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An AI-Driven Adaptive Interactive Multimedia Learning System to Enhance Student Engagement and Learning Performance in Malaysian Higher Education

Suraya Binti Mohktaza Zain
i25035104@student.newinti.edu.my
INTI International University, Malaysia
ORCID iD: 0009-0003-7455-1278
(Corresponding Author)

Kumutha Raman
kumutha.raman@newinti.edu.my
INTI International University, Malaysia
ORCID iD: 0009-0007-6630-8883

Norariffuddin Bin Abd Rahman
norariffuddin@unikl.edu.my
Universiti Kuala Lumpur, Malaysia
ORCID iD: 0009-0002-7067-1400

Alia Amira Abd Rahman
alia@unikl.edu.my
Universiti Kuala Lumpur, Malaysia
ORCID iD: 0000-0001-7255-1934

Nor Syahidatul Amira Dzulkepli
amira.dzulkepli@unikl.edu.my
Universiti Kuala Lumpur, Malaysia
ORCID iD: 0009-0002-1489-7827

Abstract

Artificial intelligence (AI) has created new opportunities for the development of intelligent and personalised learning environments in higher education. The increasing use of digital and multimedia resources in education has also created new opportunities for learning. However, most conventional multimedia learning environments are static and do not adapt to the differing needs of the individual learners. Although there has been increasing research activity in artificial intelligence, adaptive learning, learning analytics and multimedia-based education, these areas have mostly been investigated separately. There is therefore a need for a framework that integrates these different areas of study, particularly in the higher education setting. Hence, this paper proposes an AI-driven adaptive interactive multimedia learning framework for Malaysia's higher education institutions. The conceptual

framework for the development of the proposed model is based on the synthesis of existing literature on areas such as AI in education, adaptive learning, interactive multimedia learning, learning analytics, personalised learning, and intelligent educational technologies. The framework incorporates five major components: interactions with multimedia content, interactive multimedia content itself, learning analytics, an AI analytics engine, and an adaptive learning module. The interaction with the multimedia content allows for the collection of data about the learners, which is analysed by the learning analytics and AI analytics engine to recognise patterns in the learners' interactions with the multimedia content. These analyses enable the adaptive learning module to provide recommendations for the personalised learning of each of those learners. While the proposed framework provides a structure for integrating AI, learning analytics, adaptive learning, and multimedia content within a Malaysian higher education learning environment, the framework itself has yet to be empirically implemented. Thus, while the potential for the framework to provide benefits to learners within higher education is present, such potential is presented as a proposition for future investigation. As such, future research will focus upon the development of the proposed framework and its implementation as a functional prototype according to an appropriate research design.

Keywords Artificial Intelligence; Adaptive Learning; Interactive Multimedia; Learning Analytics; Higher Education; Student Engagement

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Introduction

Artificial intelligence (AI) technologies are becoming increasingly common in higher education, and AI has received considerable attention for its potential uses in this sector. For example, AI tools have been discussed as being able to analyse educational data, thereby enabling customised instruction for students, automating some educational processes, and providing recommendations to educators and students based upon that analysis. A literature review investigating AI applications in higher education reveals that AI applications have been increasingly investigated in domains like teaching, learning, assessment, profiling, prediction, and other institutional functions within higher education (Crompton & Burke, 2023). Another review of the literature that investigates AI applications within higher education reveals that areas like adaptive learning systems and the personalisation of learning experiences for individual students within higher education have been discussed as important applications of artificial intelligence within those educational institutions (Bond et al., 2024).

The increasing use of AI in education does not automatically imply the development of systems that support personalised and effective learning for the students. The AI systems must be appropriately connected to the learning processes, the students, and the educational environment in which they are to be deployed. Recent research regarding AI in education has focused upon aspects of human-centred design, stakeholder involvement, trust, reliability, and privacy in the deployment of AI in learning analytics systems (Alfredo et al., 2024).

Another important component of many of the learning environments that are developed today is the use of multimedia components within those learning environments. Multimedia elements can include components like text, images, audio files, video files, animation files, quizzes, simulations, and a variety of other activities that can help to introduce the content of those learning environments. Furthermore, research into the effectiveness of incorporating multimedia learning elements into learning environments suggests that there are learning design principles that must be considered within those learning environments (Çeken & Taşkın, 2022).

Recent evidence also shows that multimedia is used extensively in higher education. Multimedia can improve students' learning experience and learning outcomes, but it can also impose excessive cognitive demands on them if used inappropriately (Staneviciene & Žekienė, 2025).

Many e-learning platforms are largely static. The same content is delivered to all students without considering their level of knowledge or their engagement with the course materials. Adaptive learning platforms seek to address this problem by altering the learning experience based on information gathered about the students. A recent scoping review has found that personalised adaptive learning can

improve students' academic performance and engagement, although it poses some challenges in its implementation (du Plooy et al., 2024).

Another important component of the proposed model is the use of learning analytics. Learning analytics is the gathering, analysis and interpretation of data from learners' interactions with digital learning environments. In particular, research on higher education in the post-pandemic era shows increasing interest in, and use of, learning analytics to better understand the behaviour of learners within higher education institutions (Bunsu & Abd Halim, 2023).

