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RESEARCH ARTICLE

Effectiveness of Using Augmented Reality Application in the Subject of Educational Technology for Undergraduate Students

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ABSTRACT

In line with the Fourth Industrial Revolution's technological advancement, this study investigates the integration of Augmented Reality (AR) applications within higher education in Malaysia. Focusing on the field of Educational Technology, the research employs Cognitive Theory in Multimedia Learning as a foundational strategy for developing AR applications to enhance understanding of complex subject matter. The effectiveness of these AR applications is assessed through a quasi-experimental design, involving pre-test and post-test data collection with 56 undergraduate students at Universiti Teknologi Malaysia, Johor, Malaysia. A non-parametric analysis, the Wilcoxon Signed-Rank Test, is applied to measure the impact of AR application usage on the treatment group as compared to the control group. Results indicate a positive effect of AR-based learning methods on the educational experience of undergraduate students in the subject of Educational Technology. Additionally, student perceptions are examined through Likert scale questionnaires, revealing positive attitudes toward AR applications. To conclude, this study advocates for the integration of the Cognitive Theory of Multimedia Learning in AR applications, emphasizing its potential to enhance the efficacy of AR-based education within the context of Educational Technology for undergraduate students.

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1. INTRODUCTION

Education in Malaysia has, in recent years, focused on developing the concept of twenty-first century pedagogy and emphasizes the use of ICT in classrooms. Education system, as we know, always evolves and changes with the passage of time. The majority of educators and learners today possess mobile devices and are prepared to perform mobile learning. According to Ling et. al., (2020),the trend nowadays is to employ mobile technologies for educational purposes. Research also indicates that most educators and learners see the usage of mobile learning favorably. In the realm of Information and Communication Technology (ICT), one technology that has been gaining traction is Augmented Reality (AR). Augmented reality technology is characterized in computer science by its ability to superimpose virtual elements onto the real world, facilitate real-time interaction, and accurately register objects in three-dimensional space. Augmented Reality application enables more natural human-machine interactions and helps preserve and conserve the user's environment. This process can be achieved by integrating virtual objects with the real environment (Manikam et. al., 2023). AR applications in the classroom can help increase students' interest and engagement and students are better able to interact and collaborate with others. This shows that AR provides students with a variety of opportunities, increases students' motivation and improves academic achievement.

Using AR can also enrich students' learning experience and help them gain more knowledge through their surrounding environment. Pertaining to enhance the educational process, Augmented Reality has enormous potential, particularly in technical and vocational education. Combining offline and online learning resources is one notable application of AR technologies. By substituting virtual resources in place of costly equipment, such as laboratory supplies and equipment, it is possible to reduce costs (Halim et al., 2020).

According to Nurul' et al., (2022), the Augmented Reality (AR) approach can increase the effectiveness of learning activities through engagement mechanisms. AR technology can capture students' interest, thus simultaneously improving their performance and making their learning experience more enjoyable. The usage of AR system has been considered in a number of fields, demonstrating the value and advantages of doing so in business, marketing, and even education. The main pros of AR application in education are typically observed in the areas of student activities, affordability, and safety. When teaching practical skills in technical and vocational courses, AR can assist in presenting knowledge in a thorough and meaningful way (Halim et al., 2020). A significant correlation between students' motivation when using the enriched notes and an improvement in performance in the academic topic where it was used was the study's most vital contribution. In addition, it is proven that using Augmented Reality has a positive impact in learning (Cabero-Almenara et al., 2019).

AR technology will become common and can make it easier for students not only to read books but help in visualizing the content of the lesson. However, AR is not necessarily advantageous in all topics. Having said that, in a way, it helps students gain a better understanding of certain academic subjects and topics (Nadiah et al., 2019). Azuma (1997) stated that many college students find it difficult to understand and absorb complicated topics in disciplines like biology, physics, and engineering. By offering immersive and interactive visualization, AR may improve their comprehension. In undergraduate mathematics, traditional teaching strategies frequently fail to engage students and do not take into account of different learning preferences. Teachers might develop interactive mathematical simulations and models using Augmented Reality technology, resulting in a more interesting and individualised learning experience (Kerawalla et al., 2006). Liarokapis et al., (2004) noted that in undergraduate courses offered in the Educational Technology program, students frequently lack opportunities for practical application of theoretical concepts and hands-on learning. By utilising Augmented Reality technology, teachers can design hypothetical situations and environments that allow students to actively interact with educational technology resources and ideas, encouraging a more hands-on and interactive approach to learning. Traditionally explained through textual explanations and two-dimensional graphics, complex notions and theories are difficult for undergraduate students studying educational technology to understand. Since AR offers immersive visualisations that are interactive, it has the potential to improve students' learning experiences by promoting a deeper comprehension of Educational Technology topics (Bacca et al., 2014).

