profesional, malah boleh mengundang kepada penyakit mental yang lebih serius seperti kemurungan, gangguan kebimbangan, dan dalam kes yang ekstrem, keinginan untuk menamatkan hidup.

Dalam usaha mencari penyelesaian kepada permasalahan ini, pelbagai pendekatan psikoterapi moden telah diperkenalkan termasuklah terapi tingkah laku kognitif (CBT), terapi berasaskan kesedaran (mindfulness), dan kaunseling sokongan. Namun begitu, pendekatan-pendekatan ini kadangkala tidak mencukupi atau tidak berakar pada kepercayaan spiritual yang dianuti oleh seseorang individu (Koenig, 2009; Pearce, 2016). Dalam hal ini, pendekatan Islam yang bersumberkan al-Qur'an menawarkan dimensi alternatif yang lebih menyeluruh, iaitu bukan sahaja merawat gejala luaran tetapi juga menyentuh aspek rohani dan batin manusia.

Al-Qur'an dalam kerangka Islam bukan sekadar sebuah kitab perundangan atau panduan akhlak, tetapi juga berfungsi sebagai shifa', iaitu penyembuh kepada penyakit dalaman manusia. Allah SWT berfirman:

"وُنَزِّلُ مِنَ الْقُرْآنِ مَا هُوَ شِفَاءٌ وَرَحْمَةٌ لِّلْمُؤْمِنِينَ"

"Dan Kami turunkan daripada al-Qur'an sesuatu yang menjadi penawar dan rahmat bagi orang-orang yang beriman." (Surah al-Isra', 17:82)

Ayat ini menegaskan bahawa kandungan al-Qur'an berupaya merawat kelukaan jiwa dan memperkukuh kestabilan emosi, sekali gus menjadi terapi bagi mereka yang sedang berdepan dengan kelelahan spiritual (Badri, 2000; al-Ghazali, 2005).

Surah ad-Duha merupakan salah satu surah dalam al-Qur'an yang sangat signifikan dalam konteks pemulihan emosi dan psikospiritual. Ia diturunkan kepada Nabi Muhammad SAW setelah satu tempoh ketiadaan wahyu yang dikenali sebagai fathrah al-wahy, yang mana Baginda SAW mengalami tekanan perasaan yang amat mendalam dan hampir merasa dirinya ditinggalkan oleh Allah SWT (Ibn Kathir, 2000; Badri, 2000; al-Sabuni, 1981). Situasi ini merupakan manifestasi jelas kelesuan emosi yang dialami oleh seorang individu yang sangat dekat dengan Allah, yang kini merasakan kekosongan batin dan kegelisahan dalaman.

Namun, melalui Surah ad-Duha, Allah SWT memberikan respons yang sangat lembut, penuh kasih sayang dan motivasi psikospiritual. Wahyu ini bukan sahaja bertujuan untuk meyakinkan Rasulullah SAW bahawa Allah tidak meninggalkannya, bahkan menjadi sumber terapi untuk menyembuhkan luka batin Baginda. Frasa-frasa seperti:

"مَا وَدَّعَكَ رَبُّكَ وَمَا قَلَىٰ"

"Tuhanmu tidak meninggalkanmu dan tidak membencimu."
(Surah ad-Duha, ayat 3)

"وَلَا آخِرُهُ خَيْرٌ لَّكَ مِنَ الْأُولَىٰ"

"Dan sesungguhnya akhirat itu lebih baik bagimu daripada dunia."
(Surah ad-Duha, ayat 4)

...merupakan ayat-ayat yang mengandungi unsur penguatan semangat, harapan masa depan yang lebih baik, dan jaminan kasih sayang Ilahi yang abadi. Surah ini memperlihatkan satu bentuk terapi Qurani yang berasaskan pendekatan kasih sayang, harapan dan pemulihan spiritual.

Dalam tradisi tafsir, Surah ad-Duha sering kali dibincangkan dari sudut sejarah penurunannya dan signifikansi wahyu dalam menyokong perjuangan Nabi SAW (al-Ṭabarī, 2001; Ibn Kathīr, 2000; al-Qurṭubī, 1967). Namun, pendekatan tafsir psikospiritual membolehkan kita memahami kandungan ayat-ayat tersebut dari perspektif pemulihan jiwa, kestabilan emosi dan penguatan rohani. Ia bukan hanya untuk Rasulullah SAW, tetapi juga sebagai sumber inspirasi dan terapi kepada umat Islam yang berdepan dengan tekanan emosi dalam kehidupan seharian. Oleh yang demikian, makalah ini akan memberikan tumpuan kepada analisis kritikal terhadap tafsir Surah ad-Duha dalam kerangka psikospiritual. Ia akan menggabungkan pendekatan tafsir klasik dan kontemporari, disertai dengan kerangka psikologi Islam serta konsep terapi Qurani. Fokus utamanya ialah menilai sejauh mana mesej dalam surah ini dapat diaplikasikan sebagai bentuk rawatan atau terapi bagi individu yang mengalami kelesuan emosi, terutamanya dalam konteks realiti kehidupan moden hari ini.

Sorotan Literatur

Sorotan literatur berperanan penting dalam mengenal pasti perkembangan wacana ilmu yang berkaitan dengan topik kajian, serta memperlihatkan jurang ilmiah (research gap) yang ingin ditangani oleh kajian ini. Dalam konteks kajian ini, dua pendekatan utama tafsir menjadi kerangka perbandingan: pendekatan tafsir klasik yang bersifat literal dan tekstual, serta pendekatan kontemporari yang meneliti dimensi psikospiritual dan aplikasi terapeutik ayat-ayat al-Qur'an.

Tafsir Klasik: Fokus pada Makna Literal dan Asbab al-Nuzul

Karya-karya tafsir klasik seperti Jāmi' al-Bayān oleh al-Ṭabarī, al-Jāmi' li Aḥkām al-Qur'ān oleh al-Qurṭubī, dan Tafsīr al-Qur'ān al-'Aẓīm oleh Ibn Kathīr merupakan antara rujukan utama ulama terdahulu dalam memahami Surah ad-Duha. Ketiga-tiga mufassir ini menekankan aspek asbāb al-nuzūl dan makna lafziyah (literal) dalam mentafsirkan ayat-ayat.

Sebagai contoh, al-Ṭabarī (w. 310H) menyatakan bahawa Surah ad-Duha diturunkan sebagai tahqiq terhadap kegelisahan yang melanda jiwa Nabi SAW selepas fatrah wahyu. Al-Qurṭubī pula membincangkan konteks sosial dan tanggapan masyarakat Quraisy terhadap Nabi SAW semasa ketiadaan wahyu, dengan memberi tumpuan kepada penguatan ketuhanan (rubūbiyyah) dan janji Ilahi. Ibn Kathīr dalam tafsirnya turut memberi penekanan kepada hubungan surah ini dengan kasih sayang Allah SWT serta penegasan bahawa wahyu tidak pernah terputus secara mutlak daripada Rasulullah SAW.

Namun, meskipun tafsir klasik ini kaya dengan penjelasan linguistik, sejarah dan hukum, ia kurang menekankan dimensi emosi dan psikologi manusia dalam pengalaman menerima wahyu, terutama dalam konteks kesihatan mental dan pemulihan spiritual.

Tafsir Kontemporari: Pendekatan Psikospiritual dan Terapi Jiwa

Sebaliknya, tafsir kontemporari memperlihatkan anjakan paradigma dengan menekankan pengaruh psikospiritual ayat-ayat al-Qur'an terhadap pembentukan jiwa, ketenangan batin dan terapi emosi. Antara tokoh terkemuka yang mengembangkan pendekatan ini ialah:

- **Prof. Malik Badri** (2000), dalam karyanya *Contemplation: An Islamic Psychospiritual Study*, mengupas konsep tafakkur dan tadabbur terhadap ayat-ayat al-Qur'an sebagai medium rawatan psikologi yang berkesan. Beliau mengaitkan Surah ad-Duha sebagai contoh bagaimana wahyu mampu menenteramkan hati Nabi SAW ketika kegelisahan spiritual memuncak.
- **Abdullah Nasih 'Ulwan** (2001) dalam kitabnya *Tarbiyat al-Awlad fi al-Islam*, menjelaskan bahawa Surah ad-Duha membentuk asas kepada pendidikan ruhani, dengan menanamkan nilai keyakinan, optimisme, dan kebergantungan kepada Allah SWT dalam menghadapi cabaran emosi.
- **Said Hawwa** (2000), dalam *al-Asas fi al-Tafsir*, menekankan dimensi tarbawi dan tazkiyah dalam Surah ad-Duha. Menurutnya, ayat-ayat dalam surah ini mengandungi pendekatan pendidikan hati melalui bahasa kasih sayang Tuhan, suatu ciri penting dalam psikoterapi Islam.

Tafsiran kontemporari ini membuka ruang yang lebih luas untuk memahami fungsi Qurani sebagai terapi kepada keresahan dan kelelahan emosi. Ia juga menggabungkan pendekatan hermeneutik, psikologi Islam, dan kajian empirikal yang memberikan dimensi baharu kepada wacana tafsir.

Penyelidikan Empirik Terkini: Kesahihan Kesan Terapi al-Qur'an

Kajian empirikal yang dijalankan oleh Haque & Badri (2020) mendapati bahawa pendekatan psikoterapi berasaskan al-Qur'an memberikan impak positif terhadap pengurangan gejala kemurungan, kecemasan, dan kelelahan emosi dalam kalangan pesakit Muslim. Melalui metodologi kuantitatif dan kualitatif, kajian mereka membuktikan bahawa amalan tadabbur dan pembacaan surah tertentu, termasuk Surah ad-Duha, meningkatkan keseimbangan emosi dan ketenangan jiwa.

Dalam kajian lain, Bouhdiba (2009) dalam *Humanism in Islam*, menegaskan bahawa al-Qur'an ialah sumber utama penyembuhan holistik dalam tradisi Islam, bukan hanya dari sudut akidah, tetapi juga psikologi dan sosial. Beliau merujuk kepada Surah ad-Duha sebagai simbol pemulihan spiritual yang mengandungi mesej kelembutan Ilahi dan jaminan masa depan yang lebih baik, sesuai dengan prinsip terapi naratif dalam psikologi moden.

Analisis Kesimpulan Literatur

Sorotan literatur menunjukkan bahawa terdapat perbezaan pendekatan antara tafsir klasik dan kontemporari dalam memahami Surah ad-Duha. Pendekatan klasik lebih menekankan teks, konteks, dan makna literal, manakala pendekatan kontemporari menekankan aspek pengalaman dalaman, emosi dan kesan penyembuhan ayat.

Kajian ini memilih untuk mengintegrasikan kedua-dua pendekatan ini dalam satu analisis kritikal bagi mengenal pasti potensi fungsi terapi psikospiritual Surah ad-Duha secara holistik. Ini bukan sahaja menambah nilai kepada wacana tafsir semasa, tetapi juga memperkukuh lagi hubungan antara ilmu tafsir dengan disiplin psikologi Islam dalam menangani isu semasa seperti kelesuan emosi.

Metodologi

Bagi memastikan kajian ini mencapai objektifnya dalam memahami dan menilai peranan Surah ad-Duha sebagai bentuk terapi psikospiritual terhadap kelesuan emosi, pendekatan metodologi yang sistematik dan bersifat disiplin telah digunakan. Kajian ini menggabungkan pendekatan tafsir tematik (tafsir maudhu'i) dan analisis psikospiritual, berserta analisis isi kandungan terhadap teks-teks tafsir literatur dan psikologi Islam yang relevan.

Pendekatan Tafsir Maudhu'i (Tematik)

Pendekatan tafsir maudhu'i dipilih kerana ia memberi ruang kepada kajian untuk menelusuri tema tertentu dalam al-Qur'an secara mendalam, dalam kes ini, tema pemulihan emosi dan kesejahteraan psikospiritual melalui Surah ad-Duha. Kaedah tafsir ini berbeza daripada tafsir tahlili (analitis) yang membincangkan ayat secara urutan, sebaliknya ia menyusun dan menghubungkan ayat berdasarkan tema yang dipilih.