The integration of learning analytics with the existing concepts of AI and adaptive learning presents an opportunity to develop the functionality of learning environments to respond to the interactions of the learners with those environments. While current multimedia learning environments may present content such as videos, animations, text-based content, and quizzes for the learners to interact with, an intelligent multimedia learning environment could use learning analytics to automatically determine the content that should be presented to each individual learner.

Despite the potential benefits of integrating learning analytics into multimedia learning environments, the literature on this topic is lacking, specifically within the context of Malaysian higher education. Accordingly, this paper proposes a framework that integrates multimedia learning environments, learner interactions with those environments, learning analytics, AI-driven analytics and adaptive learning.

Problem Statement

With the increasing availability of digital learning technologies, higher education institutions can provide various digital learning resources and activities. These learning activities can include digital learning materials such as videos, animations, quizzes, and more. While these learning resources can enhance the learning experience for students, their presence does not indicate that the learning environment is adaptive to the individual learners in the environment.

Conventional learning environments that use multimedia learning resources provide the same learning resources and activities to all the learners in the environment without considering the differences in the knowledge and skills of each of the students. Thus, students with different needs in the learning environment are required to follow the same learning activities as others in the environment.

The potential for AI-supported adaptive learning and learning analytics to address the identified problems within the current learning environments is present. Previous studies on the impacts of

personalised adaptive learning systems have indicated that they can lead to positive impacts upon students' performances within their educational institutions (du Plooy et al., 2024). Furthermore, learning analytics has been recognised as a potentially useful approach for supporting learning and timely intervention in higher education institutions (Bunsu & Abd Halim, 2023). However, the potential issues associated with the use of students' personal information can pose some challenges in the implementation of these technologies.

Thus, the problem that is to be solved by the proposed study is not the lack of AI and multimedia technology within Malaysian higher education institutions. Instead, the issue is the lack of an integrated learning approach that incorporates AI, multimedia technology, adaptive learning, learning analytics, and takes into consideration the potential issues related to the data of the students within those institutions. Thus, this research proposes the development of a conceptual framework for an adaptive multimedia learning environment for implementation in Malaysian higher education institutions to allow for personalised learning for their students.

Research Gap

The literature indicates several areas of fragmentation. Much research has been done in the field of artificial intelligence in higher education concerning its use in areas like prediction, assessment, personalised learning, intelligent tutoring and adaptive systems (Crompton & Burke, 2023; Bond et al., 2024). However, the presence of AI functionality does not necessarily indicate that the systems have been integrated with interactive multimedia learning environments.

In addition, there are also variations in the information that is collected from learners within adaptive learning systems, the ways in which the learning resources provided to the learners are adapted based upon that information, and the learning resources that are provided to the learners altogether. While reviews of adaptive learning systems indicate that they can improve the academic performance of students, the specific adaptations to those learning systems can vary from study to study (du Plooy et al., 2024).

Similarly, research has also been conducted on learning analytics as a means of understanding the behaviour and engagement of the learners within a learning environment. However, research regarding the impact of learning analytics upon the design of learning resources is limited. For example, only a minority of studies that have incorporated learning analytics reported that the use of such analytics led to improvements in the design of the learning resources (Drugova et al., 2024). Furthermore, while research has investigated the importance of multimedia learning design, few

learning environments currently adapt their multimedia learning elements to the needs of individual learners.

Another gap exists in the integration of these various components within the Malaysian higher education context. While there has been research performed on the incorporation of AI and digital learning technologies within higher education in Malaysia, the integration of AI, learning analytics, adaptive learning, and multimedia learning within a unifying learning framework within the Malaysian higher education context is lacking.

Thus, the gap does not lie in a lack of research on the individual components of such a framework. Instead, the gap in the knowledge is in the development of a framework that incorporates AI, learning analytics, adaptive learning, and multimedia learning within the Malaysian higher education context. Accordingly, this study intends to fill such a gap in the literature by developing a conceptual framework for incorporating these various technologies and components into a unifying learning framework within Malaysian higher education.

Research Objectives

The objectives of this study are:

1. To identify the research gaps and requirements in the integration of AI, adaptive learning, learning analytics and interactive multimedia learning in Malaysian higher education.
2. To develop a conceptual framework for an AI-driven adaptive interactive multimedia learning environment.
3. To propose the system architecture and adaptive learning workflow for the implementation of the proposed framework in the Malaysian higher education context.

Research Questions

The following research questions will be addressed in this research:

RQ1: What are the research gaps and requirements for the integration of AI, adaptive learning, learning analytics and interactive multimedia learning in the higher education of Malaysia?

RQ2: How can AI, learning analytics, adaptive learning and interactive multimedia learning be integrated into a framework for personalised learning?

RQ3: What is the system and learning architecture that can be used to implement the proposed AI-driven adaptive interactive multimedia learning framework?

Significance of the Study

The proposed framework has potential theoretical and practical significance. The theoretical significance of this study lies in the fact that the framework connects AI, learning analytics, adaptive learning, and interactive multimedia learning. Often these technologies are considered independently. The framework examines the interrelationship between these technologies within the context of an adaptive learning environment.

Practically, the framework can guide those involved in the development of digital learning environments, such as instructional designers, educators, educational technologists, and higher education institutions. For the Malaysian context in particular, the framework can help to guide the relationship between multimedia content and adaptive learning within higher education through the use of learning analytics and AI.