2. LITERATURE REVIEW

2.1 Educational technology

Inquiry into how technology might be used to improve learning is often referred to as the field of Educational Technology (Jenkinson, 2009). The multifaceted field of Educational Technology is currently going through a period of expansion. With the founding of the Institute of Educational Technology in 1969, early works on the United Kingdom's Open University gave Educational Technology a significant boost as an applied educational science(Issroff et al., 2002). According to Agodini (2003) tools have long been used in schools as part of teaching and learning. For example, textbooks, televisions, videotape players, and computers are often found in modern classrooms, and many secondary schools have classrooms equipped with tools used in commercial and manufacturing operations. All of these tools can be broadly considered forms of Educational Technology. Technology, in this context, is defined as computers and, in particular, technology applications created to support teaching and learning sessions.

According to Mishra et al., (2009) Educational Technology is one of the studies that facilitates learning and improves achievement through the creation, use, and management of technological processes and resources. One way to improve education is to harness the potential of new technologies. Keeping up with technology requires continuous learning and training. Teachers who do not keep up with the latest Educational Technology developments such as using technology tools will most likely be left behind. Educators today have the option of upgrading and devoting time to learning new features, or staying with the status quo and using what they are familiar. The latter option boosts productivity temporarily but ultimately hurts it for two reasons. First, new features which have the potential to increase efficiency are unfortunately never applied. Second, research demonstrates that individuals who use the new features tend to become more productive than those who do not.

The use of new technologies in education involves methodical and well-organized procedures and strategies. According to Stosic (2015) effectiveness, depth of knowledge, and other aspects of education can all be improved through Educational Technology. It is a methodical approach to planning the implementation and evaluation of the educational process. When using Educational Technology, priority should be placed on the educational value of the tool, the extent to which it is suitable for knowledge acquisition, whether there is interaction between the user and the tool, and whether its use produces positive results. Students can freely master course material with the help of Educational Technology, choose their own pace, repeat any topics that are not clear enough, get immediate feedback after assessment, and monitor their progress. Modern learning has many advantages over conventional learning, especially through the use of interactive multimedia content, and receiving instructor and student feedback when using teaching technology. The use of Educational Technology and conventional teaching differ in several important ways. However, a study by the Center for Educational Research in Pittsburgh in the context of Individualized Instruction revealed that computers are more effective than teachers in matching individuals' specific learning styles.

For the purposes of enhancing academic learning objectives in K–12 classrooms, Cheung et al., (2013) define Educational Technology as a range of technology-based programs or application that support the learning process rather than teaching users how to use the technology. Educational Technology is increasingly becoming an important element in improving student teaching and learning. To achieve these goals, teachers must be able to incorporate technology into their instructional strategies. According to research, particularly in the field of Educational Technology, kids do not display 'technostress', a sort of stress connected to the introduction of technology, because they have a relatively thorough understanding of it as compared to adults (Fernández-Batanero et al., 2021). According to Bogart et al., (2016) the study discovered that students generally believed that Educational Technology tools were beneficial. This might be because teachers were able to create new teaching methods for their classes using the technology. Students, in fact, felt that they could learn more effectively in a technologically enhanced learning environment than they could in a typical classroom as a result.

2.2 Augmented reality technology

Augmented Reality technology has advanced along with various types of hardware, notably with the introduction of countless devices and mobile application. Hanid et al., (2020) stated that Augmented Reality technology can improve spatial imagination by utilizing a digital plane that is merely a simulation. AR is currently becoming popular in education. Cinema, in the opinion of cinematographer Morton Heilig, is an activity that may captivate the audience by successfully engaging all of their senses. According to Carmigniani et al., (2011) Augmented Reality first appeared in 1950s. Augmented reality is the physical environment of the real world enhanced by the inclusion of computer-generated virtual data in the form of Augmented Reality. By incorporating virtual data into both the immediate environment and any indirect view of the real environment, Augmented Reality attempts to make the user's life easier. Teachers using AR were able to create interesting teaching strategies/approaches for their classes using AR. Application for Augmented Reality that calls for both the removal of physical objects from the environment and the insertion of virtual objects are known as mediated or decreased reality. The equivalence of removing an object from the

real environment is to cover it with virtual data that matches the background, giving the user the impression that the object is absent.

