INFLUENCES OF MULTIMEDIA AND INTERACTIVITY IN AUGMENTED REALITY LEARNING APPLICATION IN ENHANCING UNDERGRADUATE STUDENTS' MOTIVATION

By

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Augmented reality (AR) has been extensively used for education. Many studies have proved that AR provides numerous benefits in education. However, there is not much work on investigation on questions regarding how learning with AR works for students, such as how multimedia and interactivity motivates students' learning interest. Therefore, the objectives of this study are to identify features of AR that can enhance student motivation, evaluate the effects of different combinations of multimedia elements on motivation within AR learning experiences, and assess how varying levels of interactivity in AR learning environments influence students' motivation. To explore that, an intensive literature review was conducted to identify the features that could influence learning motivation. An experiment was conducted to do two heuristic evaluations on an existing AR learning application to justify this research direction. This experiment has identified some design guidelines and

acknowledged that multimedia and interactivity could be candidates for value-added factors in AR learning applications that can enhance students' learning motivation.

To further investigate how multimedia and interactivity influence students' learning motivation, a mobile AR learning application for students to learn basic computer knowledge, namely secondary storage devices animated augmented reality application (SDAAR) was developed. The application was made flexible to implement different multimedia elements and interactivity.

The subsequent experiment investigated the influence of various combinations of multimedia elements on motivation and change or topic perception. A between-subjects design study was adopted to conduct a comparative 3 x 2 factorial design experiment with a total of 144 participants. It was found that for the lower level of Bloom's taxonomy, 3D animation and audio description is essential to retain attention of learners. 3D animation and description to be delivered by concurrent narration with text could provide a more satisfactory learning experience. Whereas description by text only is not advisable.

Experiment three investigated if a higher level of interactivity can enhance students' learning motivation and technology acceptance. With eight different experimental conditions, a comparative study was carried out with a total of 87 participants. It was found that interactivity could significantly enhance students' technology acceptance toward ARLE. The higher level of interactivity can enhance more confidence in users as compared to the low level of interactivity.

The study contributes to the field by providing a comprehensive understanding of how specific features of AR can enhance student motivation. It reveals the effects of various multimedia combinations and levels of interactivity within AR learning environments, offering insights into how these factors individually and interactively impact motivation. This knowledge can guide the design and implementation of more effective AR educational tools, tailored to maximize student engagement and learning outcomes.

Keywords: Augmented Reality Learning, Interactivity, Motivation, Multimedia

SDG: GOAL 4: Quality Education

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Sarjana Master Sains

PENGARUH MULTIMEDIA DAN INTERAKTIVITI DALAM APLIKASI PEMBELAJARAN REALITY IMBUHAN DALAM MENINGKATKAN MOTIVASI PELAJAR SARJANA MUDA

Oleh

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Reality Imbuhan (Augmented reality, AR) telah digunakan secara meluas untuk pendidikan. Banyak kajian telah membuktikan bahawa AR memberikan banyak faedah dalam pendidikan. Walau bagaimanapun, tidak banyak kerja untuk penyiasatan mengenai soalan mengenai cara pembelajaran dengan AR berfungsi untuk pelajar, seperti cara ia memotivasikan minat belajar pelajar. Oleh itu, objektif kajian ini adalah untuk mengenal pasti ciri-ciri AR yang boleh meningkatkan motivasi pelajar, menilai kesan gabungan berbeza elemen multimedia terhadap motivasi dalam pengalaman pembelajaran AR, dan menilai bagaimana tahap interaktiviti yang berbeza-beza dalam persekitaran pembelajaran AR mempengaruhi motivasi pelajar. Untuk menerokainya, kajian literatur intensif telah dijalankan untuk mengenal pasti ciri-ciri yang boleh mempengaruhi motivasi pembelajaran. Satu eksperimen telah dijalankan untuk melakukan dua penilaian heuristik pada aplikasi pembelajaran AR sedia ada untuk mewajarkan hala tuju penyelidikan ini. Eksperimen ini telah

mengenal pasti beberapa garis panduan reka bentuk dan mengakui bahawa multimedia dan interaktiviti boleh menjadi calon untuk faktor nilai tambah dalam aplikasi pembelajaran AR yang boleh meningkatkan motivasi pembelajaran pelajar.