Tafsiran surah dilakukan dengan berpedoman:

- **Asbab al-nuzul (sebab penurunan)** sebagai latar sejarah dan psikologi wahyu,
- **Struktur surah dan gaya bahasa** sebagai unsur naratif dan simbolik,
- **Hubungan antara ayat** dalam membina mesej keseluruhan,
- **Tafsiran klasik dan kontemporari** sebagai sumber triangulasi perspektif.

Dengan kaedah ini, Surah ad-Duha tidak hanya dilihat dalam konteks teks semata-mata, tetapi juga sebagai satu unit naratif yang menyampaikan mesej penyembuhan rohani, pemulihan harga diri, dan keyakinan terhadap masa depan.

Analisis Psikospiritual

Pendekatan ini berpaksikan gabungan prinsip psikologi Islam dan kerohanian Islam dalam menganalisis kandungan ayat. Analisis ini mengambil kira dimensi emosi, jiwa, dan pengalaman batin dalam memahami kesan ayat-ayat terhadap kesejahteraan psikologi. Aspek yang dianalisis termasuk:

- **Kesan emosi daripada setiap ayat**, seperti rasa dikasihi, diberi harapan, dan dihargai.
- **Simbolisme dan metafora Qurani** yang merawat luka batin.
- **Dialog Ilahi** sebagai terapi komunikasi antara Tuhan dan insan.

Analisis ini mengambil inspirasi daripada kerangka pemikiran tokoh seperti Malik Badri, yang menekankan bahawa al-Qur'an mempunyai mesej psikoterapeutik yang halus, yang mampu menyentuh lapisan terdalam dalam jiwa manusia jika ditadabburi secara mendalam.

Sumber Data dan Teknik Pengumpulan

Kajian ini menggunakan data kualitatif yang dikumpulkan daripada dua sumber utama:

1. **Teks Surah ad-Duha** sebagai sumber utama.
2. **Tafsir klasik dan kontemporari** seperti:
 - *Tafsir al-Ṭabarī*, *Tafsir Ibn Kathīr*, *al-Qurṭubī* (klasik),
 - *Tafsir Fi Zilal al-Qur'an* (Sayyid Qutb), *al-Asas fi al-Tafsir* (Said Hawwa), dan karya *Malik Badri* (kontemporari).
3. **Literatur psikologi Islam**, khususnya berkaitan:
 - Terapi kerohanian dan emosi dalam Islam,
 - Kelesuan emosi dari perspektif psikologi kontemporari,
 - Hubungan antara wahyu, tadabbur dan kesihatan mental.

Setiap tafsir dan rujukan dinilai secara kritikal bagi mengenal pasti mesej yang bersifat psikospiritual dan terapeutik.

Teknik Analisis

Teknik analisis kandungan (content analysis) digunakan untuk mengenal pasti, mengkategorikan dan mentafsir mesej-mesej utama dalam Surah ad-Duha yang berkaitan dengan pemulihan emosi. Beberapa aspek yang dinilai termasuk:

- **Mesej eksplisit dan implisit** ayat terhadap jiwa yang keletihan.
- **Perubahan ton suara wahyu** – dari kelembutan kepada penguatan dan motivasi.
- **Perbandingan antara makna literal dengan kesan psikospiritual.**

Seterusnya, analisis kritikal turut digunakan untuk mengkaji keberkesanan ayat-ayat tersebut sebagai satu bentuk terapi Qurani, dengan mempertimbangkan konteks kehidupan moden yang mencabar kestabilan emosi manusia.

Validasi Data dan Perspektif Triangulasi

Bagi meningkatkan ketepatan dan kebolehpercayaan kajian, pendekatan triangulasi sumber digunakan dengan menggabungkan pelbagai jenis tafsir, wacana psikologi dan penulisan ilmiah kontemporari. Ini membantu memastikan bahawa analisis yang dilakukan tidak bersifat sepihak atau terlalu literal, sebaliknya mengambil kira pelbagai perspektif dan lapisan makna yang terkandung dalam Surah ad-Duha.

Kesimpulan Metodologi

Gabungan pendekatan tafsir maudhu'i dan analisis psikospiritual memberikan kerangka kukuh untuk memahami Surah ad-Duha secara menyeluruh dan mendalam. Melalui metodologi ini, kajian ini mampu menilai secara kritikal mesej ayat-ayat suci sebagai rawatan terhadap kelesuan emosi, serta membuka ruang kepada penggunaan wahyu sebagai alternatif dalam psikoterapi Islam yang berpaksikan nilai-nilai kerohanian dan kemanusiaan.

Analisis Psikospiritual Surah ad-Duha

Surah ad-Duha yang terdiri daripada sebelas ayat pendek bukan sahaja merupakan respon terhadap kegelisahan yang dialami oleh Rasulullah SAW selepas fathrah wahyu, tetapi juga menjadi model wahyu pemulihan yang penuh kelembutan dan penguatan (Ibn Kathir, 2000; al-Sabuni, 1981; Badri, 2000). Ia mengandungi mesej-mesej yang berfungsi sebagai terapi psikospiritual secara bertahap—bermula dengan pengakuan kasih sayang Ilahi, pemulihan harga diri, pengingatan terhadap nikmat, dan akhirnya dorongan kepada amal kebajikan sebagai terapi sosial.

Ayat 1–2: Simbol Harapan dan Pemulihan

وَالضُّحَى • وَاللَّيْلِ إِذَا سَجَى

“Demi waktu dhuha. Dan demi malam apabila sunyi sepi.”
(Surah ad-Duha, ayat 1–2)

Ayat ini dibuka dengan dua sumpah Ilahi, iaitu waktu dhuha dan malam yang sunyi. Dalam tradisi tafsir klasik, sumpah ini ditafsirkan sebagai bukti keagungan ciptaan Allah dan kitaran alam semula jadi. Namun, dari sudut psikospiritual, ia menyampaikan konsep dualiti

kehidupan: terang dan gelap, harapan dan kekeliruan, aktif dan pasif (al-Qurṭubī, 1967; Ibn Kathīr, 2000; Badri, 2000).

- **Waktu dhuha**, yang menggambarkan cahaya pagi, membawa simbol kebangkitan, harapan, dan permulaan baharu. Dalam psikologi positif, cahaya sering dikaitkan dengan energi mental dan motivasi.
- **Malam yang sunyi**, sebaliknya, membawa konotasi kesedihan, kehampaan, dan kerohanian yang kelim, sebagaimana yang dialami oleh Rasulullah SAW dalam tempoh fatrah wahyu.

Namun, penting untuk diperhatikan bahawa Allah SWT bersumpah kepada kedua-dua fasa, menunjukkan bahawa kedua-duanya adalah ciptaan Ilahi dan memiliki nilai tersendiri. Ini memberi mesej psikospiritual yang sangat penting: fasa kegelapan bukan penolakan, tetapi ruang refleksi dan persiapan untuk cahaya.

Ayat 3–5: Pemulihan Keyakinan Diri

مَا وَدَّعَكَ رَبُّكَ وَمَا قَلَىٰ • وَلَآ خِرَةُ خَيْرٌ لَّكَ مِنَ الْأُولَىٰ • وَلَسَوْفَ يُعْطِيكَ رَبُّكَ فَتَرْضَىٰ

“Tuhanmu tidak pernah meninggalkanmu dan tidak pula membencimu. Dan sesungguhnya akhirat itu lebih baik bagimu daripada kehidupan yang permulaan (di dunia). Dan kelak, Tuhanmu pasti akan memberikan kepadamu (nikmat dan kurnia-Nya) sehingga engkau menjadi redha.”

(Surah ad-Duḥā, ayat 3–5)

Ayat ini menyentuh titik paling kritikal dalam kelesuan emosi: perasaan ditinggalkan dan tidak dihargai. Rasulullah SAW dalam kesunyian fatrah wahyu telah dilanda keraguan dalaman, yang diburukkan lagi oleh cercaan musuh-musuh Baginda.

- **"Tuhanmu tidak meninggalkanmu dan tidak membencimu"** merupakan satu deklarasi pemulihan spiritual yang sangat mendalam. Allah bukan sahaja menolak persepsi negatif Baginda, tetapi juga mengangkat kembali harga dirinya. Dalam psikologi, ini setara dengan terapi kognitif yang membetulkan distorsi pemikiran seperti “saya tidak disayangi” atau “Tuhan telah melupakan saya”.
- **“Dan sesungguhnya akhir itu lebih baik bagimu daripada permulaan”** adalah ayat yang mengalihkan fokus jiwa yang terluka kepada masa depan yang lebih baik. Ia adalah bentuk reframing psikologi, satu teknik untuk memberi sudut pandang baharu yang positif terhadap pengalaman pahit masa kini.
- Ayat terakhir dalam rangkaian ini, **"Dan kelak Tuhanmu pasti memberikan nikmat kepadamu sehingga engkau redha"**, adalah jaminan kasih sayang Ilahi yang bukan hanya menyembuhkan, bahkan menyuburkan harapan. Ia memberikan gambaran masa depan yang menyenangkan dan menjadi satu bentuk terapi harapan (hope therapy) dalam konteks keimanan.

Ayat 6–8: Refleksi dan Kesyukuran sebagai Penstabil Emosi

أَلَمْ يَجِدْكَ يَتِيمًا فَآوَىٰ • وَوَجَدَكَ ضَالًّا فَهَدَىٰ • وَوَجَدَكَ عَائِلًا فَأَغْنَىٰ

“Bukankah Dia telah mendapatimu sebagai seorang yatim lalu Dia melindungimu? Dan Dia mendapati engkau tidak mengetahui (petunjuk), lalu Dia memberi petunjuk. Dan Dia mendapati engkau dalam keadaan miskin, lalu Dia memberikan kecukupan.”
(Surah ad-Duḥā, ayat 6–8)

Dalam ayat ini, Allah SWT menyuruh Rasulullah SAW merenung kembali sejarah kehidupannya, dari seorang anak yatim kepada insan yang mendapat naungan, dari ketiadaan ilmu kepada mendapat hidayah, dan dari kefakiran kepada kecukupan. Ini adalah teknik yang sangat selari dengan terapi naratif, di mana individu dibimbing untuk melihat kembali kisah hidupnya dalam cahaya yang berbeza.

- Allah mengemukakan **tiga keadaan lemah dan terancam** yang pernah dialami Rasulullah SAW, dan dalam setiap satu, Allah hadir sebagai penyelamat. Ini membina rasa kesyukuran, pengiktirafan akan pertolongan Ilahi, dan peningkatan keyakinan bahawa bantuan itu tidak pernah terputus.
- Dalam konteks psikospiritual moden, ini adalah bentuk **penguatan identiti positif**: daripada menjadi mangsa takdir kepada menjadi insan yang dipimpin dan disayangi.
- Ayat ini juga mendorong kepada **mekanisme coping religius**, iaitu menenangkan diri melalui ingatan terhadap nikmat dan rahmat masa lalu.

Ayat 9–11: Amal Sosial sebagai Terapi Rohani

فَأَمَّا الْيَتِيمَ فَلَا تَقْهَرْ • وَأَمَّا السَّائِلَ فَلَا تَنْهَرْ • وَأَمَّا بِنِعْمَةِ رَبِّكَ فَحَدِّثْ

“Maka terhadap anak yatim, janganlah engkau berlaku kasar. Dan terhadap orang yang meminta (bantuan), janganlah engkau mengherdik. Dan adapun nikmat Tuhanmu, maka nyatakanlah (dengan bersyukur dan menyebarkannya).”
(Surah ad-Duḥā, ayat 9–11)

Ayat-ayat penutup ini beralih daripada terapi dalaman kepada aksi sosial dan amal kebajikan. Ia menunjukkan bahawa pemulihan emosi dan spiritual tidak lengkap tanpa tindakan positif yang keluar dari diri ke arah masyarakat.

- **Larangan mengherdik anak yatim dan menolak peminta** ialah arahan yang membentuk empati sosial. Dalam terapi Islam, amal soleh dilihat sebagai mekanisme penyembuhan dalaman. Ia mengembalikan makna hidup melalui tindakan memberi, bukan hanya menerima.
- Perintah untuk **menyebut nikmat Tuhan** ialah bentuk **terapi afirmasi positif**, yang mana individu disaran untuk sentiasa mengiktiraf dan menyatakan kebaikan dalam hidup. Dalam psikologi, ini membantu membina self-worth dan keseimbangan afektif.
- Secara keseluruhan, ayat-ayat ini mendorong individu yang mengalami tekanan batin untuk **keluar dari kesedihan melalui amal dan penglibatan sosial**, suatu pendekatan yang terbukti berkesan dalam terapi logoterapi oleh Viktor Frankl dan terapi spiritual Islam.