With the use of Augmented Reality, which is still a relatively new technology, the virtual and physical worlds can be mixed in different ways to provide a level of immersion that other virtual devices are unable to match. Recent developments in computer and image processing technology enable the deployment of AR devices outside of indoor settings. For example, AR devices are used in surgical sessions and inspections in hazardous environments. This is to support complex analysis, decision making and control processes. Most systems from AR only work indoors and cover small areas. With the advancement of computers, image processing, and wireless technology, complex analysis can be supported and management processes can be facilitated (Zlatanova, 2002). In order to evaluate the level of operation and pinpoint urgent issues that require more research, the researcher looked at how outside wireless systems are now set up. The focus is on techniques, apparatus, systems, and tools that can be used to deliver augmented information to mobile users in the form of texts, images or more. Augmented Reality system encompasses the creation of a single environment by fusing the interactive digitally generated world with the interactive actual world. As AR is completely interwoven with the real environment, the virtual person responds as the user moves around in it.

Furthermore, although virtual things are not physically present, they can move, and that movement is still observed. The study by Zlatanova, (2002) claims that there are three main issues with wireless AR devices. The first is to match virtual objects with actual ones by fusing the physical world with computer-generated imagery. Depending on the method employed, AR systems must provide users with the impression of an integrated work environment. AR systems come in a variety of shapes and are divided into various categories. The AR system must therefore determine the direction, position, and speed of movement in important situation. The third issue has to do with wireless interaction between the computer and the user. Thus, without addressing some of the more widespread problems for mobile users and virtual reality systems, an overview of wireless AR systems cannot be considered complete (Zlatanova, 2002).

Additionally, Augmented Reality is becoming a widespread notion and, for many, a necessary component of daily life. Although the technology to achieve this has existed for a while, AR has only lately been "feasible" on consumer devices. The public has finally gained access to AR thanks to the Flash implementation of its identification algorithms and the rising popularity of mobile operating systems like Android and iOS. AR is already present in our audio and visual media, such as entertainment, journalism, etc., and is only starting to make a meaningful impact in other areas. There are many applications of Augmented Reality, but the opportunities it offers for education are regarded as the most promising. Learning can become a reality with AR and through it, students can have instant access to various location-specific information compiled and provided by various sources. The term AR refers to a broad range of technologies that overlay text, video, and other computer-generated media on top of a user's perspective of the physical world. Virtual reality and Augmented Reality are closely related since Augmented Reality is a development of VR. People may have first come across web application that let them read quick response codes (QR) via their webcams. For instance, digital data, such as 3D animations, can be connected to an image on paper or another surface by utilizing a QR code (marker). Users of the AR application can project digital content over their actual environment on the screen using a computer by holding the marker in front of the webcam. The digital material typically moves and rotates together with the marker (Yuen et al., 2011).

Today, almost everyone owns a cell phone and may utilize AR application without extra hardware, according to Hsieh, (2021) . Between VR, AR, and MR, AR is the least expensive and most user-friendly application. Three characteristics define AR: a blend of actual and virtual reality, in-the-moment interaction, and 3D perspective. Marker based, marker less, and location-based for AR are the three different types of AR triggers. The fiducial marker and the QR code, which humans can recognize as a picture, are two examples of marker-based Augmented Reality. Graphics, pictures, and other pertinent elements are included in marker less Augmented Reality. People are unable to recognize the image because of its attribute. Utilizing GPS to determine the user's location, AR overlays 2D, 3D, and virtual information onto real-world environments through a location-based webpage displayed on a mobile device. As of today, the application of Augmented Reality has increased rapidly,

particularly in the field of education. Related studies have revealed a rising demand for information on how long Augmented Reality in education will be sustainable, however, according to Hsieh, (2021) the significance and advantages of AR application in education have been virtually undisputed. A lot of facets of daily living are also gradually incorporating AR. Teachers, in this context, employ AR digital resources in the classroom to help students think more critically by making connections to practical experiences.