Untuk menyiasat lebih lanjut bagaimana multimedia dan interaktiviti mempengaruhi motivasi pembelajaran Pelajar, aplikasi pembelajaran AR mudah alih untuk pelajar mempelajari pengetahuan asas komputer, iaitu peranti storan sekunder, aplikasi realiti bertambah animasi (SDAAR) telah dibangunkan. Aplikasi ini dibuat fleksibel untuk menanamkan elemen multimedia dan interaktiviti yang berbeza.

Eksperimen seterusnya menyiasat pengaruh pelbagai gabungan elemen multimedia ke atas motivasi dan perubahan atau persepsi topik. Kajian reka bentuk antara subjek telah diterima pakai untuk menjalankan eksperimen reka bentuk faktorial perbandingan 3 x 2 dengan jumlah 144 peserta. Didapati bahawa untuk tahap taksonomi Bloom yang lebih rendah, animasi 3D dan penerangan audio adalah penting untuk mengekalkan perhatian pelajar. Animasi dan penerangan 3D yang akan disampaikan melalui penceritaan serentak dengan teks boleh memberikan pengalaman pembelajaran yang lebih memuaskan. Manakala penerangan melalui teks sahaja tidak digalakkan.

Eksperimen ketiga disiasat jika tahap interaktiviti yang lebih tinggi boleh meningkatkan motivasi pembelajaran dan penerimaan teknologi pelajar.

Dengan lapan keadaan eksperimen yang berbeza, satu kajian perbandingan telah dijalankan dengan seramai 87 orang peserta. Didapati bahawa interaktiviti boleh meningkatkan penerimaan teknologi pelajar dengan ketara terhadap ARLE. Tahap interaktiviti yang lebih tinggi boleh meningkatkan keyakinan pengguna berbanding tahap interaktiviti yang rendah.

Kajian ini menyumbang kepada bidang ini dengan memberikan pemahaman yang komprehensif tentang cara ciri khusus AR boleh meningkatkan motivasi pelajar. Ia mendedahkan kesan pelbagai gabungan multimedia dan tahap interaktiviti dalam persekitaran pembelajaran AR, menawarkan pandangan tentang cara faktor ini secara individu dan interaktif memberi kesan kepada motivasi. Pengetahuan ini boleh membimbing reka bentuk dan pelaksanaan alat pendidikan AR yang lebih berkesan, disesuaikan untuk memaksimumkan penglibatan pelajar dan hasil pembelajaran.

Kata Kunci: Pembelajaran Reality Imbuhan, Interactiviti, Multimedia, Motivasi

SDG: MATLAMAT 4: Pendidikan Berkualiti

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LIST OF ABBREVIATIONS

2D	Two Dimensional
3D	Three Dimensional
AR	Augmented Reality
mAR	mobile Augmented Reality
ARLE	Augmented Reality Learning Experiences
BARA	Brain Anatomy Revision Application
IMMS	Instructional Materials Motivation Survey
LO	Learning Object
PU	Perceived usefulness
PEOU	Perceived ease of use
SDAAR	Secondary Storage Device Animated Augmented Reality
TAM	Technology Acceptance Model
UI	User Interface
UPM	Universiti Putra Malaysia