However, it must be stated again that this study makes a conceptual contribution to the existing literature. No empirical research was conducted to test the framework to determine whether it will improve engagement or performance in digital learning environments. Such studies will be required in the future to develop and test a prototype of the framework.

Literature Review

Artificial Intelligence in Education

Artificial intelligence (AI) is an important research area in higher education. AI has many applications in higher education from assessment to recommendation systems, intelligent tutoring systems to personalised learning systems and adaptive learning systems. Crompton and Burke (2023) performed a systematic review of the literature on AI in higher education to determine where AI is used in higher education. Their research study revealed the extent of AI application in higher education. Similarly, Bond et al. (2024) conducted a meta-systematic review to determine the applications of AI in higher education. Their findings also indicated that the major areas of application of AI in higher education are in the development and use of adaptive systems and personalisation technologies in higher education.

Nevertheless, there is a range of educational and human factors to consider before the implementation of AI systems in higher education. Alfredo et al. (2024) carried out a research study to ascertain the significance of human factors in AI and learning analytics systems. The study revealed the importance of human control, trustworthiness, reliability, safety and stakeholder participation in AI and learning analytics systems. Consequently, in the proposed framework, AI is positioned as an analytical

component that supports the learning experiences of students rather than as an autonomous component that replaces teachers in the higher education classroom.

Adaptive Learning Systems

Adaptive learning refers to learning environments that adapt to individual learners; the elements of the learning experience are modified according to information regarding those individual learners.

Evidence suggests that incorporating elements of personalised adaptive learning into the educational experience can lead to positive influences upon the learners' academic performance and engagement with the learning process. A 2024 scoping review of personalised adaptive learning reported improvements in academic performance in a substantial proportion of the studies reviewed; however, technological, time and resource constraints were often present within those studies (du Plooy et al., 2024).

Adaptive learning can be positively influenced by the incorporation of AI technologies. AI technologies can allow for the analysis of larger amounts of data regarding the learners, which can inform decisions regarding the adaptation of the learning experience. However, appropriate information regarding the learners, learning objectives, content, and the ability to adapt the learning experience according to that information is required for any adaptive learning technology to be effective.

Adaptive learning, therefore, is the component of e-learning that transforms analytical information regarding the learner into changes to the learning content and learning recommendations for that learner.

Interactive Multimedia Learning Environments

Interactive multimedia learning environments allow for the integration of various media and provide interactivity between the media and the learners. Some examples of multimedia include video content, animation, quizzes, simulations, graphics, and scenario activities.

Research in multimedia learning has demonstrated that learning outcomes are dependent upon the principles that are applied to the media rather than the number of media types that are used within the learning environment. Çeken and Taşkın (2022) examined the effect of multimedia learning principles in different educational environments.

A recent systematic review of the use of multimedia technologies in higher education reveals that they are widely used and beneficial to learning outcomes, but can also have detrimental effects, such as cognitive overload, if not designed properly (Staneviciene & Žekienė, 2025).

Within the framework that is proposed, multimedia is the primary learning environment in which the students interact with the learning content. Furthermore, the framework extends the concept of multimedia learning by incorporating artificial intelligence analysis and adaptivity.

Learning Analytics and Student Engagement

Learning analytics refers to the collection, analysis, and interpretation of data relating to the learners and the learning processes. In digital learning environments, such data can include information about the learners' interactions with the learning environment and its components. For instance, learning analytics software can monitor the learners' access to learning environments, the time spent on certain learning activities within those environments, the completion of tasks within those environments, the scores achieved on quizzes within those environments, and the actions taken by the learners within those environments. Bunsu and Abd Halim (2023) have explored the field of learning analytics in higher education and found a growing relationship between learning analytics and artificial intelligence (AI). Learning analytics can be used to create adaptive learning by interpreting this data regarding the learners' actions within a learning environment.

However, simply collecting this data does not indicate that its use will be beneficial to the learning processes. Data collection and monitoring are only the first steps towards implementing effective learning analytics. For instance, Drugova et al. (2024) found that research connecting learning analytics to improvements in learning design is still immature. Thus, frameworks must still be created that connect learning analytics to the adaptation of instruction to the individual learners to ensure that the collected data can effectively be used to support the adaptive learning processes.

AI-Driven Learning Analytics

The integration of artificial intelligence (AI) and learning analytics enables the analysis of the data that is generated during the complex learning processes to identify patterns in the learning processes. AI can enable learning analytics through the performance of tasks such as the prediction of learner performance, providing recommendations to the learners, classification of the learning processes, profiling of the learners, and the provision of feedback to the learners. Recent research indicates the use of AI methods in learning analytics to provide learners with real-time feedback related to their individual performance (Ouyang & Zhang, 2024).

However, the use of AI to analyse the data from the learners presents challenges to the educational processes. For example, Alfredo et al. (2024) called for AI and learning analytics approaches to be focused on the individuals involved in the learning processes rather than the algorithms

that underpin the AI systems. Therefore, the AI-driven analytics will be one of the components that supports the learning analytics process for analysing and interpreting the data from the learners while maintaining the necessary supervision from educators involved in the learning processes.