2.3 Augmented reality in education

Researchers discuss some of the benefits and drawbacks of its application to teaching and to various scientific disciplines. Additionally, they contrast how using AR and traditional learning affects pupils. The usage of AR is advantageous in the teaching of technical courses since it tends to make the teacher's job easier. Teachers are not required to describe every part of the student's device while using AR application in a lab. With smart gadgets like a smartphone, tablet, and other mobile devices, this information is accessible in real-time. In the lab, students are encouraged to exercise more work autonomy. This application should be supplemented with a communication module with a teacher who can correct any ambiguity (Martin et al., 2018). According to Kesim et al. (2012), Augmented Reality technology is not a recent development. It is widely used in a variety of industries, including the military, healthcare, engineering, manufacturing, and others. For example, the usage of AR can enhance group projects. This entails creating a cutting-edge computer interface that merges the virtual and physical worlds to improve in-person and remote cooperation. AR application encourages face-to-face interaction over multi-screen interactions. However, when a webcam is directed at the book, designed visualizations and interactivity are visible. In this context, the book is printed as usual. The computer can be configured to accomplish this by installing specialized software, using specialized mobile application, or via websites. Any existing book can be converted into an Augmented Reality edition using this technology once it has been published. The simplest approach to connect two disparate worlds is through 3D objects, diverse media and imagination, simulations with variety interactions. The printed page of a textbook can be made to appear alive with Augmented Reality. This enables even those without computer literacy to enjoy rich interactive experiences.

According to Iatsyshyn, (2020) AR in education necessitates the creation of fresh approaches, instructional materials, and revised curricula. The fundamental tenets of applying Augmented Reality to education include creating a flexible environment, adapting educational content to incorporate required materials, developing research techniques that can be applied to education with Augmented Reality elements, and creating adaptive materials. The researcher highlighted that a taxonomy of AR technology for education is proposed, along with examples including AR maps, tutorials, and textbooks that describe the usage of AR technology. The outcomes of an educational experiment in which students were split into an treatment and control group were also discussed in this study. The control group finished the identical educational module using textbooks and conventional techniques, whereas the experimental group used Augmented Reality (AR) technology to try to complete the "Solar System and Beyond" module. The study discovered that the experimental group had greater achievement levels and more favorable opinions about the course (Iatsyshyn, 2020).

According to Nincarean et al., (2013) the development of modern technology has altered the nature of education, particularly when technology is used in conjunction with suitable and acceptable pedagogical foundations. This combination opens up new possibilities for raising the standard of the teaching and learning process. One of the newest technologies, Augmented Reality, for instance, offers a fresh approach to education. Teachers are constantly seeking for ways to incorporate new technologies into their classrooms to improve the learning experience for students to keep up with the latest development in information technology. Educational academics are rapidly recognizing the promise of AR as an emerging technology with significant educational applications. The capacity to link the virtual and physical worlds opens up new possibilities for raising the standard of teaching and learning processes. When AR is used in conjunction with other technologies, such as mobile devices, its effectiveness may be further increased. The term Mobile Augmented Reality (MAR) is used to describe AR when it is integrated with cutting-edge technologies like mobile devices.

The application of Augmented Reality in education is gaining traction. Augmented Reality technology can be used to recognize and label real-world objects. The use of AR technology, which combines the capabilities of conventional and computer-based teaching methods, has an impact on the quality of independent learners' and general secondary learners' educational experiences. This study thus strengthens the argument for using Augmented Reality technology in education and illuminates its potential applications. The use of Augmented Reality in teaching opens up new possibilities and enables the development of visual representations of educational materials by implementing this AR technology in the learning environment and supplementing it with relevant visual data. With better spatial imagination, students are better able to understand processes, properties, and prove theorems more deeply (Gurevych et al., 2021).

Research question

This study was also conducted to investigate the following research questions:

i. What is the achievement level of undergraduate students for the subject of Educational Technology by using the Augmented Reality application based on Cognitive Theory of Multimedia Learning before and after intervention?
ii. What is the perception of undergraduate students for the subject of Educational Technology by using the Augmented Reality application based on Cognitive Theory of Multimedia Learning in the aspects;
    a) Knowledge?
    b) Effectiveness?
    c) Use?