CHAPTER 1

INTRODUCTION

1.1 Research Background

Augmented reality (AR) is a technology that superimposes digital content onto the real world. AR enhances the real world by adding computer-generated elements. There are various applications of AR across different fields. In recent years, the integration of AR technology in education has gained significant attention. AR applications have become a promising strategy to improve the learning process in the current era of technology-driven education. AR applications provide immersive and engaging learning experiences that attract and inspire students (Akçayır & Akçayır, 2017). The learning experiences facilitated by AR technology are defined as Augmented Reality Learning Experiences (ARLE) (Santos et al., 2014). The benefits of ARLEs include their support for kinesthetic learning, capacity for better visualization, ability to increase student motivation and engagement, satisfaction with learning, and knowledge retention (Alzahrani, 2020). The most frequently cited advantage is learning gain, which refers to increased student performance in the classroom, motivation is the second most mentioned benefit (Garzón & Acevedo, 2019).

Individuals are motivated to participate in learning activities by a variety of internal and external influences. The degree of a student's involvement, effort, and perseverance in acquiring knowledge and skills is greatly influenced by their motivation in the context of education. Therefore, understanding how different factors contribute to students' motivation is crucial for creating effective learning environments that foster engagement and achievement. Among all, multimedia elements and interactivities are the crucial factors (Chen & Liao, 2015; Kurniawan et al., 2018).

Previous research has shown that multimedia can significantly impact learners' motivation (Abdulrahaman et al., 2020; Ehrhart & Lindner, 2023). Visual media, such as pictures, and animations, can improve understanding, attention, and give concrete examples of abstract ideas. Similarly, audio elements, such as narration or background music, can evoke emotions, create an immersive atmosphere, and enhance information processing. Textual information, such as written instructions or captions, can complement visual and auditory content, providing additional context and supporting comprehension. By integrating multimedia elements, mobile AR applications can engage learners through multiple sensory channels, enhancing their understanding and motivation of learning. Furthermore, interactivity features within mobile AR applications enable students to actively participate in the learning process, promoting satisfaction and confidence in learning.

Interactivity is another key element that influences motivation in learning environments. The interactive nature of mobile augmented reality applications allows students to actively explore and manipulate virtual objects, fostering a sense of agency and autonomy, which enhances their motivation.

Understanding how different multimedia elements and interactivity within mobile AR applications impact learners' motivation is essential for designing effective educational interventions. This thesis intends to investigate the impact of various multimedia elements, such as visual media, audio, and textual information, as well as the influence of interactivity, on the motivation of learning utilising mobile augmented reality applications.

1.2 Motivation and Importance of Study

Studying the implementation of multimedia and interactivity in AR for learning can contribute to the design and development of learning environments. By understanding how learners interact with AR content, researchers can tailor the learning experiences for more effective educational interventions that cater to diverse learners.

Research in this area can contribute to the broader field of educational technology and instructional design. By investigating the impact of multimedia and interactivity in AR, researchers can contribute to the development of best practices, guidelines, and frameworks for integrating AR into educational contexts. The findings of the study will provide insight into the implementation of multimedia elements and interactivities that have a beneficial impact on learners' motivation in the context of mobile augmented reality applications. Educators, instructional designers, and developers will benefit from the findings' knowledge of the multimedia components and interactive features that maximise motivation and improve the learning process with mobile augmented reality applications.

1.3 Problem Statement

Many positive effects have been found when using AR in education to enhance learning performance, motivation, enjoyment, and engagement (Ali et al., 2022; Garzón et al., 2019; Liono et al., 2021; Majeed & Ali, 2020). However, it is still unclear exactly how AR is better at assisting learning than other learning technologies like mobile device learning applications or desktop learning settings. There has not been much research done on how learning with AR affects students, such as how it motivates their interest in learning (Buchner & Kerres, 2023). The features of AR applications that can help increase student motivation have not been specifically identified (Bacca et al., 2018), and it is not known how or why motivation is increased.

Although it was cited that multimedia elements and interactivity are crucial factors, there is limited understanding of how different combinations of multimedia elements and interactivity features impact learners' motivation within AR context. While research has explored the influence of multimedia (Ehrhart & Lindner, 2023; Lee & Osman, 2012) and interactivity (Hwang et al., 2013) on motivation in traditional educational settings, there is insufficient investigation into how these factors uniquely interact within mobile AR applications, which present distinct features and user experiences.