Kesimpulan Analisis Psikospiritual

Keseluruhan Surah ad-Duha ialah satu struktur terapi berasaskan wahyu yang lengkap: bermula dengan penerimaan emosi, diikuti dengan pemulihan kognitif dan spiritual, diakhiri dengan tindakan sosial sebagai pemaknaan hidup. Ia menunjukkan bahawa al-Qur'an bukan sahaja memberi panduan akidah dan hukum, tetapi juga merupakan manual penyembuhan jiwa yang sangat mendalam dan relevan, khususnya untuk mereka yang mengalami kelesuan emosi.

Analisis Kritikal

Kajian terhadap Surah ad-Duha dalam kerangka psikospiritual menunjukkan bahawa ayat-ayat suci al-Qur'an bukan sahaja berfungsi sebagai sumber petunjuk dan nilai-nilai akhlak, bahkan juga sebagai terapi emosi dan pemulihan jiwa bagi mereka yang mengalami kelesuan emosi dan tekanan hidup. Namun begitu, untuk menjadikan Surah ad-Duha sebagai modul intervensi psikospiritual yang berkesan, satu penilaian kritikal perlu dibuat terhadap kekuatan serta cabaran dan kelemahan yang perlu diatasi.

Kekuatan Surah ad-Duha dalam Konteks Terapi Psikospiritual

1. Struktur Terapi Emosi yang Komprehensif

Surah ad-Duha menawarkan satu susunan ayat yang bersifat terapeutik secara bertahap, yang bermula dengan pendekatan penenangan jiwa, pemulihan harga diri, pengingatan terhadap sejarah peribadi, dan akhirnya dorongan untuk beramal. Ini sejajar dengan prinsip terapi psikologi yang progresif, bermula dari penerimaan, penyembuhan, hingga kepada tindakan. Dari segi psikoterapi Islam, struktur ini menepati prinsip tazkiyat al-nafs iaitu proses menyucikan jiwa melalui kesedaran dan penyerahan kepada Allah.

2. Sentuhan Terus kepada Dimensi Spiritual dan Eksistensial

Salah satu kekuatan utama surah ini ialah keupayaannya menyentuh dimensi spiritual dan eksistensial manusia secara mendalam. Ayat-ayat seperti "Tuhanmu tidak meninggalkanmu..." dan "Dan sesungguhnya akhirat itu lebih baik bagimu..." memberikan pengukuhan makna hidup, keyakinan kepada masa depan dan pengharapan yang berasaskan tauhid. Dalam konteks psikologi eksistensial, ia membantu individu membina semula makna kewujudan dan menangani krisis diri.

3. Potensi Sebagai Modul Intervensi Psikospiritual

Surah ad-Duha berpotensi besar untuk dikembangkan sebagai modul psikoterapi Islam yang boleh digunakan oleh para kaunselor, pendidik dan pendakwah, khususnya bagi membantu individu yang mengalami keletihan emosi, kemurungan ringan atau kehilangan motivasi. Modul ini boleh dimasukkan dalam program pembangunan sahsiah, bimbingan kaunseling Islam, atau terapi kelompok berdasarkan pendekatan tadabbur Qurani.

Kelemahan dan Cabaran Pelaksanaan

1. Keperluan Bimbingan Khusus untuk Terjemahan Praktikal

Walaupun mesej dalam Surah ad-Duha sangat relevan secara psikospiritual, ia tidak dapat difahami secara terapeutik tanpa bimbingan dan kefahaman tafsir yang mendalam. Terdapat risiko kesalahfahaman jika ayat ditafsir secara literal tanpa mempertimbangkan konteks

psikologi dan pengalaman spiritual seseorang. Oleh itu, ia menuntut kewujudan pakar dalam kedua-dua bidang: tafsir dan psikologi.

2. Kepentingan Integrasi dengan Terapi Moden

Untuk menjadikan pendekatan ini lebih holistik dan efektif, ia perlu diintegrasikan dengan pendekatan terapi moden seperti Cognitive Behavioural Therapy (CBT), terapi naratif, atau logoterapi. Integrasi ini membolehkan kaunselor menggunakan kerangka Qurani seperti Surah ad-Duha dalam sesi rawatan sambil masih berlandaskan metodologi sains psikologi semasa. Tanpa integrasi ini, mesej surah mungkin kekal dalam ruang spiritual semata-mata dan kurang kesan terhadap rawatan gangguan klinikal yang kompleks.

3. Keterbatasan Penyelidikan Empirik

Salah satu kekangan utama ialah kekurangan kajian lapangan dan bukti empirikal yang menilai keberkesanan Surah ad-Duha sebagai modul terapi. Walaupun kajian teoretikal dan sorotan tafsir menyokong keberkesanannya, namun tanpa data kualitatif atau kuantitatif daripada responden sebenar (klien, pelajar, pesakit), nilai terapinya sukar disahkan secara ilmiah. Maka, penyelidikan lanjutan diperlukan untuk menguji aplikasi surah ini dalam konteks rawatan sebenar.

Kesimpulan Analisis Kritikal

Secara keseluruhannya, Surah ad-Duha menunjukkan potensi luar biasa sebagai alat terapi psikospiritual dalam menangani kelesuan emosi. Ia mengandungi mesej penguatan diri, ketenangan batin, dan pengaktifan nilai sosial sebagai asas kesejahteraan mental. Walau bagaimanapun, kekuatan tersebut hanya akan dapat dimanfaatkan sepenuhnya jika diterjemahkan dengan bimbingan yang tepat, pendekatan integratif, dan disokong oleh kajian empirikal. Kajian ini mencadangkan agar Surah ad-Duha dikembangkan sebagai modul intervensi Islamik secara sistematik dan saintifik agar ia bukan sahaja berfungsi secara rohani, tetapi juga menyumbang kepada pembangunan model terapi yang berasaskan wahyu.

Jadual 1: Kekuatan Surah ad-Duha dalam Konteks Terapi Psikospiritual dan Cabaran Pelaksanaannya

Kekuatan	Penjelasan
Struktur terapi emosi yang komprehensif	Mengandungi unsur penenangan, refleksi, dan motivasi secara bertahap.
Sentuhan kepada dimensi spiritual	Menjawab isu eksistensial seperti rasa ditinggalkan dan kehilangan makna hidup.
Potensi sebagai modul intervensi	Sesuai untuk guru, kaunselor, dan pendakwah dalam terapi psikospiritual.
Kelemahan & Cabaran	
Kelemahan & Cabaran	Penjelasan
Perlu bimbingan tafsir-terapi	Mesej al-Qur'an memerlukan pentafsir profesional untuk aplikasi terapi.
Perlu integrasi dengan terapi moden	Agar lebih efektif dan selari dengan pendekatan klinikal semasa.

Kurang kajian lapangan

Tiada bukti empirik kukuh yang
mengesahkan keberkesanan praktikalnya.

Rumusan dan Cadangan

Rumusan

Kajian ini telah mengetengahkan Surah ad-Duha sebagai satu unit wahyu yang sangat signifikan dalam konteks pemulihan psikospiritual, khususnya dalam menangani kelesuan emosi, tekanan jiwa, dan krisis eksistensial yang sering melanda manusia moden. Surah ini bukan sekadar ayat-ayat pujian dan peringatan, tetapi merupakan skrip terapi Ilahi yang turun pada saat Rasulullah SAW mengalami kekosongan batin dan kegelisahan spiritual akibat fatrah wahyu.

Melalui analisis tafsir tematik dan pendekatan psikospiritual, kajian ini membuktikan bahawa Surah ad-Duha mengandungi struktur terapi yang lengkap: bermula dengan penenangan emosi, disusuli dengan pemulihan harga diri, refleksi terhadap sejarah peribadi, dan akhirnya dorongan kepada amal kebajikan sebagai pemaknaan hidup. Prinsip-prinsip ini sejajar dengan pendekatan terapi moden seperti terapi kognitif, terapi naratif, dan logoterapi yang menekankan pemulihan makna, harapan, dan identiti diri (Badri, 2000; Corey, 2017; Frankl, 1985).

Lebih penting lagi, Surah ad-Duha memperlihatkan bahawa pemulihan spiritual adalah akar kepada keseimbangan emosi dan mental. Ia menampilkan Allah SWT sebagai penyembuh yang Maha Lembut, yang memulihkan insan bukan melalui hukuman, tetapi melalui kasih sayang, pengiktirafan, dan jaminan masa depan yang lebih baik. Oleh itu, wahyu ini sangat sesuai dijadikan modul intervensi psikospiritual dalam pelbagai bidang—termasuk pendidikan, kaunseling, pembangunan sahsiah, dan terapi Islam.

Namun, untuk memanfaatkan sepenuhnya potensi surah ini, perlu ada usaha sistematik untuk menterjemahkan mesej wahyu ke dalam pendekatan terapi yang praktikal dan saintifik, serta digabungkan dengan metodologi moden agar ia tidak kekal pada tahap spiritual semata-mata tetapi benar-benar membantu dari sudut kesihatan mental yang menyeluruh.

Cadangan Kajian Lanjut

Berdasarkan dapatan dan analisis yang telah dibuat, berikut merupakan beberapa cadangan yang boleh dikembangkan oleh penyelidik masa hadapan atau institusi berkaitan:

Cadangan Kajian	Penjelasan
1. Penilaian keberkesanan Surah ad-Duha dalam intervensi terapi Islamik	Satu kajian empirikal boleh dijalankan untuk menilai kesan penggunaan ayat-ayat Surah ad-Duha dalam sesi terapi kaunseling Islam. Kajian ini boleh melibatkan skala simptom emosi sebelum dan selepas intervensi.
2. Kajian lapangan bersama remaja dan pelajar IPT	Golongan remaja dan pelajar universiti sering terdedah kepada tekanan emosi. Surah ad-Duha boleh diuji sebagai bahan intervensi dalam program pembangunan

	sahsiah atau sesi bimbingan kelompok, untuk mengenal pasti perubahan tahap kesejahteraan psikospiritual.
3. Pembinaan modul terapi naratif Islam berasaskan Surah ad-Duha	Modul ini boleh dibina berasaskan pendekatan terapi naratif Qurani, di mana klien diajak untuk menyusun semula naratif hidup mereka dengan merujuk struktur pemulihan dalam Surah ad-Duha: dari kegelapan kepada cahaya, dari kegelisahan kepada ketenangan.
4. Latihan profesional kepada guru, kaunselor dan pendakwah	Latihan dan bengkel boleh dilaksanakan bagi melatih para guru pendidikan Islam, kaunselor dan pendakwah menggunakan Surah ad-Duha sebagai sumber bimbingan spiritual dan sokongan psikologi dalam persekitaran mereka.
5. Kajian perbandingan dengan pendekatan terapi Barat	Kajian ini juga boleh mengkaji persamaan dan perbezaan antara mesej Surah ad-Duha dengan prinsip-prinsip terapi Barat (seperti CBT dan logoterapi), bagi membina kerangka terapi hibrid Islam-Barat yang lebih berkesan dan diterima umum.

Kesimpulan Akhir

Surah ad-Duha adalah satu bentuk wahyu yang sangat mendalam dan penuh kasih sayang Ilahi. Ia bukan hanya untuk menghibur Rasulullah SAW, tetapi juga sebagai model pemulihan jiwa untuk umat Islam sepanjang zaman. Dengan pendekatan yang betul, ia mampu menjadi terapi Qurani yang saintifik dan menyentuh jiwa, serta membantu umat manusia keluar daripada kelesuan emosi menuju kehidupan yang lebih bermakna dan seimbang.