Student Engagement in Digital Learning

Another important consideration in digital learning is the way in which students interact with learning resources. Learning analytics is one means of providing indicators of the digital engagement of students. Furthermore, learning analytics has been used to understand how students interact with their digital learning environments and how that interaction relates to their performance in their courses (Bunsu & Abd Halim, 2023). Rather than relying solely on behavioural indicators, engagement can also be modelled as a multidimensional concept that incorporates both behavioural indicators and learners' perceptions of the learning environment, which future studies could examine. Finally, while the framework does not assume that adaptive multimedia learning environments will automatically increase engagement, it proposes that students' interactions with these environments can be used to provide them with more appropriate learning experiences.

AI, Adaptive Learning, Multimedia and Personalisation

The literature on each of the discussed technologies indicates that each technology provides important capabilities to the digital learning environment. However, most of the literature on these technologies reviews each component separately, without discussing how they can be interconnected to create a single learning environment.

Artificial intelligence, for instance, provides analytical and decision-making capabilities to the digital learning environment (Crompton & Burke, 2023; Bond et al., 2024). Learning analytics provides the data to the learning environment to determine how the learners are interacting with the digital learning environment (Bunsu & Abd Halim, 2023; Drugova et al., 2024). Adaptive learning can use the data from the learning analytics technologies to adjust the learning content provided to each of the learners according to their individual needs (du Plooy et al., 2024). Finally, interactive multimedia provides the actual learning content that is to be learned by the students within the digital learning environment (Çeken & Taşkın, 2022).

The integration of these components creates the possibility of a more responsive learning environment. The interaction of the learners with the multimedia content creates behavioural and performance data. That data can be processed by the learning analytics application. The AI component can analyse that data to determine any patterns or learning needs of the learners. Based on those

recognised learning needs, the adaptive learning component can create appropriate content for that learner or take some other action to address their needs.

The integration of these components creates a learning process in which the learners interact with the multimedia content, the data from that interaction is analysed to determine the needs of the learners, and the learning experience is adapted based on those analyses. The adapted learning experience leads to the learners' new interactions with the multimedia content, leading to the cycle of data analysis and adaptation of learning experience to continue. Thus, this integration introduces the idea of a learning experience that can respond to the behaviour and performances of the learners engaging with the multimedia content.

Another group of issues that must be considered in integrating these components relates to human-centred and ethical concerns. The collection and processing of the data from the learners will raise issues related to their privacy, transparency, and the security of that collected data (Alfredo et al., 2024; Prinsloo et al., 2023). Thus, in addition to considering the technical aspects of the integration of these components, it is also important to consider the role of educators in the framework and in addressing such ethical issues.

Based on these considerations of the needs of each of the components of the proposed framework, it becomes evident that there is a need for a framework that incorporates each of these elements: the interaction of the learner with the multimedia elements, the use of multimedia elements to facilitate learning, the implementation of learning analytics to evaluate that learning, the use of AI to analyse that learning, and the adaptation of the learning elements to improve the learning of the students. This identified need in the literature introduces the research gap in the field and leads to the development of the proposed framework for AI-driven learning analytics and adaptation, which will be presented in the following sections.

Research Gap Synthesis

Based on the reviewed literature, there are four major gaps in the existing literature on intelligent multimedia learning systems.

- *Gap 1:* Fragmentation of technological components. Despite the extensive investigation of AI, adaptive learning, learning analytics, and multimedia learning, there is a lack of conceptualisation of the integration of these technological components into a unified learning architecture.

- *Gap 2:* Limited connection between learning analytics and multimedia learning adaptation. Although learning analytics has the potential to adapt multimedia learning content according to the learner's behaviour, analytics does not necessarily translate to changes in the multimedia learning content.
- *Gap 3:* Need for contextualisation within the Malaysian higher education sector. Most of the investigations reported in the literature address higher education in general rather than the Malaysian context specifically. The need exists for the conceptualisation of multimedia learning systems specifically for the Malaysian higher education context.
- *Gap 4:* Limited investigation into the implementation of integrated frameworks. There is a need for further investigation into the implementation of integrated intelligent multimedia learning system frameworks, as most of the investigations reported in the literature relate to the adaptation of learning technologies in specific contexts.

These identified research gaps provide the basis for the proposed framework for intelligent multimedia learning systems.

Methodology

Research Approach

This research adopts the method of developing a conceptual framework. This is not an empirical experimental study; it does not involve the collection of participant data, pre-test/post-test measurements or statistical hypothesis testing. The proposed framework is developed through systematic synthesis of relevant literature and conceptual integration of identified technological and pedagogical components.

This is consistent with the current state of the research, as the proposed framework has not yet been implemented and evaluated empirically. Therefore, the study concentrates on developing a theoretically based framework to give a basis for further development of prototypes and empirical tests.

Framework Development Process

The framework development process consists of four stages:

- (i) Literature identification
- (ii) Gap identification
- (iii) Component integration, and
- (iv) Framework and architecture development, as illustrated in Figure 1.