There is also a need to investigate how the integration of multimedia elements, such as 3D models, 3D animation, audio, and textual information, can be effectively utilized within mobile AR to enhance motivation. To maximize learners' motivation, it is also crucial to comprehend how interactive features, such as the ability to manipulate virtual objects, work in the mobile AR context.

Existing studies often overlook the examination of specific combinations or configurations of multimedia and interactivity within mobile AR applications. By investigating the influence of specific combinations, researchers can identify the most effective strategies for maximizing motivation and engagement in mobile AR learning environments.

Basically, the issues that we need to solve are

1. It is unclear how and what features in AR can assist in learning and increase learning motivation among students.
2. There is limited understanding of how different combinations of multimedia elements impact students' motivation within AR context.
3. The effects of varying combinations and quantities of interactive elements on motivation in AR learning remain unclear

1.4 Research objectives

This study aims to investigate the implementation of multimedia and interactivity in mobile augmented reality learning experiences to enhance undergraduate students' motivation of learning. The following objective were outlined to achieve the aim.:

1. To identify the development guidelines and features of AR that have potential to increase motivation of learning of students.
2. To determine the impact of various combination of multimedia elements in AR learning experiences on students' motivation.

3. To assess the impact of AR learning experience's level of interactivity on students' motivation.

1.5 Research Scope

This study focuses on investigating factors to enhance the motivation of students on the lower two levels of Bloom's taxonomy, namely remember and understand. Therefore, a simple prototype of mobile AR that can be used to teach computer secondary knowledge was developed. This knowledge can be useful to any student and can be used by any students. Only three computer secondary devices were chosen so that the learning time would not be too long. This ARLE can enhance students' understanding of computer secondary devices, their functionalities, and their relevance in the Information and communication technology (ICT) field.

The prototype was developed with a simple user interface (UI) to introduce the selected computer secondary devices. The UI provides interactive elements, such as 3D models, animations, and textual information, to explain the features, connections, and usage of each device. The prototype includes a short lesson that highlights the key aspects of the computer secondary devices, providing a foundation for further exploration and understanding. The UI design was made simple so that it would not divert the attention of users. Interactivities features were made simple to avoid introducing too many moderating factors or bias.

In this study, to increase the level of relevance among the participants, participants were recruited from undergraduate students in the field of ICT in Malaysia higher learning institutions. This target group was chosen to align with the context of ICT education and to understand the potential impact of multimedia and interactivity in mobile AR on their motivation for learning.

The primary focus of this research is to investigate the impact of multimedia and interactivity in mobile AR on the motivation for learning among ICT undergraduate students. Variables such as learning outcomes, effectiveness, or knowledge retention are not included in this study.

1.6 Outline of the Thesis Structure

This thesis consists of six chapters. The overview of each chapter in this paper is outlined as follows:

Chapter 1 provides the background of the study, problem statements, research objectives, project scope, and significance.

Chapter 2 consists of the literature review and background study on articles, journals, and published research papers related to this research. Some essential theoretical frameworks were also laid out. A summary provides an insight to this research.

Chapter 3 explains the research methodology and overall strategy that was taken and the flow that was used for the research investigation. It also comprises the development and implementation process for the application prototype.

Chapter 4 explains the details of experiment conducted to identify development guidelines and support research direction.

Chapter 5 shows the second experiment of this research, which comprises the details of the study of the impact of various combinations of multimedia elements in ARLE on students' motivation of learning.

Chapter 6 presents the third experiment of this research, which covers the details of the study of the impact of ARLE's interactivity on students' motivation of learning.

Chapter 7 draws a conclusion of this thesis, summarizes the research findings, lists out limitations of the current work, and suggests potential future works.

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