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PENGAPLIKASIAN REALITI TERIMBUH (AR) DALAM PENDIDIKAN ISLAM

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Abstrak: Kajian ini membincangkan pengaplikasian teknologi Realiti Terimbuh atau Realiti Tambahan (AR) dalam bidang Pendidikan Islam sebagai satu pendekatan inovatif bagi meningkatkan keberkesanan proses pengajaran dan pembelajaran. Teknologi AR menawarkan pengalaman pembelajaran yang imersif dan interaktif, yang dapat membantu pelajar memahami konsep-konsep abstrak dalam Islam seperti ibadah haji, sejarah Islam, dan sirah Nabawiyah secara lebih mendalam. Penulisan ini turut meninjau konsep AR, aplikasinya dalam konteks pendidikan Islam, serta penilaian terhadap kesesuaian penggunaannya menurut perspektif Islam berdasarkan prinsip maqasid syariah dan etika digital. Walau bagaimanapun, terdapat pelbagai cabaran dalam pelaksanaan teknologi ini termasuk kekurangan kemahiran guru, keterbatasan infrastruktur, kos tinggi, serta isu sensitiviti agama. Kajian ini mencadangkan agar pelaksanaan AR disokong oleh dasar yang jelas, latihan guru yang berterusan, dan kerjasama antara pakar teknologi dan ilmuwan Islam bagi memastikan keberkesanan serta kepatuhan syariah dalam penggunaannya. Secara keseluruhannya, pengaplikasian AR dalam Pendidikan Islam berpotensi menjadi medium PdP yang berkesan dan berdaya saing jika dilaksanakan secara terancang dan beretika.

Kata Kunci: Realiti Terimbuh, Pendidikan Islam, Maqasid Syariah, Etika Digital, Inovasi PdP

Pengenalan

Kementerian Pendidikan Malaysia (KPM) telah melaksanakan pelbagai inisiatif bagi melahirkan tenaga pengajar yang kompeten serta memastikan mereka kekal berkhidmat dalam sistem pendidikan negara. Hal ini berpunca daripada hakikat bahawa sektor pendidikan merupakan pemacu utama kepada pembangunan modal insan dan kemajuan sosioekonomi sesebuah negara. Sehubungan itu, menerusi pelaksanaan *Pelan Pembangunan Pendidikan Malaysia 2013–2025* (Kementerian Pendidikan Malaysia, 2012), pelbagai strategi dan kerangka pembangunan menyeluruh telah digubal bagi mencapai matlamat dan aspirasi pendidikan negara. Dalam kerangka ini, guru dan pemimpin sekolah dikenalpasti sebagai individu penting yang memainkan peranan utama dalam menjana kejayaan murid. Kualiti pendidikan yang tinggi amat bergantung kepada keupayaan guru dalam membina jati diri, mengasah kemahiran, serta menyemai nilai-nilai murni dalam kalangan generasi pelajar.

Peranan Teknologi Maklumat dan Komunikasi (TMK) atau *Information and Communication Technology (ICT)* dalam dunia pendidikan telah mendapat perhatian sejak sekian lama. Dengan peningkatan akses dan penggunaan ICT dalam kehidupan seharian, kemahiran menguasai

teknologi ini menjadi semakin penting dalam menghadapi cabaran semasa. Pengintegrasian ICT dalam proses Pengajaran dan Pembelajaran (PdP) telah dimulakan oleh Unit Komputer dalam Pendidikan di bawah Pusat Perkembangan Kurikulum, KPM. Teknologi ini digunakan bukan sahaja sebagai bahan bantu mengajar berbentuk tutorial dan penerokaan, malah sebagai medium komunikasi serta aplikasi interaktif.

Seiring dengan perkembangan teknologi, pendekatan dalam proses pembelajaran turut mengalami transformasi. Menurut Zain (2010), kemajuan teknologi mampu memperluas kaedah dan bentuk pembelajaran yang bersesuaian dengan keperluan pelajar. Jika dibandingkan dengan kaedah tradisional, pendekatan baharu yang berasaskan teknologi lebih fleksibel, interaktif, dan mampu meningkatkan keberkesanan pembelajaran. Namun demikian, kaedah tradisional tidak seharusnya diabaikan sepenuhnya kerana teknologi berperanan sebagai pelengkap kepada guru dan bukannya pengganti kepada proses pendidikan.

Pembelajaran merupakan proses penting bagi seseorang pelajar dalam memperoleh pengetahuan serta kemahiran, sama ada melalui pengalaman, latihan yang dilalui ataupun melalui pengajaran. Elizabeth et al. (2002) menyatakan bahawa bentuk pembelajaran tradisional yang masih banyak diamalkan oleh pelajar pada masa kini bersifat pasif. Kebanyakan pelajar menghabiskan waktu persekolahan mereka dengan hanya mendengar, menghafal maklumat daripada guru yang mengajar secara satu hala seperti kuliah atau ceramah, tanpa adanya interaksi aktif. Ini amat ketara dalam subjek Pendidikan Islam, di mana pelajar lebih cenderung menjadi pendengar pasif yang mencatat dan mengingat fakta tanpa terlibat secara langsung dalam aktiviti pembelajaran.

Pendekatan pembelajaran yang hanya menumpukan kepada guru sebagai pusat penyampaian ilmu ini perlu diberi nafas baharu. Sistem pengajaran yang lebih aktif dan melibatkan pelajar secara langsung sangat penting untuk memastikan mereka lebih fokus dan terlibat. Melalui pengajaran aktif, pelajar akan terdorong untuk mengaitkan pengetahuan sedia ada dengan ilmu baharu, sekali gus memperkukuh kefahaman mereka (Khoo, H.E., 2003). Kajian Barbara (2003) pula mendapati bahawa pendekatan pembelajaran berasaskan masalah mampu meningkatkan minat pelajar, menjadikan mereka lebih bersemangat untuk hadir ke kelas, menggalakkan kerjasama antara rakan sekelas, dan mempertingkatkan daya ingatan terhadap maklumat untuk tempoh yang panjang. Tambahan pula, pendekatan ini membantu pelajar mengembangkan maklumat yang diperolehi serta menyokong konsep pembelajaran sepanjang hayat.

Tambahan pula, kepesatan inovasi seperti kemudahan capaian internet, penggunaan telefon pintar, media sosial serta kecerdasan buatan telah membuka ruang kepada pelbagai bentuk pembelajaran digital yang bersifat adaptif dan tersuai mengikut keperluan semasa. Dalam konteks ini, teknologi komputer dapat disesuaikan kepada tiga komponen utama dalam pendidikan: sebagai alat pengurusan dan pentadbiran, alat sokongan penyelidikan, serta sebagai media penyampaian dalam pengajaran dan pembelajaran (V. Pang et al., 2011). Penggunaan teknologi secara menyeluruh bukan sahaja membantu meringankan tugas-tugas pengurusan malah turut memperkasa fungsi PdP agar lebih sistematik dan berkesan.

Penggunaan teknologi dalam sektor pendidikan kini merupakan suatu tuntutan penting dalam memenuhi keperluan masyarakat moden. Pendidikan global sedang bergerak aktif ke arah pemantapan integrasi teknologi digital dan komunikasi bagi mendepani cabaran kompleks abad



ke-21 (Abdullah, 2019). Salah satu inovasi yang semakin mendapat perhatian dalam dunia pendidikan ialah *Augmented Reality* (AR), iaitu teknologi yang menggabungkan elemen digital ke dalam persekitaran sebenar secara masa nyata (Milgram, 1994). Teknologi ini membolehkan pengguna berinteraksi dengan elemen sintetik dalam bentuk dua dimensi (2D) atau tiga dimensi (3D), sekali gus menghasilkan pengalaman pembelajaran yang lebih dinamik dan bermakna (Azuma, 1997).

AR berfungsi menerusi tiga pendekatan utama iaitu kaedah berasaskan penanda (*marker-based*), tanpa penanda (*markerless*), dan penjejakan menggunakan sistem kedudukan sejagat (*global positioning system tracker*). Dalam konteks pendidikan, AR berupaya menyediakan pengalaman pembelajaran yang lebih kontekstual dan autentik, membolehkan pelajar mengawal proses pembelajaran secara sendiri, serta memberi ruang untuk penerokaan persekitaran secara interaktif (Hamilton, 2010).

Dalam bidang Pendidikan Islam, pendekatan pengajaran yang menggunakan AR terbukti dapat meningkatkan minat pelajar dalam mempelajari Al-Quran. Kajian oleh Roslinda Ramli (2020) menunjukkan bahawa teknologi ini memberi impak positif terhadap proses hafazan dan bacaan tilawah Al-Quran. Tambahan pula, penyelidikan oleh Hayatunnufus (2018) mendapati bahawa AR dapat mempermudah pembelajaran hafazan bagi murid berkeperluan khas seperti pelajar kurang pendengaran, berbanding kaedah tradisional seperti bahasa isyarat dan tulisan.

Selain itu, aplikasi berasaskan AR juga telah dibangunkan untuk membantu penguasaan tulisan jawi, seperti yang dibuktikan melalui kajian Suhaimi (2019) menerusi pembangunan aplikasi Jawi-AR yang terbukti meningkatkan kefahaman dan minat pelajar. Selaras dengan itu, Nik Norizzati Mohd Saidi (2023) turut menekankan potensi besar AR dalam menarik minat kanak-kanak untuk mendalami ilmu agama seawal usia, menjadikannya sebagai medium pembelajaran Islam yang efektif dan interaktif.

Guru Pendidikan Islam (GPI) masa kini berdepan dengan cabaran yang semakin mencabar berikutan peningkatan gejala sosial serta kemerosotan akhlak dalam kalangan remaja. Kesan daripada perkembangan pesat teknologi telah menyebabkan unsur negatif mudah mempengaruhi pelajar, malah menjadi sebahagian daripada gaya hidup mereka, berbanding aktiviti yang memberi manfaat. Sekiranya isu-isu ini tidak ditangani dengan pendekatan yang berkesan, ia berpotensi memberi kesan yang lebih buruk terhadap masa depan generasi muda. Justeru, GPI perlu menerapkan pendekatan pedagogi yang lebih kontemporari dan seiring dengan kehendak era Revolusi Industri 4.0 semasa menjalankan sesi pengajaran dan pembelajaran.

Walau bagaimanapun, masih terdapat sebilangan guru yang mengekalkan gaya pengajaran tradisional yang berpusatkan guru sepenuhnya. Mereka lebih cenderung menyampaikan nota di papan hitam manakala pelajar pula hanya bertindak sebagai penerima pasif kepada segala isi pelajaran. Lazimnya, PdP Pendidikan Islam telah berlangsung secara satu hala sejak sekian lama. Hakikatnya, guru memainkan peranan penting dalam memilih strategi, pendekatan serta bahan bantu mengajar yang mampu mencetuskan minat pelajar dan seterusnya menyumbang kepada perkembangan kemahiran serta kecerdasan mereka (Kamarudin, 1990). Pendekatan “Chalk and Talk” masih menjadi pilihan utama dalam kalangan guru kerana ia dianggap mampu menyelesaikan isu bilangan pelajar yang ramai dalam satu kelas serta memenuhi

tuntutan menamatkan sukatan pelajaran dalam tempoh yang ditetapkan (Becker dan Watts, 2001).

Sebagai sebahagian daripada tuntutan pendidikan abad ke-21, pendekatan pengajaran dan pembelajaran masa kini perlu berasaskan kepada murid sebagai pusat tumpuan utama. Elemen-elemen seperti komunikasi berkesan, pemikiran kritis, kreativiti, kerjasama, serta penghayatan nilai murni dan etika memainkan peranan penting dalam membentuk struktur pembelajaran yang menyeluruh dan berkesan (Kementerian Pendidikan Malaysia, 2017). Untuk memastikan keberhasilan proses pembelajaran dan memenuhi objektif pendidikan nasional, Badrul Hisham dan Mohd Nasruddin (2016) menegaskan bahawa pemikiran kritis harus dijadikan asas kepada pendekatan pedagogi dan perlu sentiasa diperkukuh melalui latihan dan amalan berterusan.

Dalam konteks ini, guru sebagai agen utama perubahan pendidikan dituntut untuk memiliki ciri-ciri profesionalisme yang tinggi, termasuklah berfikir terbuka, kreatif, inovatif, dan mampu membuat keputusan serta menyelesaikan masalah secara rasional. Keupayaan ini mencerminkan pemikiran pedagogi yang sejajar dengan kehendak abad ke-21. Selain itu, penguasaan terhadap ilmu pengetahuan semasa dan celik teknologi maklumat dan komunikasi (ICT) menjadi keperluan asas yang tidak boleh dipandang remeh. Gabungan semua aspek ini menjadi asas kepada pembentukan pendidik yang berdaya saing, berkemahiran tinggi dan mampu menyumbang kepada kualiti pendidikan yang unggul.