3. CONCEPTUAL FRAMEWORK

The conceptual framework, according to Crandall et al., (2015), can be utilised to guide future research and practice. Conceptual modelling is the abstraction of real-world components to the right degree of abstraction depending on the issue. It is the first stage of a modelling project, and it influences and directs all subsequent phases. Cognitive Theory of Multimedia Learning forms the basis of the study goals, combined with Augmented Reality elements and Educational Technology elements. Therefore, in developing an Augmented Reality application, Augmented Reality elements will be used and mutually supported by Educational Technology elements. The Education Technology elements are incorporated in the learning content for the problem-solving process in the Educational Technology subject. The combination of all these elements culminates in the formation of a conceptual framework. This framework is aimed at addressing Research Question Two which entails students' knowledge, effectiveness and perception towards the use of Augmented Reality application. Figure 1 shows the illustrated conceptual framework for this study.

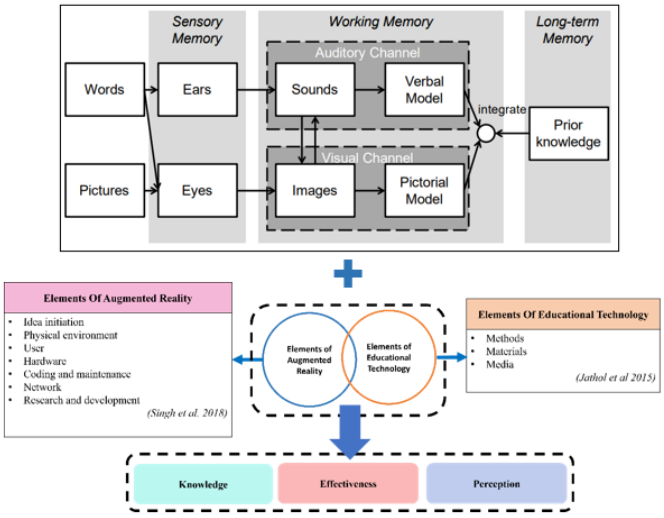


Figure 1: Conceptual framework

In order to achieve the purpose and aim of the study, a conceptual framework is required. The conceptual framework is developed in such a way so as to be more oriented towards the objectives of the study. The Cognitive Theory of Multimedia Learning, which is the foundation for creating learning materials of Educational Technology subject, is applied in the development of Augmented Reality application. With the use of the Augmented Reality application medium, the content of the educational material is displayed. As a result, the developed Augmented Reality application adapting elements of the Augmented Reality system based on Singh et al, (2018) are then meticulously and methodically combined with elements of Educational Technology (Jathol et al., 2015). By identifying design components for Augmented Reality apps, researchers have since created and developed Augmented Reality application. According to a study by Singh et al, (2018) seven basic elements are used in the design of Augmented Reality application development. Amongst others, Initiation of ideas, physical environment, user, hardware, coding and maintenance, cloud and networking, and finally research and development are the seven key components of Augmented Reality development.

These components are employed in the creation of Augmented Reality application in the context of this study. Beginning with the idea initiation, researchers consider how AR will be utilised and what type of assistance and setup are required for users. Physical environment in which the AR application will be used must be known in advance. The next term is "user," which refers to a person with the abilities to use, operate, and alter Augmented Reality. Hardware devices, such as smartphones or tablets, are tools that consumers will employ to carry out specific tasks. Coding enables AR technology to get instructions regarding how to perform tasks and what steps will direct users to perform tasks. To fix any issues with the AR code, maintenance is needed. The network over which AR data will be transmitted is necessary. The network unit will be the conduit via which all data about objects and methods of doing tasks will be transmitted. Since no system is 100% efficient, research and development (R&D) aims to improve existing systems. R&D is therefore a crucial component in making the system more user-friendly. In the context of this study, the production of materials in project-based learning is implemented based on Educational Technology elements adapted from Jathol et al., (2015) namely materials, methods and media. Materials here refer to materials used in the production of student projects such as handout notes or notes from the slides. The method is the way students solve problems, which is by watching instructional videos through AR, while the media is the medium used to convey and deliver solutions to problems, which in this case refers to students using the AR application.

4. DEVELOPMENT OF EduTECH-AR

The Augmented Reality application, named as EduTech-AR was developed in this study. In general, this framework for developing Augmented Reality application is based on the ADDIE design model that divides the work process into five phases which is analysis, design, development, implementation, and evaluation (Molenda, 2003) . This is because the ADDIE Model is used to describe a systematic approach to teaching development and is essentially synonymous with the development of educational systems.