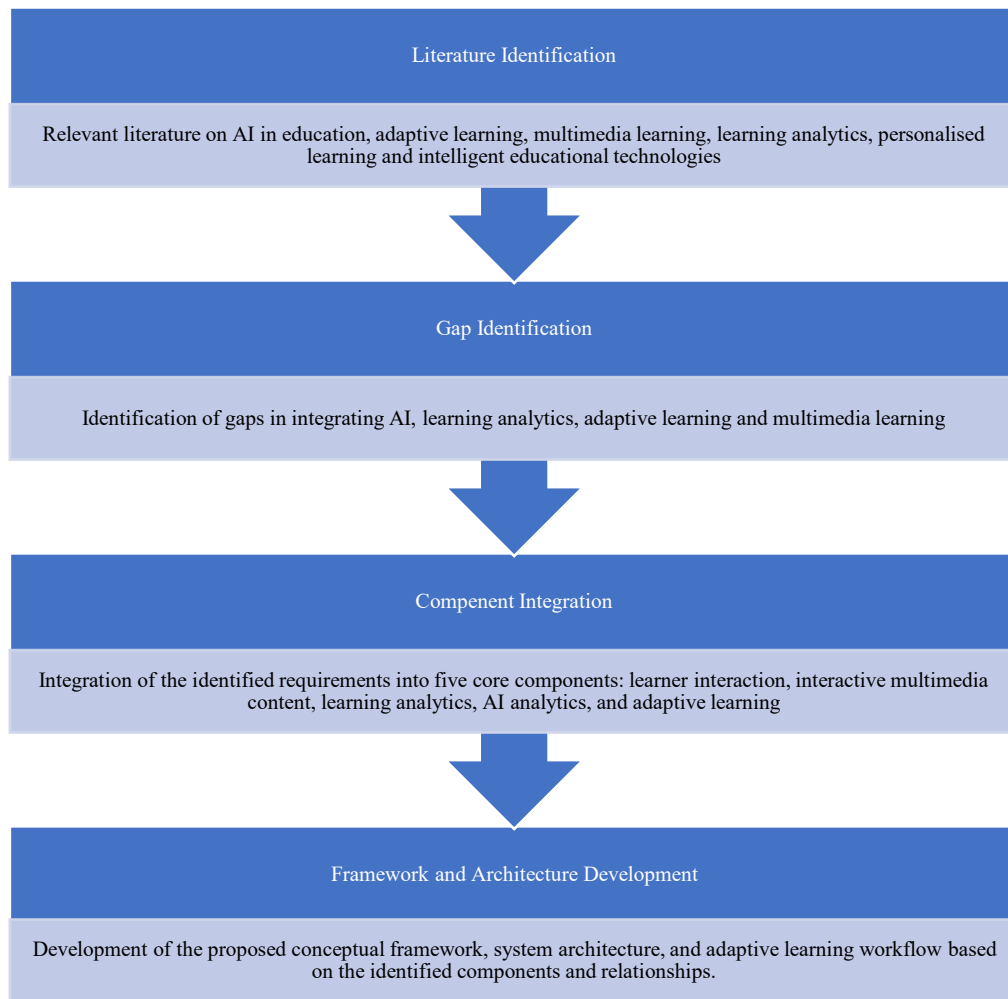


Figure 1. Framework Development Process

Proposed Framework Components

The framework consists of five main components: learner interaction, interactive multimedia content, learning analytics, AI analytics engine, and adaptive learning module. These components work together as a cycle in which the learners interact with the multimedia content, which is analysed by the learning analytics and AI analytics engine to determine adaptations to the learning module for each learner.

Learner Interaction

The interactions between the learners and the learning environment (and its multimedia content) are the first major component of the framework.

Interactive Multimedia Content

This component comprises the content that is published and made available to the learner as part of the learning environment.

Learning Analytics

This component covers the collection and analysis of the interactions of learners with the multimedia content.

AI Analytics Engine

This component analyses the data collected through learning analytics to determine recommendations for adapting the learning module.

Adaptive Learning Module

This module adapts the learning content according to the insights generated by the learning analytics component and the AI analytics engine. The interaction among these components forms an iterative cycle in which learner data inform AI-driven analysis, which subsequently supports adaptive adjustments to the multimedia learning experience.

Ethical and Human-Centred Considerations

Given that the framework involves the collection and analysis of data from the learners, considerations regarding privacy, confidentiality, informed consent, data security, transparency, and the use of AI in this context must be addressed during the future implementation of such a system. Such considerations are important, especially due to the nature of the information that must be collected from the learners. Research on learning analytics has, for example, highlighted concerns regarding the privacy, confidentiality and data security of students when learning analytics systems are implemented (Prinsloo et al., 2023). Therefore, future developments of this system should incorporate aspects like data governance, transparency, accountability, and human oversight of the system.

Proposed AI-Driven Adaptive Interactive Multimedia Learning Framework

Framework Overview

The proposed framework incorporates elements of interactive multimedia learning, learner interaction, learning analytics, AI-driven analytics and adaptive learning into a continuous learning cycle.

The cycle begins when the learner interacts with the multimedia learning materials, and data relating to these interactions are collected by the system. This data is captured by the learning analytics system and made available to the AI analytics engine for analysis. Based upon the analysis of the data collected from the learner, the adaptive learning module determines the responses that should be provided to the learner.

These responses may include any of the following:

- Providing the learner with personalised learning content recommendations
- Adjusting the difficulty of the learning content provided to the learner
- Providing additional learning materials to the learner
- Providing feedback to the learner based upon their interactions with the learning content
- Providing additional practice activities for the learner to undertake
- Providing alternative multimedia learning resources to the learner.

The learner's interaction with these recommended or alternative learning resources will create new data for the system to analyse. This analytical cycle can be repeated as often as necessary to provide the learner with a personalised learning experience based upon their interactions with the learning environment and its resources.