Adapun berkaitan pembelajaran Bahasa Arab, terdapat kajian berkaitan penggunaan Teknologi Realiti Terimbuh dalam pembelajaran kosa kata bahasa Arab dalam kalangan pelajar KAFA di sekolah rendah (Yusof, Mohd. et al, 2023). Aplikasi pendidikan mudah alih untuk pelajar KAFA diharap dapat memberi impak positif kepada mereka dalam pembelajaran kosa kata bahasa Arab dengan penggabungan teknologi realiti terimbuh dan mungkin memberi kesan yang baik terhadap pencapaian dan motivasi pelajar sebagai strategi yang berguna. Selain itu, terdapat kajian lain mengenai pembelajaran kata kerja Arab dengan bantuan Teknologi Realiti Terimbuh dengan memanfaatkan penggunaan elemen multimedia yang sentiasa digunakan termasuk teks, objek 3D, animasi grafik audio, dan video yang sangat menarik. perhatian pelajar dalam pembelajaran mereka

Kesimpulannya, reality terimbuh mewakili kemajuan yang signifikan dalam teknologi pendidikan, menawarkan pengalaman pembelajaran yang imersif dan interaktif yang dapat meningkatkan penglibatan dan pemahaman pelajar di pelbagai disiplin. Semasa penyelidikan terus meneroka aplikasinya dan keberkesanannya, adalah penting bagi pendidik dan institusi untuk menangani cabaran yang berkaitan dengan pelaksanaannya bagi merealisasikan sepenuhnya potensi AR dalam pendidikan.

Objektif Kajian

1. Mengetahui pasti konsep dan potensi aplikasi Realiti Terimbuh atau Realiti Tambahan (AR) dalam Pendidikan Islam.
2. Meneliti peranan Realiti Terimbuh atau Realiti Tambahan (AR) sebagai alat bantu pengajaran dan pembelajaran yang interaktif dan imersif dalam meningkatkan pemahaman pelajar terhadap Pendidikan Islam.
3. Mengetahui pasti cabaran utama dalam pelaksanaan teknologi Realiti Terimbuh atau Realiti Tambahan (AR) dalam Pendidikan Islam di sekolah.

Definisi Realiti Terimbuh (AR)

Augmented Reality (AR) atau dalam bahasa Melayu disebut sebagai *Realiti Terimbuh*, merujuk kepada teknologi yang menggabungkan elemen digital seperti grafik, bunyi, teks dan video ke dalam pandangan dunia sebenar secara masa nyata. Teknologi ini berfungsi dengan meningkatkan persepsi pengguna terhadap realiti fizikal yang sedia ada melalui lapisan maklumat tambahan yang dijana oleh komputer. AR boleh berlaku secara langsung (live) atau tidak langsung, dan lazimnya membabitkan interaksi antara persekitaran sebenar dengan kandungan maya yang disepadukan secara dinamik (Azuma, 1997; Milgram & Kishino, 1994). Tidak seperti Realiti Maya (VR) yang menggantikan sepenuhnya dunia sebenar dengan persekitaran simulasi, AR menambah baik dunia sebenar dengan unsur digital tanpa menyingkirkannya. Teknologi ini membolehkan pengguna terus berinteraksi dengan persekitaran fizikal sambil menerima maklumat tambahan dalam bentuk visual atau audio. Contoh umum penggunaan AR dapat dilihat dalam siaran langsung sukan, di mana paparan skor atau data pemain disisipkan ke atas rakaman perlawanan dalam masa nyata (Billinghurst et al., 2015).

Melalui teknologi AR yang canggih — seperti sistem penglihatan komputer (*computer vision*), pengesanan objek (*object recognition*) dan sistem kedudukan GPS — maklumat berkaitan persekitaran pengguna boleh dianalisis dan dimanipulasi secara digital. Ini menghasilkan pengalaman yang lebih interaktif, informatif dan mendalam. Maklumat ini boleh dilapiskan secara kontekstual berdasarkan lokasi atau objek yang dikesan dalam dunia sebenar (Zhou et al., 2008).

Aplikasi Augmented Reality Dalam Pelbagai Bidang

Teknologi AR telah diterapkan secara meluas dalam bidang-bidang berisiko tinggi yang memerlukan ketepatan dan visualisasi tinggi sebelum tindakan dijalankan. Antaranya termasuk bidang ketenteraan, kejuruteraan, perubatan dan pembuatan (Lee, 2012). Dalam bidang perubatan contohnya, AR digunakan semasa perancangan pembedahan berasaskan data imbasan seperti CT scan atau MRI. Pakar bedah dapat memvisualisasikan struktur anatomi pesakit secara tiga dimensi sebelum atau semasa prosedur dijalankan. Ini membantu meningkatkan ketepatan, keselamatan dan keyakinan semasa proses pembedahan berlangsung (Yuen et al., 2011).

Konsep AR Dalam Pendidikan Islam

Augmented Reality (AR) atau dalam bahasa Melayu disebut sebagai *Realiti Terimbuh*, merujuk kepada teknologi yang menggabungkan elemen digital seperti grafik, bunyi, teks dan video ke dalam pandangan dunia sebenar secara masa nyata. Teknologi ini berfungsi dengan meningkatkan persepsi pengguna terhadap realiti fizikal yang sedia ada melalui lapisan maklumat tambahan yang dijana oleh komputer. AR boleh berlaku secara langsung (live) atau tidak langsung, dan lazimnya membabitkan interaksi antara persekitaran sebenar dengan kandungan maya yang disepadukan secara dinamik (Azuma, 1997; Milgram & Kishino, 1994).

Tidak seperti Realiti Maya (VR) yang menggantikan sepenuhnya dunia sebenar dengan persekitaran simulasi, AR menambah baik dunia sebenar dengan unsur digital tanpa



menyingkirkannya. Teknologi ini membolehkan pengguna terus berinteraksi dengan persekitaran fizikal sambil menerima maklumat tambahan dalam bentuk visual atau audio. Contoh umum penggunaan AR dapat dilihat dalam siaran langsung sukan, di mana paparan skor atau data pemain disisipkan ke atas rakaman perlawanan dalam masa nyata (Billinghurst et al., 2015).

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Teknologi *Augmented Reality* (AR), atau realiti terimbuh, merupakan satu inovasi digital yang membolehkan integrasi elemen-elemen maya seperti teks, grafik, imej 3D, video dan bunyi ke dalam dunia sebenar secara masa nyata. Teknologi ini memperkayakan persepsi pengguna terhadap persekitaran fizikal dengan menambahkan lapisan maklumat yang boleh diakses melalui peranti digital seperti telefon pintar, tablet, atau *head-mounted display* (Azuma, 1997; Craig, 2013). Tidak seperti realiti maya (VR) yang menggantikan dunia sebenar dengan simulasi digital sepenuhnya, AR mengekalkan interaksi pengguna dengan dunia nyata sambil membekalkan maklumat tambahan secara interaktif dan bersifat kontekstual (Milgram & Kishino, 1994).

Dalam konteks pendidikan, AR berfungsi sebagai alat bantu mengajar yang menyokong pendekatan pembelajaran visual, kinestetik dan konstruktivis. Ia membolehkan pelajar melihat objek maya yang berkaitan secara langsung dengan situasi pembelajaran sebenar, lalu meningkatkan kefahaman terhadap topik yang dipelajari. Teknologi ini sangat berpotensi dalam subjek-subjek yang melibatkan kandungan bersifat abstrak, simbolik dan rohaniah, termasuk dalam Pendidikan Islam (Billinghurst et al., 2015).

1. Menyesuaikan AR dengan Matlamat Pendidikan Islam

Konsep pendidikan Islam menekankan pembangunan menyeluruh insan dari segi intelek, emosi, rohani dan jasmani, selaras dengan nilai-nilai syariah dan maqasid syariah. Teknologi AR dapat dimanfaatkan sebagai medium PdP yang membantu pelajar memahami kandungan agama secara lebih visual dan kontekstual, terutamanya dalam topik seperti ibadah haji, sejarah Rasulullah SAW, tajwid dan tulisan jawi. Dengan menyediakan simulasi interaktif, AR memberi peluang kepada pelajar mengalami dan menghayati pengalaman rohani yang sukar disampaikan melalui kaedah konvensional (Yusoff, 2021; Roslinda Ramli, 2020).

2. Penyampaian Konsep Abstrak Secara Visual dan Interaktif

AR amat berguna dalam menyampaikan konsep-konsep abstrak yang menjadi teras dalam Pendidikan Islam. Misalnya, pelajar boleh menggunakan aplikasi AR untuk meneroka struktur Kaabah, memahami pergerakan solat, atau menyusuri sirah nabi dalam bentuk simulasi 3D. Ini bukan sahaja membantu dalam pemahaman kognitif, tetapi turut merangsang penghayatan nilai-nilai Islam melalui pengalaman pembelajaran bermakna (Estudante & Dietrich, 2020; Akour et al., 2022).

3. Potensi Menyokong Keperluan Pendidikan Inklusif

Konsep AR dalam Pendidikan Islam juga memberi impak positif dalam konteks pembelajaran inklusif. Kajian oleh Hayatunnufus (2018) menunjukkan bahawa aplikasi AR boleh membantu murid berkeperluan khas seperti pelajar cacat pendengaran dalam menghafaz al-Quran dengan lebih mudah dan berkesan berbanding kaedah tradisional seperti bahasa isyarat.

4. Menepati Nilai Islam dan Prinsip Syariah

Dari sudut syariah, penggunaan teknologi seperti AR dianggap harus selagi mana penggunaannya mematuhi garis panduan Islam. Kandungan AR perlu bebas daripada unsur lucuh, penyelewengan fakta sejarah, dan perlambangan yang boleh menjejaskan akidah. Justeru, penghasilan kandungan AR bagi Pendidikan Islam mestilah dikawal dan dirujuk kepada autoriti agama seperti JAKIM atau panel syariah institusi pendidikan (Kamaruddin, 2015; Al-Qaradawi, 1994).

Secara keseluruhan, konsep AR dalam Pendidikan Islam membawa pendekatan baharu yang lebih visual, interaktif dan kontekstual, sejajar dengan kehendak pembelajaran abad ke-21. Ia tidak hanya berfungsi sebagai alat bantu pengajaran, malah sebagai medium memperkukuh penghayatan nilai-nilai Islam dalam kalangan pelajar. Namun, pelaksanaan teknologi ini perlu dikawal dari aspek kandungan, metodologi, serta pematuhan terhadap prinsip etika dan syariah Islam agar tidak menimbulkan kekeliruan atau penyimpangan dalam pendidikan agama.

Realiti Terimbuh Menurut Perspektif Islam

Teknologi Realiti Terimbuh (AR) merupakan salah satu inovasi digital yang membolehkan pengguna berinteraksi dalam persekitaran simulasi yang menyerupai dunia sebenar. Walaupun teknologi ini membawa banyak manfaat dari sudut pendidikan, perubatan, dan hiburan, dalam kerangka Islam, penggunaannya perlu dinilai berdasarkan prinsip-prinsip syariah, maqasid syariah dan etika digital Islam.

1. Konsep Realiti Maya dalam Kerangka Islam

Dalam Islam, segala bentuk teknologi dilihat sebagai alat (wasilah) yang bersifat neutral; yang menentukan hukum penggunaannya ialah tujuan (maqasid) dan kesannya. Realiti maya, meskipun berbentuk simulasi, masih berada dalam ruang interaksi manusia dan oleh itu tertakluk kepada penilaian hukum syarak. Menurut Al-Qaradawi (1994), segala kemajuan teknologi adalah harus selagi tidak bercanggah dengan prinsip asas Islam seperti menjaga akidah, akhlak, dan maruah manusia.