EduTech-AR development requires both software and hardware prerequisites. Every hardware and software used has an impact on the creation of Augmented Reality applications. In this study, the software required is Unity, which is a game engine platform that helps in producing a program or game in 2D and 3D interactively, Visual Basic Studio and Android. The hardware required is a laptop, smartphone or tablet and also an AR Marker which is a target image for users to scan into the application.

4.1 Information design of EduTech-AR

The process of organizing and arranging the strategy for delivering the content and information is as follows. A software flow chart serves as a summary of all the stages. A flow chart is a method that explains the process and flow of an AR application from the beginning to the end. Figure 2 shows the flowchart of the developed EduTech-AR.

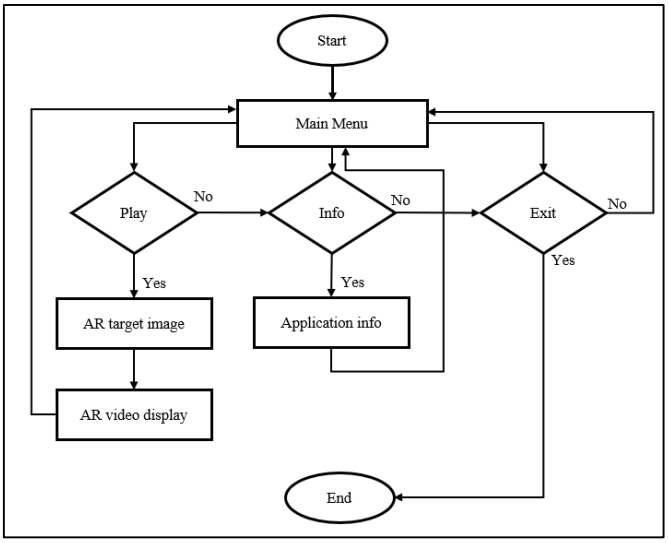
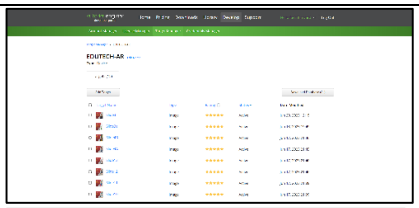


Figure 2: Flowchart of EduTech-AR

In the development of EduTech-AR, the researcher has been guided by the study from Singh et al., (2018) who found that there are seven elements of Augmented Reality which are 'initiation of ideas, physical environment, users, hardware, coding and maintenance, cloud and networking, and finally research and development'. Implementation in the design of this study is detailed in Table 1.

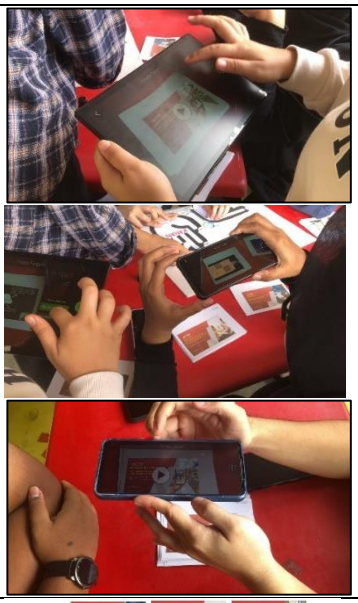
Table 1: Elements of augmented reality application

Elements	Explanation	Display
Initiation of ideas	Applications for Augmented Reality will be used in the context of educational technologies.	
Physical environment	Applications for Augmented Reality will be utilised to enhance learning both inside and outside of the classroom.	
User	Users include relevant lecturers and undergraduate students.	
Hardware	An Android-powered smartphone serves as a necessary hardware.	 

Coding and maintenance	EduTech-AR uses Unity software version 2022 and the Vuforia plugin.	
Cloud and networking	The video displayed in Augmented Reality will be placed on the hosting server and the video will not be embedded in the application to reduce the size of the application.	
Research and Development	EduTech-AR that has been developed depends on the Vuforia plugin used and the existing technology can be upgraded based on the capabilities of the current user device.	 

Next, EduTech-AR was created using the elements of Educational Technology based on Jathol et al., (2015).

Table 2: Elements of educational technology

Elements	Explanation	Display
Method	EduTech-AR uses devices such as smartphones and tablets as a method in teaching-learning situations.	
Materials	This AR application uses AR markers for students to scan the markers to display teaching videos related to Educational Technology topics.	