Framework Architecture

The proposed framework for an AI-driven adaptive interactive multimedia learning system is presented in Figure 2. The framework comprises five main components: learner interaction, interactive multimedia content, learning analytics, the AI analytics engine and the adaptive learning module. Learners interact with the system, and the system collects data that is analysed by the learning analytics and AI analytics engine to provide feedback to the adaptive learning module that will adapt the learning experience for the next iteration of the learning cycle.

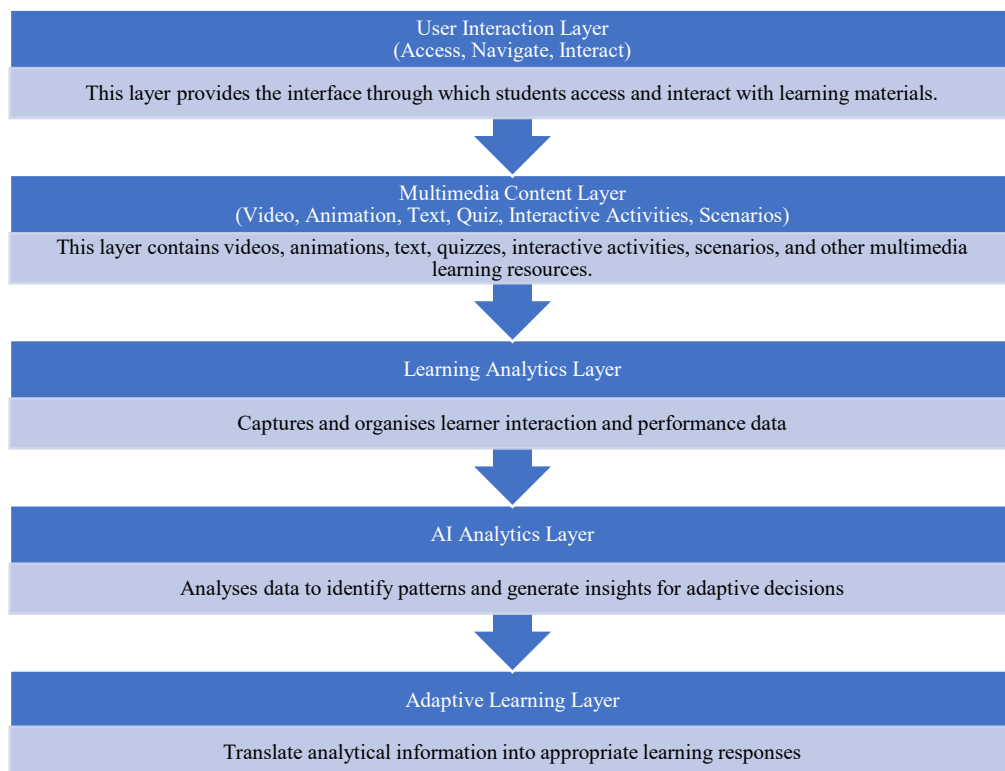


Figure 2. Proposed AI-Driven Adaptive Interactive Multimedia Learning Framework

Following the four-stage framework development process presented in Figure 1, the resulting framework incorporates the five components that have been identified. The framework incorporates steps in which the learners interact with the multimedia learning content. The data that is collected from such interactions can be analysed to determine the behaviour of the learners while engaging with the multimedia content. Based upon the information that is analysed by the AI analytics engine, the adaptive learning module can provide learners with new content and activities tailored to their individual needs. The learners interact with the content that was provided to them and new data is collected, enabling the cycle to repeat itself.

Adaptive Learning Workflow

The following workflow outlines the processes through which the system supports continuous adaptive learning:

- Step 1: Learner accesses multimedia learning content
The learner interacts with multimedia content that has been developed for the system.
- Step 2: Learner interaction is captured
The interactions that the learner makes within the multimedia content are captured by the system.
- Step 3: Learning analytics processes learner data
The learning analytics component of the system processes the data regarding the interactions of the learner with the multimedia content.
- Step 4: AI analytics identifies learning patterns
The AI analytics engine analyses the processed learner data to recognise any patterns in their learning behaviour, difficulties and needs.
- Step 5: Adaptive learning response is determined
Based on the recognised learning patterns and needs of the individual learner, the adaptive learning module will determine an appropriate learning response to each identified need.
- Step 6: Personalised learning content is delivered
According to the determined adaptive learning response, the learning platform will deliver personalised learning content to the relevant learner according to their needs.
- Step 7: New learner interaction data are generated
The learner interacts with the newly adapted learning content, and this interaction produces new interaction data for that learner which can be fed back into the analytics process for analysis.

By performing each of these steps in sequence, the platform establishes an adaptive learning cycle that allows for the continuous monitoring of each learner's behaviour, the adaptation of the learning experience to each individual learner, and the feedback of new data for further analytics and adaptation.

Framework Alignment with Research Questions

The framework directly addresses the research questions.

- RQ1: The literature review indicates a research and development need for intelligent learning systems that integrate artificial intelligence (AI), learning analytics, adaptive learning, and multimedia elements within the Malaysian higher education context.
- RQ2: The second research question is addressed through the development of a proposed framework that integrates the five identified components into a unified intelligent learning environment.
- RQ3: The third research question is addressed through the proposed system architecture and adaptive workflow, which illustrate how learner interaction data are transformed into actionable analytical insights and subsequently used to generate personalised learning responses.