2. Isu Etika dan Akhlak Penggunaan AR

Teknologi AR melibatkan unsur visual, persekitaran maya dan pengalaman mendalam yang boleh mempengaruhi emosi dan persepsi pengguna. Oleh itu, ia harus digunakan secara beretika dan berpandukan nilai-nilai Islam. Konten maya yang menampilkan unsur lucuh, kekerasan melampau, atau penyelewengan fakta sejarah Islam jelas dilarang (haram). Bahkan, ulama kontemporari seperti Sheikh Taha Jabir Al-Alwani berpendapat bahawa teknologi yang

menjauhkan manusia daripada nilai hakiki dan tanggungjawab sebagai khalifah harus ditolak (Al-Alwani, 2003). Dalam konteks pendidikan Islam, penggunaan AR harus mematuhi garis panduan akhlak Islam, misalnya menutup aurat watak maya, tidak menggambarkan wajah para nabi, dan tidak mencipta suasana yang boleh mengelirukan akidah pelajar.

3. Kesesuaian Penggunaan AR dalam Pendidikan Islam

Menurut Hassan et al. (2020), AR boleh menjadi alat bantu yang efektif dalam memperkukuh pengajaran dan pembelajaran Pendidikan Islam, khususnya dalam topik seperti ibadah haji, sejarah Islam, dan sirah Nabawiyah. Ia membantu pelajar memahami konsep abstrak secara visual dan interaktif, sekaligus meningkatkan penghayatan. Namun, perlu ada kawalan terhadap kandungan yang dibangunkan agar selari dengan kefahaman Ahli Sunnah wal Jamaah dan tidak bercanggah dengan nas syarak.

4. Prinsip Maqasid Syariah dan Teknologi

Pendekatan maqasid syariah memberi justifikasi kukuh terhadap penggunaan teknologi moden jika ia menjamin lima objektif utama syariah: menjaga agama (din), nyawa (nafs), akal ('aql), keturunan (nasl), dan harta (mal). VR dalam pendidikan dapat menyumbang kepada penjagaan akal melalui ilmu, dan membantu memahami agama dengan lebih mendalam. Namun, jika penggunaannya melampaui batas seperti menyebabkan ketagihan, kecelaruan identiti atau pembaziran harta, maka ia boleh menjadi makruh atau haram (Kamaruddin, 2015).

Secara umumnya, Islam tidak menolak kemajuan teknologi seperti AR, tetapi menuntut agar penggunaannya diselaraskan dengan prinsip syariah dan nilai etika Islam. Dalam konteks pendidikan Islam, teknologi AR boleh dimanfaatkan secara bijaksana dan berhikmah, dengan kawalan terhadap kandungan, batasan penggunaannya, dan pemantauan oleh pihak berautoriti. Ini penting bagi memastikan ia bukan sahaja menjadi alat bantu PdP yang canggih, tetapi juga menyumbang kepada pembangunan sahsiah pelajar Muslim yang seimbang dan holistic.

Peranan Augmented Reality (AR) dalam Pendidikan Islam

Augmented Reality (AR) merupakan satu teknologi interaktif yang menggabungkan elemen maya seperti grafik, teks, audio dan animasi ke dalam persekitaran sebenar secara masa nyata. Dalam konteks pendidikan, AR membuka ruang baharu kepada kaedah pengajaran dan pembelajaran (PdP) yang lebih inovatif, khususnya dalam menyampaikan konsep abstrak dan bersifat rohaniah seperti yang terdapat dalam Pendidikan Islam. Penggunaan AR tidak hanya terhad kepada aspek visualisasi semata-mata, tetapi turut melibatkan penglibatan kognitif, emosi dan sosial pelajar, selaras dengan tuntutan pembelajaran abad ke-21.

Salah satu peranan utama AR dalam Pendidikan Islam ialah kemampuannya untuk membantu pelajar memahami konsep abstrak secara visual dan interaktif. Topik-topik seperti ibadah haji, peristiwa hijrah Rasulullah SAW, struktur Masjidil Haram, serta adab-adab harian dalam Islam dapat divisualisasikan dengan lebih jelas dan bermakna menggunakan teknologi ini. Melalui paparan 3D dan interaksi maya, pelajar dapat mengalami simulasi seolah-olah berada dalam persekitaran sebenar tanpa perlu berada di lokasi tersebut secara fizikal (Chang, 2021; Estudante & Dietrich, 2020). Keupayaan ini menjadikan pengajaran lebih efektif dan membantu pelajar membina pemahaman secara mendalam serta kontekstual.

Menurut pendapat Fatin Nur Fatimah Ishak & Mohd Isa Hamzah (2019), buku teks Augmented Reality dapat digunakan dalam pendidikan Islam. Misalnya, murid-murid dapat mengimbas gambar kaabah dan penghijrahan Nabi Muhammad S.A.W. dengan menggunakan buku teks AR. AR juga sangat sesuai digunakan dalam proses PdP pendidikan Islam kerana pendidikan Islam terdedah dengan kaedah simulasi atau tunjuk cara seperti simulasi pergerakan solat dan Amirah Syafiqah Anuar & Khadijah Abdul Razak (2022) pula berpendapat bahawa pengaplikasian AR dalam proses PdP dapat meningkatkan tahap kognitif, minat, sikap serta tahap motivasi murid. Secara tidak langsung penggunaan AR dapat membantu para guru pendidikan Islam untuk mencapai objektif pembelajaran khususnya dalam bidang Sirah.

Selain itu, AR turut berperanan dalam meningkatkan penglibatan dan motivasi pelajar semasa proses PdP berlangsung. Unsur gamifikasi yang terdapat dalam banyak aplikasi AR menjadikan pembelajaran lebih menyeronokkan dan bersifat pelajar-sepusat (student-centred). Kajian menunjukkan bahawa penggunaan AR dalam bilik darjah dapat mendorong pelajar untuk lebih aktif, memberi tumpuan, serta berinteraksi dengan kandungan pembelajaran secara berkesan (Akour et al., 2022; Hsu et al., 2017). Ini amat penting dalam Pendidikan Islam yang bukan sahaja menekankan aspek kognitif, tetapi juga aspek penghayatan nilai dan pembentukan sahsiah.

Tambahan pula, AR memberikan ruang kepada pelajar untuk belajar secara kolaboratif dan kontekstual. Misalnya, pelajar boleh bekerjasama dalam kumpulan kecil untuk meneroka aplikasi AR yang memaparkan suasana di Tanah Suci, kemudian membincangkan pengalaman mereka dan membuat refleksi terhadap nilai-nilai murni yang dapat dihayati daripada ibadah haji. Pendekatan ini selari dengan falsafah Pendidikan Islam yang menekankan pembelajaran melalui pengalaman dan muhasabah (Mazzuco et al., 2022; Macariu et al., 2020).

Dari sudut pedagogi guru, AR menjadi alat bantu mengajar yang efektif dalam menyampaikan topik-topik sukar. Guru boleh menggunakan bahan berbentuk simulasi atau paparan 3D untuk menjelaskan konsep secara lebih jelas berbanding dengan kaedah tradisional seperti kuliah atau penerangan teks. Teknologi ini juga boleh membantu guru menjimatkan masa dalam menyampaikan kandungan yang kompleks, sekaligus memperkayakan pendekatan PdP yang lebih berkesan (Yusoff, 2021).

Walau bagaimanapun, penggunaan AR dalam konteks keagamaan perlu diteliti dengan berhati-hati agar tidak menimbulkan unsur penyimpangan, penyelewengan fakta atau menyinggung sensitiviti agama. Oleh itu, penghasilan kandungan AR dalam Pendidikan Islam perlu melibatkan kolaborasi rapat antara pakar teknologi, ilmuwan Islam, dan pihak berautoriti seperti Bahagian Pendidikan Islam (BPI) dan Jabatan Kemajuan Islam Malaysia (JAKIM) bagi menjamin kesahihannya.

Guru juga memainkan peranan penting dalam mendidik pelajar agar menggunakan teknologi secara beretika dan berhemah. Dalam konteks Pendidikan Islam, nilai-nilai seperti adab, tanggungjawab, dan batasan syariah harus diterapkan dalam penggunaan AR agar teknologi tidak disalah guna atau menjejaskan sensitiviti agama. Oleh itu, guru berfungsi sebagai pendidik moral dan pembimbing akhlak dalam dunia maya, memastikan bahawa kemajuan teknologi berjalan seiring dengan pembinaan sahsiah pelajar.

Akhir sekali, penggunaan AR dalam Pendidikan Islam berpotensi memperkuat penghayatan nilai Islam. Melalui penceritaan digital (digital storytelling), pelajar dapat menyelami kisah-kisah sirah dan memahami nilai-nilai seperti amanah, tolong-menolong, dan tawakal dalam suasana visual yang memberi kesan emosi. Hal ini bukan sahaja meningkatkan pemahaman, tetapi turut membentuk jati diri Muslim yang seimbang dari aspek intelek, emosi dan rohani.

Secara keseluruhannya, teknologi AR menawarkan pelbagai manfaat kepada Pendidikan Islam, terutamanya dalam menjadikan PdP lebih interaktif, kontekstual, dan bermakna. Walaupun penggunaannya masih dalam peringkat awal, potensi AR sebagai alat sokongan pedagogi yang selaras dengan kehendak syariah dan prinsip etika Islam wajar diteroka dan dimanfaatkan secara lebih meluas dalam sistem pendidikan arus perdana.

Cabaran Pengaplikasian Teknologi Augmented Reality (AR) dalam Pendidikan Islam

Walaupun teknologi Augmented Reality (AR) menawarkan pelbagai manfaat dalam meningkatkan kualiti pengajaran dan pembelajaran, khususnya dalam subjek Pendidikan Islam yang bersifat abstrak dan nilai, pelaksanaannya dalam konteks pendidikan arus perdana tidak terlepas daripada pelbagai cabaran yang signifikan. Cabaran ini perlu dikenalpasti dan ditangani agar teknologi ini dapat dimanfaatkan secara berkesan, beretika dan selaras dengan kehendak syariah.

Antara cabaran utama dalam pengintegrasian teknologi Revolusi Industri 4.0 dalam bidang pendidikan ialah kekangan dari aspek infrastruktur, yang menjadi asas paling penting tetapi sering kali diabaikan. Tanpa kelengkapan teknologi yang memadai seperti capaian internet berkelajuan tinggi, peranti pintar, dan perisian yang menyokong pengajaran digital, usaha untuk melaksanakan pembelajaran berasaskan teknologi akan terus terbatas dan sukar dicapai secara menyeluruh. Menurut Syuhaidah Sulaiman dan Mohd Isa Hamzah (2019), para pendidik sering berdepan dengan pelbagai kekangan, antaranya keterbatasan dari sudut teknikal, kekangan masa, serta kekurangan bantuan sokongan. Ini menunjukkan bahawa tanpa prasarana yang stabil, penggunaan teknologi dalam kelas tidak dapat dimanfaatkan sepenuhnya.

Di samping itu, Abdullah et al. (2021) turut melaporkan bahawa semasa tempoh pandemik Covid-19, kekurangan kemudahan asas seperti akses internet dan peranti digital menjadi aduan utama terutama sekali dalam kalangan pelajar yang berada di kawasan luar bandar. Fenomena ini mencerminkan wujudnya jurang digital yang ketara, sekali gus menggagalkan usaha untuk merealisasikan pendidikan digital yang bersifat inklusif dan adil kepada semua lapisan masyarakat. Kajian oleh Ishak et al. (2020) pula mendapati ketidakseimbangan dalam keupayaan untuk mengikuti pembelajaran dalam talian mencetuskan cabaran dalam merancang strategi pengajaran yang menyeluruh dan responsif terhadap pelbagai keperluan pelajar.

Lebih membimbangkan, sesetengah institusi pendidikan juga menghadapi kesukaran apabila sistem teknologi yang digunakan tidak serasi dengan pendekatan pengajaran Islam yang berteraskan nilai-nilai tradisi. Mohd Azam Mahat dan Mohamad Khairi Haji Othman (2023) menekankan bahawa ketiadaan sumber digital dan bahan rujukan yang sesuai turut menjadi antara faktor yang menyukarkan proses pengajaran berasaskan teknologi ini dilaksanakan secara menyeluruh dan berkesan.