Discussion

Overview

The main contribution of the proposed framework is the combination of AI-driven analytics and interactive multimedia learning. While traditional multimedia learning environments can provide rich and engaging learning representations, they may remain relatively static in responding to individual learner behaviour. The proposed framework introduces an analytical layer through which learner interaction data can inform adaptive learning decisions. Consequently, multimedia is positioned not merely as a means of content presentation, but as an integral component of an interactive learning environment in which learning content and activities can potentially respond to learner behaviour and identified learning needs.

Integration of Learning Analytics and Adaptive Learning

Learning analytics forms the data foundation of the proposed framework, providing the information necessary to make adaptive decisions. The framework thus establishes a connection between the learners, the learning analytics and the adaptation of the multimedia content and activities. These concepts are supported by existing research in learning analytics and artificial intelligence (AI), which indicates that analytics can provide insights into the behaviour of learners within a course and that AI

systems can analyse the data provided by learning analytics systems (Bunsu & Abd Halim, 2023; Ouyang & Zhang, 2024).

Implications for Malaysian Higher Education

The integration of the proposed framework would have several implications for higher education institutions in Malaysia. Most importantly, the framework can assist in integrating artificial intelligence (AI) within the existing digital learning environments of higher education institutions in Malaysia. Additionally, the framework can assist educators within those institutions in recognising which students may require additional support by providing insights from the data collected through the learning analytics elements of the framework. Finally, the incorporation of interactive multimedia elements into the intelligent learning environment may increase the motivation and engagement of students. Overall, these implications indicate the potential for the framework to be beneficial to the higher education institutions in Malaysia.

Expected Educational Benefits

The implementation of the proposed framework is expected to offer several educational benefits to students in higher education institutions. For instance, the provision of personalised learning pathways and content recommendations may lead to increased student engagement. Furthermore, the fact that the learning content can be continuously adapted based upon the students' performance within the courses may lead to increased knowledge and achievement by those students.

Finally, the use of learning analytics is likely to provide educators with insights into the learning of their students. These insights are likely to enable educators to better teach and support their students. Thus, the overall quality of education provided within higher education institutions may be enhanced by the implementation of this framework.

Human-Centred and Ethical Considerations

The implementation of the proposed framework would involve the continuous collection and analysis of learner data, which raises important human-centred and ethical considerations. Issues relating to privacy, confidentiality, informed consent, data security and transparency must be addressed before such a system is deployed (Alfredo et al., 2024; Prinsloo et al., 2023). Learners should be informed about what data are collected, how these data are analysed and how the resulting recommendations are generated. Furthermore, consistent with a human-centred approach, the AI analytics engine is intended to support, rather than replace, the professional judgement of educators. Educators should therefore retain oversight of the adaptive decisions made by the system and be able to review or override its

recommendations. Appropriate data governance and accountability mechanisms will thus be essential for any future implementation of the framework within Malaysian higher education institutions.

Theoretical Contribution

The theoretical contribution of this research is the integration of several existing concepts within the field of educational technology into a conceptual learning architecture. The interactive multimedia learning concepts can be integrated with learning analytics concepts, for instance, to enable artificial intelligence (AI)-driven analytics to provide adaptive learning processes that can provide each learner with a personalised learning experience. Therefore, by bringing together these disparate concepts and components into a learning architecture, this research can contribute to the literature and help frame future research on multimedia learning in higher education that utilises AI, learning analytics and adaptability features.

Practical Contribution

From a practical perspective, the proposed framework can be valuable to various stakeholders within higher education. For instance, instructional designers can utilise the framework to consider how the content that is to be learned by the student can interact with the learner and with the data that can be collected from those learners. Educators can utilise the framework to consider how the interaction of the students with the learning systems can be used to provide adaptive learning to those students. Moreover, developers of educational technology can utilise the framework to conceptualise the technology that is required to create an adaptive multimedia learning system that is driven by artificial intelligence. Finally, the higher education institutions that host these learning environments can utilise the framework to conceptualise the potential integration of artificial intelligence, learning analytics, and adaptive learning systems into their current digital learning environments.

Limitations

The main limitation of this study is that the proposed framework has not yet been implemented within an actual learning environment within higher education. Thus, this study does not provide any empirical evidence regarding the improvements in engagement in learning, the improvements in learning performance, the effectiveness of the framework compared to conventional methods of delivering multimedia learning content, the accuracy of the AI-based recommendations for each learner, or even in relation to learning outcomes for learners over time. Thus, this framework is a conceptual framework that can be utilised as the basis for future studies to test the effectiveness of implementations of the proposed framework.

A further limitation is that the framework has not yet been tested across different academic disciplines. The needs of learners and the learning processes involved may differ from one discipline to another. Thus, future studies may be performed to determine the applicability, usability, and effectiveness of the framework in different learning environments within higher education institutions.

Future Research

Future research should investigate the proposed framework through several stages. During the first stage, a prototype of the proposed system is to be developed. Following the development of the prototype, testing of the system can help to determine its functionality, usability, and learning requirements. Furthermore, conducting a pilot study of the system will help to determine its functionality, interaction with learners, and the feasibility of the learning processes that are to be implemented within the system. Following the pilot study, future research can develop an empirical study that evaluates the framework of the system. Furthermore, employing a quasi-experimental study to evaluate the system prior to and following implementation of the adaptive learning environment can help to determine whether learners who use the adaptive learning environment exhibit different learning outcomes from those who use conventional multimedia learning systems.