1. Kekurangan Kemahiran dan Pengetahuan Guru

Salah satu cabaran utama ialah kekurangan kemahiran teknikal dan pedagogi dalam kalangan guru, khususnya dalam kalangan Guru Pendidikan Islam (GPI). Kebanyakan guru tidak terdedah secara mendalam kepada teknologi AR dalam latihan asas perguruan dan tidak dibekalkan dengan modul khusus berkaitan penggunaannya dalam konteks pengajaran Islam. Ini menyebabkan integrasi AR dalam bilik darjah sukar dilaksanakan secara efektif (Mohd Azhar, 2019; Mazzuco et al., 2022). Tambahan pula, penggunaan AR bukan sahaja memerlukan pengetahuan teknikal, tetapi juga kemahiran reka bentuk pengalaman pembelajaran berasaskan pelajar (student-centred learning).

Menurut pandangan Suhid dan Fakhrudin (2012), Pendidikan Islam bukan sekadar satu mata pelajaran, sebaliknya ia merupakan suatu sistem yang berpaksikan kepada asas pemikiran falsafah yang lahir daripada pandangan hidup Islam itu sendiri. Asas pemikiran ini amat penting kerana ia berperanan dalam membentuk masyarakat yang berpengetahuan, beriman, bertakwa, dan memiliki sahsiah serta kemahiran yang seimbang. Tanpa hala tuju yang berpanduan falsafah Islam, kehidupan seseorang individu boleh menjadi tidak berarah, pendidikan akan kehilangan matlamat, dan segala usaha serta aktiviti mungkin tidak mendapat nilai di sisi Allah SWT (Syuhaidah Sulaiman & Mohd. Isa Hamzah, 2019).

Dalam konteks pendidikan abad ke-21, para pendidik tidak boleh bergantung semata-mata kepada pengetahuan isi kandungan, malah perlu memperluaskan diri dengan kemahiran teknologi dan kemampuan mengintegrasikannya dalam proses pengajaran (Oster & Peled, 2014). Oleh itu, penguasaan terhadap teknologi dalam pendidikan bukan lagi satu pilihan tetapi satu keperluan mendesak. Noryana Mohd Nor et al. (2019) menekankan bahawa guru perlu menguasai tiga bidang utama dalam pedagogi moden iaitu teknologi, pengetahuan kandungan, dan pedagogi. Maka, penerapan elemen teknologi harus diberi perhatian yang serius, dan bukan hanya menumpukan kepada aspek kandungan pelajaran semata-mata.

Dalam subjek Pendidikan Islam sendiri, penggunaan teknologi semakin berkembang dengan adanya pelbagai aplikasi digital seperti Al-Quran Digital, Smart Hadith, e-Jawi dan lain-lain lagi. Inisiatif ini bertujuan memudahkan guru menyampaikan pengajaran dengan lebih berkesan dan interaktif. Kajian oleh Sylviano Abu Bakar dan Hasmadi Hassan (2019) mendapati bahawa guru-guru Pendidikan Islam di sekolah rendah telah menunjukkan tahap kesiapsiagaan yang tinggi dari segi pengetahuan untuk mengadaptasi teknologi dalam PdPc. Dapatan ini turut disokong oleh kajian Syuhaidah Sulaiman dan Mohd. Isa Hamzah yang menyatakan guru masa kini berada pada tahap yang baik dari sudut penguasaan ilmu untuk menjayakan pembelajaran digital secara berkesan.

2. Keterbatasan Akses kepada Infrastruktur dan Peralatan

Akses kepada kemudahan teknologi seperti tablet, telefon pintar, sambungan internet berkelajuan tinggi serta perisian AR yang berkualiti masih tidak seimbang, terutama di sekolah luar bandar dan berpendapatan rendah. Ketidaksamarataan digital ini menyukarkan penyertaan semua pelajar secara saksama dalam pengalaman pembelajaran menggunakan AR (Radianti et al., 2020; Estudante & Dietrich, 2020). Kekurangan makmal komputer atau peranti pintar di sesetengah sekolah menimbulkan jurang digital yang mendalam. Menurut Hasbi Muin (2021),

beliau berpendapat cabaran utama ialah pelajar tidak mempunyai gajet serta data internet yang terhad. Hal ini menjelaskan ketiadaan gajet salah satu aspek cabaran kerana kaedah interaktif amat memerlukan medium interaksi seperti gajet untuk mewujudkan (PdP) secara dalam talian. Selain itu, data internet yang terhad memberi halangan kepada para guru subjek Pendidikan Islam dan para pelajar Islam. Tambahan pula, kaedah interaktif yang dilaksanakan dalam subjek Pendidikan Islam melibatkan tahap penggunaan data yang tinggi kerana ketika sesi (PdP) berlangsung, aplikasi-aplikasi tertentu akan digabungkan untuk menjelaskan topik-topik secara mendalam sepertimana google meet, youtube mahupun whatsapp group kepada pelajar.

3. Kos Pembangunan dan Penyelenggaraan Teknologi

Kos tinggi untuk membangunkan bahan pembelajaran berasaskan AR, termasuk kos langganan aplikasi, pembangunan kandungan 3D, latihan guru, dan penyelenggaraan peralatan digital merupakan halangan utama kepada pelaksanaan berskala besar. Banyak sekolah kekurangan bajet khas untuk teknologi inovatif seperti AR, dan masih bergantung kepada sumber bantuan kerajaan atau NGO (Macariu et al., 2020). Selain itu, proses penyelenggaraan dan naik taraf teknologi memerlukan tenaga kerja berkemahiran tinggi yang tidak semua sekolah mampu sediakan.

4. Kekangan Masa dan Beban Tugas Guru

Guru sering berdepan dengan kekangan masa dalam menguasai teknologi baharu serta menghasilkan bahan pengajaran berasaskan Realiti Terimbuh (AR) yang berkualiti. Tugas-tugas sampingan di sekolah seperti kerja-kerja pentadbiran, pemantauan disiplin, serta pelaksanaan aktiviti kokurikulum menyebabkan masa yang ada untuk meneroka dan melaksanakan inovasi pedagogi menjadi sangat terhad (Mazzuco et al., 2022). Walaupun minat untuk menggunakan teknologi seperti AR dalam PdP semakin meningkat dalam kalangan guru, pelaksanaannya secara berterusan masih sukar dicapai kerana keterbatasan masa yang tersedia.

Idris Awang (2021) turut menekankan bahawa guru Pendidikan Islam sering menghadapi kesukaran untuk menerangkan isi kandungan secara mendalam akibat masa PdP yang singkat. Keadaan ini bertambah mencabar apabila setiap subjek perlu diberikan perhatian seimbang, terutama semasa pandemik Covid-19 yang menyaksikan guru terpaksa mengejar masa untuk menyiapkan sukatan pelajaran. Dalam kebanyakan jadual waktu persekolahan, setiap subjek hanya diperuntukkan sekitar satu jam sahaja untuk sesi pengajaran, menjadikan pelaksanaan pendekatan interaktif seperti AR kurang praktikal tanpa perancangan yang rapi.

Selain itu, guru Pendidikan Islam perlu membuat persediaan awal kerana tahap pemikiran pelajar yang berbeza-beza memerlukan pendekatan yang bersesuaian. Rosliza Abdul Razak (2021) mencadangkan agar masa bagi sesi PdP dalam talian ditambah khususnya bagi subjek yang melibatkan pelbagai topik serta komponen praktikal atau amali. Hal ini kerana pengajaran interaktif dalam subjek Pendidikan Islam bukan sahaja menekankan aspek teori dan penulisan, tetapi juga melibatkan kemahiran amali seperti sebutan bacaan, pergerakan solat dan sebagainya. Justeru, pelaksanaan PdP berbentuk interaktif memerlukan masa tambahan agar pengajaran lebih berkesan dan menyeluruh.

5. Kebimbangan terhadap Kandungan Tidak Selaras Syariah

Dalam konteks Pendidikan Islam, terdapat kebimbangan berkaitan penggunaan AR yang mungkin mengandungi unsur visual yang tidak menepati sensitiviti agama, seperti watak maya yang tidak menutup aurat, penggambaran wajah Nabi atau penyimpangan fakta sejarah. Oleh itu, pembangunan kandungan AR perlu dikawal ketat dan mendapat panduan daripada ilmuwan Islam serta panel syariah bagi memastikan ia tidak bercanggah dengan akidah dan etika Islam (Yusoff, 2021; Kamaruddin, 2015).

Kementerian Pendidikan Malaysia telah mengiktiraf kepentingan program imersif, terutamanya dalam meningkatkan kemahiran bahasa dalam kalangan murid sekolah rendah (Abdullah & Mohamad, 2020). Namun begitu, isu-isu teknikal seperti kekurangan bahan VR dan video 360 darjah serta masalah sambungan internet telah menghalang penggunaan teknologi imersif secara efektif dalam pendidikan (Adnan et al., 2020). Di samping itu, kekurangan latihan guru, kaedah pengajaran yang sesuai, dan masalah teknikal turut menyumbang kepada cabaran dalam penggunaan media imersif dalam pendidikan (Erturk & Reynolds, 2020). Walaupun isu-isu ini adalah besar, penyelidikan mencadangkan bahawa untuk mengatasi halangan ini, kita perlu menangani kekangan teknikal dan melabur dalam pembangunan guru serta penambahbaikan infrastruktur. Tanpa pendekatan yang komprehensif, potensi manfaat teknologi imersif mungkin tidak dapat direalisasikan sepenuhnya. Di Malaysia, penerimaan teknologi baharu, termasuk teknologi imersif, masih berada pada peringkat awal (Aziz & Wahid, 2020). Kadar penerimaan yang perlahan ini selaras dengan penemuan yang menunjukkan bahawa hanya peratusan kecil syarikat di Malaysia telah menerima teknologi canggih (Sakrabani & Ping, 2020). Selain itu, kajian mengenai halangan penerimaan teknologi mendedahkan cabaran yang wujud dalam organisasi dan dalam persekitaran yang lebih luas (Hoang et al., 2019). Kadar penerimaan yang perlahan ini menekankan keperluan peningkatan strategi yang lebih proaktif bagi menggalakkan penggunaan teknologi. Pembuat dasar dan kementerian pendidikan harus mengenal pasti dan menangani cabaran penerimaan ini bagi mengelakkan sektor pendidikan kita ketinggalan daripada arus perkembangan global dan kehilangan manfaat daripada teknologi imersif yang diterokai.

Pandangan Masyarakat Terhadap Pendidikan Berteraskan Teknologi Digital

Secara umumnya, teknologi digital merujuk kepada satu bentuk sistem komunikasi berasaskan komputer, yang dikenali sebagai "sistem komunikasi berasaskan komputer" (William, Sawyer & Hutchinson, 2003). Kemunculan teknologi ini telah memudahkan proses penyampaian dan penerimaan maklumat melalui pelbagai peranti moden yang berasaskan teknologi digital secara lebih cepat dan efisien. Walau bagaimanapun, penggunaan teknologi digital turut mencetuskan pelbagai perdebatan, khususnya dalam menilai impak positif dan negatifnya terhadap masyarakat. Menurut kajian oleh Mohd Yuszaidy Mohd Yusoff dan Muammar Ghaddafi Hanafiah (2015), sebahagian besar masyarakat Melayu yang tinggal di kawasan luar bandar berhadapan dengan tekanan dan cabaran untuk menyesuaikan diri dengan arus perkembangan teknologi digital dalam kehidupan harian mereka. Pelbagai isu berkaitan institusi kekeluargaan turut menimbulkan kebimbangan dalam kalangan ibu bapa yang semakin ragu-ragu dan berasa terancam dengan budaya digital yang semakin menular.

Antara kesan yang dibimbangi ialah gangguan terhadap perkembangan komunikasi antara individu. Kesungguhan terhadap aktiviti digital seperti melayari internet, menonton televisyen,

penggunaan gajet dan sebagainya telah mengurangkan masa interaksi secara bersemuka dalam kalangan kanak-kanak dan remaja, yang akhirnya menyumbang kepada kecenderungan mereka untuk bersikap lebih menyendiri atau 'introvert' (Naquiah Nahar, Sahrnizam Sangi & Dharsigah A/P Baniear Salvam, 2018).

Tambahan pula, masyarakat masih cenderung memilih pendekatan tradisional dalam pembelajaran bidang-bidang tertentu, contohnya dalam pembacaan al-Quran dan pengajian Fekah, kerana dirasakan lebih sesuai dan berkesan melalui bimbingan langsung. Kebimbangan masyarakat semakin meningkat apabila memikirkan pendedahan anak-anak terhadap risiko dalam dunia digital seperti kes buli siber. Menurut Che Awang dan Alavi (2019), buli siber boleh mencetuskan tekanan emosi yang serius dalam kalangan pelajar, dan dalam beberapa kes yang ekstrem, mendorong mereka ke arah pemikiran untuk menamatkan nyawa sendiri. Selain itu, ketagihan terhadap gajet juga dikaitkan dengan pendedahan kepada bahan lucah secara tidak terkawal (Amirul Ashraaf Norman & Nooraini Othman, 2020).

Kesemua ini menjelaskan mengapa wujud kekusaran dalam kalangan masyarakat terhadap pelaksanaan pendidikan digital yang bergantung sepenuhnya kepada Teknologi Maklumat dan Komunikasi (TMK) moden.

Strategi Pengajaran Dan Pembelajaran Ar Dalam Pendidikan Islam

Kehadiran Revolusi Industri 4.0 bersama kemajuan teknologi yang pesat pada era milenial masa kini telah membawa transformasi besar dalam pelbagai sektor, termasuklah sektor pendidikan. Perubahan ini turut memberi pengaruh langsung terhadap landskap Pendidikan Islam, yang merupakan elemen penting dalam pembangunan modal insan yang seimbang. Pendidikan Islam tidak hanya mementingkan perkembangan intelek, bahkan turut menekankan pembangunan aspek jasmani, emosi dan rohani bagi melahirkan individu yang seimbang dan berkualiti. Arus perubahan Revolusi Industri 4.0 telah memberi cabaran dan peluang baharu kepada sistem Pendidikan Islam. Pendidikan ini menekankan pendekatan holistik yang berasaskan konsep tarbiah, ta'lim dan ta'dib seperti yang dihuraikan oleh Abdul Hakim (2020), dalam usaha membentuk keperibadian insan secara menyeluruh. Pendidikan Islam turut mengangkat pendekatan pendidikan bersepadu sebagai teras utama dalam mengembangkan potensi manusia secara harmonis. Pendidikan ini berlandaskan prinsip al-Quran dan al-Sunnah, digabungkan dengan ilmu bersumberkan akal bagi membentuk masyarakat Islam yang kukuh akidahnya dan mampu menghadapi cabaran dunia moden. Pendekatan ini bertujuan membimbing manusia ke arah kejayaan bukan sahaja di dunia, tetapi juga di akhirat (Tajul, 2005).

Justeru, inovasi strategi pengajaran dan pembelajaran dalam Pendidikan Islam diperlukan bagi memenuhi cara pembelajaran yang disukai oleh golongan milenial ini. Ini adalah bagi memastikan guru dapat merancang sesi pengajaran dan pembelajaran dengan lebih baik dan efisien. Penyampaian pengajaran dan pembelajaran yang menggunakan papan putih dan arahan menyalin nota serta sesi kuliah yang panjang telah menjadi kurang berkesan. Hal ini kerana kewujudan teknologi baharu yang menjadi gaya hidup generasi masa kini. Sistem pendidikan negara telah mengorak langkah ke arah pengajian yang dipandu teknologi digital yang lebih bersifat interaktif dan fleksibel.

Terdapat beberapa strategi pengajaran yang boleh diaplikasikan oleh guru Pendidikan Islam (GPI) untuk memastikan PdPc Pendidikan Islam selaras dengan era RI 4.0 iaitu melalui pembelajaran autentik, penggunaan teknologi Augmented Reality (AR) dan media sosial sebagai medium dakwah. Di samping itu, kemahiran abad ke-21, kemahiran insaniah dan kemahiran berfikir aras tinggi (KBAT) juga boleh diimplementasikan dalam PdPc Pendidikan Islam untuk melahirkan modal insan yang berkualiti.

1) Pendekatan Pembelajaran Autentik

Dalam menghadapi era Revolusi Industri 4.0, pendekatan pembelajaran autentik menjadi semakin penting bagi memastikan pelajar mampu menghubungkan ilmu yang dipelajari dengan situasi sebenar dalam kehidupan harian (Talhah, Aminudin & Ahmad, 2019). Pendekatan ini boleh diterjemahkan melalui pelbagai bentuk aktiviti seperti simulasi lakonan peranan, penyelesaian masalah dunia nyata, kajian kes, pembelajaran berasaskan projek (Project-Based Learning) dan pendekatan inkuiri. Aktiviti-aktiviti ini memberi peluang kepada pelajar untuk berinteraksi secara aktif dengan bahan pembelajaran, guru dan rakan sekelas, sekaligus mengasah kemahiran dalam aspek kognitif, emosi dan psikomotor. Tambahan pula, kajian oleh Talhah, Aminudin dan Ahmad (2019) menunjukkan bahawa kaedah ini mampu meningkatkan keyakinan pelajar dan guru, serta membentuk suasana pembelajaran yang lebih bermakna dan berkesan.

2) Integrasi Teknologi Realiti Terimbuh (Augmented Reality, AR)

Penggunaan teknologi Augmented Reality (AR) dalam pendidikan telah membuka dimensi baharu dalam proses pengajaran dan pembelajaran, khususnya dalam meningkatkan interaktiviti pelajar dengan elemen digital yang bersifat tiga dimensi. Teknologi ini membantu mewujudkan suasana pembelajaran yang lebih menarik dan mendorong pelajar untuk meneroka ilmu dengan lebih mendalam (Fatin, 2019). Melalui penggunaan AR, pelajar dapat melihat dan berinteraksi dengan objek maya dalam persekitaran sebenar, menjadikan pengalaman pembelajaran lebih menyeronokkan dan membina. Hal ini seiring dengan pendekatan konstruktivisme yang menekankan pembelajaran berasaskan pengalaman.

Sebagai contoh dalam mata pelajaran Pendidikan Islam, guru boleh menggunakan teknologi AR untuk memperincikan rukun fi'li dalam ibadah solat, dengan memaparkan pergerakan dari pelbagai sudut seperti depan, belakang, kiri dan kanan. Fatin (2019) juga menyarankan potensi pembangunan buku teks yang disokong AR, contohnya dengan membolehkan pelajar mengimbas imej Kaabah dalam topik Sirah, bagi memberikan pengalaman pembelajaran yang lebih imersif dan menyentuh emosi.

Implikasi Teknologi Augmented Reality (AR) terhadap Bidang Pendidikan Islam

Kehadiran teknologi Augmented Reality (AR) dalam ekosistem pendidikan telah membawa perubahan ketara dalam pendekatan pedagogi, penyampaian kandungan dan pengalaman pembelajaran. Dalam konteks Pendidikan Islam, teknologi ini bukan sahaja memperbaharui kaedah penyampaian, malah membawa implikasi menyeluruh terhadap pelbagai aspek seperti dasar, kurikulum, latihan guru, pembangunan bahan pengajaran serta pembentukan sahsiah pelajar. Implikasi ini perlu diteliti secara holistik agar penggunaan AR dapat dimanfaatkan secara beretika dan seimbang selaras dengan prinsip maqasid syariah.

1. Implikasi terhadap Dasar dan Kurikulum Pendidikan Islam

Kementerian Pendidikan Malaysia (KPM) perlu menyusun semula dasar dan garis panduan pelaksanaan teknologi AR yang menepati prinsip syariah, terutama dalam Pendidikan Islam yang melibatkan sensitiviti agama. Ini termasuk membangunkan modul PdP berpanduan standard kurikulum yang disemak oleh pakar pendidikan Islam dan panel syariah. AR boleh memperkayakan kurikulum dengan menyepadukan elemen visual dan interaktif dalam topik-topik seperti sirah, ibadah, dan akhlak. Namun, kurikulum perlu mengandungi semakan terhadap ketulenan kandungan digital dan ketepatan fakta sejarah serta teologi Islam (Kamaruddin, 2015).

2. Implikasi terhadap Latihan dan Kompetensi Guru Pendidikan Islam

Penerapan AR menuntut guru bukan sahaja celik teknologi, tetapi juga mahir dalam pedagogi digital Islamik. Institut Pendidikan Guru (IPG) dan institusi latihan perguruan perlu memasukkan latihan khusus tentang penghasilan dan penggunaan bahan AR secara beretika. Guru Pendidikan Islam perlu dibekalkan kemahiran membina bahan interaktif yang selari dengan tuntutan akidah dan adab Islam. Kegagalan membekalkan latihan sistematik boleh menyebabkan salah guna teknologi atau ketergantungan terhadap sumber luar yang tidak disaring (Mohd Azhar, 2019).

3. Implikasi terhadap Penyampaian Kandungan dan Kaedah Pengajaran

AR berupaya memperkayakan teknik pengajaran guru dengan memberi ruang kepada visualisasi 3D, simulasi pengalaman ibadah seperti tawaf atau wukuf di Arafah, dan penglibatan pelajar secara aktif. Ini menjadikan pengajaran lebih menarik, imersif dan sesuai untuk pelbagai tahap pemahaman pelajar. Implikasi ini memerlukan guru untuk merancang PdP secara lebih kreatif dan menyepadukan bahan digital dalam aktiviti bilik darjah (Macariu et al., 2020).

4. Implikasi terhadap Pembinaan Sahsiah dan Nilai Islam Pelajar

Teknologi AR boleh menjadi alat penyampaian nilai Islam yang efektif jika dikawal dengan baik. Melalui penceritaan digital (digital storytelling), pelajar dapat memahami peristiwa-peristiwa Islam bukan sahaja dari sudut fakta tetapi juga dari dimensi emosi dan rohani. Ini membantu pembentukan akhlak, empati, dan penghayatan terhadap ajaran Islam (Yusoff, 2021). Namun, kawalan perlu diberi perhatian agar kandungan maya tidak melalaikan, menjurus kepada hiburan semata-mata, atau bertentangan dengan prinsip tauhid.

5. Implikasi terhadap Akses dan Kesaksamaan Pendidikan

Salah satu kesan besar pelaksanaan AR ialah isu jurang digital antara sekolah bandar dan luar bandar. Sekolah yang kekurangan infrastruktur mungkin tidak dapat mengakses teknologi ini, sekali gus menyebabkan ketidaksamarataan dalam penyampaian Pendidikan Islam. Ini memerlukan perhatian pihak berkuasa untuk membekalkan sokongan infrastruktur dan dana secara adil agar semua pelajar berpeluang merasai manfaat teknologi AR (Radianti et al., 2020). Teknologi AR mempunyai implikasi besar terhadap masa depan Pendidikan Islam, bukan

sahaja dari segi pedagogi dan kandungan, tetapi juga dari aspek dasar, latihan guru dan pembinaan nilai pelajar. Pelaksanaan teknologi ini perlu dirancang secara strategik, berpandukan prinsip syariah dan disokong oleh kerangka dasar yang menyeluruh agar ia benar-benar menjadi alat bantu pengajaran yang berkesan, etikal dan seimbang.

Kesimpulan

Kesimpulannya, teknologi Realiti Terimbuh atau Realiti Tambahan (AR) dalam Pendidikan Islam membawa potensi besar dalam merubah landskap pendidikan Islam melalui penyampaian kandungan secara lebih menarik, imersif dan bermakna. Dalam menghadapi cabaran pendidikan abad ke-21, guru perlu bersikap terbuka terhadap penggunaan inovasi digital seperti AR, namun pada masa yang sama memastikan penggunaannya mematuhi batasan syariah dan nilai-nilai Islam. Pelaksanaan teknologi ini memerlukan sokongan menyeluruh daripada pelbagai pihak termasuk Kementerian Pendidikan Malaysia, institusi latihan perguruan, serta komuniti sekolah. Perancangan strategik, penyediaan infrastruktur, pembangunan kandungan berasaskan kurikulum, serta latihan pedagogi yang relevan amat penting untuk menjamin kejayaan integrasi AR dalam PdP Pendidikan Islam. Jika dilaksanakan secara bijaksana dan berhikmah, AR bukan sahaja dapat memperkukuh kefahaman pelajar terhadap ilmu agama, tetapi juga membentuk generasi Muslim yang seimbang dari aspek intelek, emosi, rohani dan sosial.

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