Another future direction for research is to investigate the relationship between the analytics features of the system and the outcomes of the learners who used the system. By implementing statistical techniques to evaluate these features, it may be possible to determine whether the analytics measurements are associated with the performance of the learners within the system.

Conclusion

Artificial intelligence (AI), adaptive learning, learning analytics and multimedia technologies present significant opportunities for higher education to develop learning environments that can accommodate and cater to individual learners. However, there is a gap in the literature regarding the integration of these technologies into a single learning environment. In attempting to address this gap, this paper proposed an AI-driven adaptive interactive multimedia learning framework for the Malaysian higher education context.

The framework comprises five main components: interaction of the learner with the learning environment, interactive multimedia content, learning analytics, AI analytics engine and an adaptive learning module. These five components are interconnected in a way that ensures that the interaction of the learner with the learning environment can be captured, assessed and analysed by the AI engine to determine the learning needs of that individual learner. Based on these analyses, the adaptive learning

module can recommend personalised learning experiences for each of these individual learners to improve their learning experience and outcomes.

The main contribution of this paper is conceptual in nature. By integrating AI and learning analytics technologies with multimedia and adaptive learning technologies, this framework can help to form the basis upon which future developments in intelligent and adaptive learning environments can be created within the Malaysian higher education system. Furthermore, this framework can help to provide a basis for future research in the areas of instructional design, learning analytics, AI-enabled adaptive learning, and personalised multimedia learning.

Nevertheless, the framework that is proposed in this paper has yet to be empirically implemented. Thus, any potential effects of the framework have yet to be demonstrated. Future research can implement the framework created in this paper to evaluate its usability, adaptability, engagement of the learners, and the learning performance of learners using the framework. Such research will help to determine the educational value of implementing AI-enabled adaptive interactive multimedia learning environments within higher education classrooms.

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Authors' Bio

Suraya Binti Mohktaza Zain is an academician within the Faculty of Creative Multimedia Technology (CMT), Universiti Kuala Lumpur, Malaysia. She is currently pursuing her Doctor of Philosophy (PhD) degree with research focused on the field of artificial intelligence in multimedia learning environments at INTI International University, Malaysia. Her research interests include creative multimedia technology, educational technology, human-computer interaction, and artificial intelligence in learning systems. She has many years of experience teaching multimedia technology programmes at the Diploma and Bachelor levels. Her experience within the Faculty of Creative Multimedia Technology includes contributing to the development of the multimedia learning environment curriculum, as well as the projects that relate to digital learning and the integration of technology into the creative technology programmes.

Dr Kumutha Raman is a Senior Lecturer at INTI International University and holds a PhD in TESL from Universiti Kebangsaan Malaysia (UKM). With over 12 years of experience in secondary school education and 3 years in higher education, her expertise lies in technology-enhanced language learning, particularly integrating Virtual Reality (VR) to elevate ESL classroom engagement and outcomes. She has received multiple international innovation awards and was awarded a Gold Medal as well as Best Thesis Award for her research presentation on VR integration in ESL classrooms. Currently, she is expanding this research into higher education settings, exploring immersive language learning experiences through VR.

Norariffuddin Bin Abd Rahman is a lecturer and visual designer based in Malaysia. He holds a master's degree in visual art and design from Semyung University, South Korea, and a bachelor's degree in Multimedia Design from Universiti Kuala Lumpur (UniKL). His academic and professional interests include multimedia design, augmented reality (AR), visual communication, interactive media, and digital art. He has professional experience in graphic design and has been involved in teaching multimedia-related subjects, including digital imaging, animation, and video production. His current research interests focus on the integration of augmented reality and visual art, particularly in developing interactive and accessible digital experiences. He is also pursuing doctoral research in Information Technology with a focus on multimedia and augmented reality applications.

Dr Alia Amira Abd Rahman is a Senior Lecturer in the Creative Multimedia Technology Section at Universiti Kuala Lumpur Malaysian Institute of Information Technology (UniKL MIIT). She holds a PhD in Art and Design, with research focusing on visual communication and visual rhetoric in digital media. Her areas of expertise include graphic design, visual communication, digital media, advertising, new media, and multimedia design. She is also an Adobe Certified Professional in Visual Design and

Video Design and is actively involved in teaching, research, professional certification, and creative multimedia projects. Her research interests include visual communication, digital storytelling, interactive multimedia, augmented reality, design education, and emerging technologies for creative and educational applications.

Nor Syahidatul Amira Dzulkepli is a Lecturer in Multimedia at Universiti Kuala Lumpur Malaysian Institute of Information Technology (UniKL MIIT), Malaysia. She has five years of academic experience teaching Diploma and bachelor's degree programmes in multimedia, interactive media, graphic design, and creative design. Her academic interests include multimedia production, interactive design, creative design, design thinking, and practice-based learning. She has experience in curriculum and syllabus development, teaching and learning material preparation, programme implementation, and academic management. Her professional background also includes experience in media production, graphic design, video editing, and visual communication, which supports her practice-oriented approach to teaching and learning in creative and multimedia-related disciplines.