Media	EduTech-AR combines audio, visual, and video elements in producing a teaching video that features the presenter's voice and slide-based visuals. This is a teaching tool meant to enhance efficiency in instruction and encourage improved learning outcomes.	 

4.2 Interaction design of EduTech AR

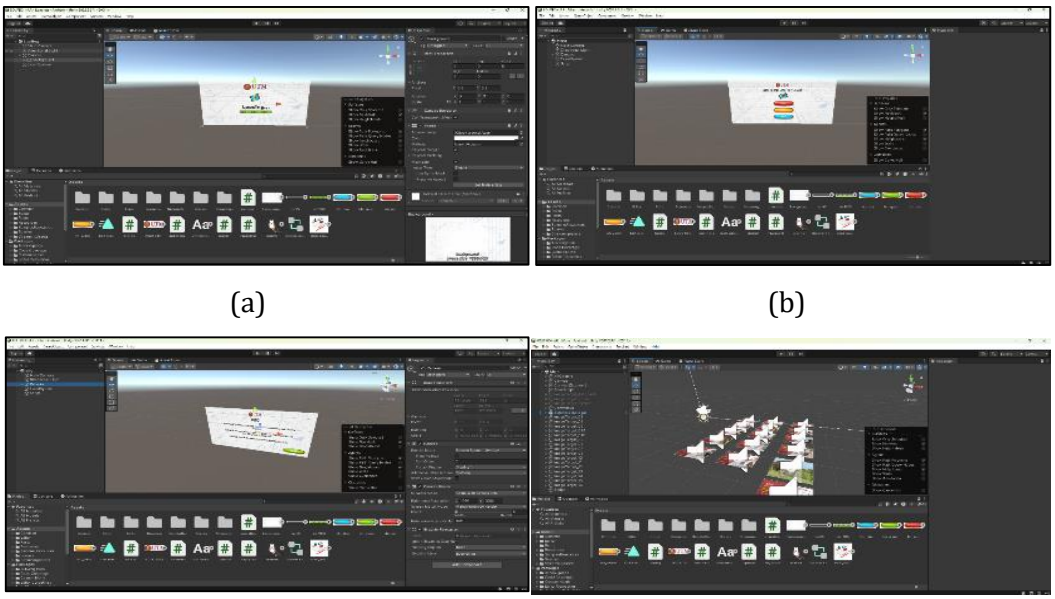
Interaction design determines the operation of functional coswers. The user has influence over the software flow process, designing the structure, or trip pattern when it is sketched out like a navigation system. Table 3 shows the interaction design structure.

Table 3: Interaction design structure

No.	Icon	Navigation Page
1.		
2.		
3.		Exit the application
4.		

4.3 Interface design of EduTech AR

Interface design plays an important role in an application that is produced because through a good interface, it is easier for users to use the application and smoothens the journey in using EduTech-AR. Figure 3 shows the main interface for the EduTech-AR application. Figure 3(a) shows the development of Main Menu. Next is the development of Interface Page as shown in Figure 3(b). Next, Figure 3(c) shows the development of Info Page and Figure 3(d) shows the development of AR Target Image (Marker).

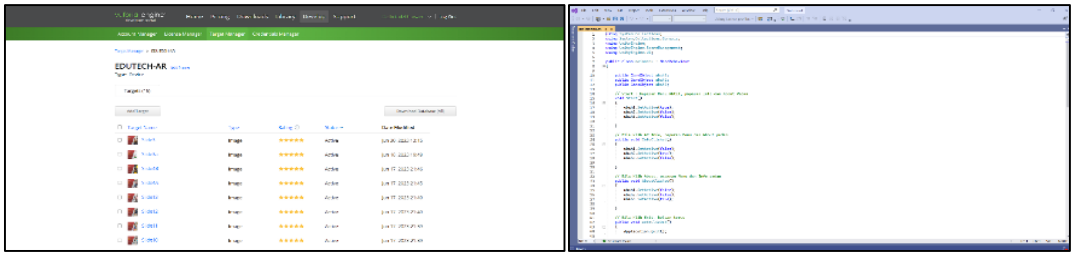


(a) (b)

(c) (d)

Figure 3: Development of main interface of EduTech-AR

Figure 4 shows the plugin and editor for EduTech-AR. Figure 4(a) shows the Vuforia plugin server for the target image (marker) and Figure 4(b) shows the script editor using Visual Basic Studio.



(a) (b)

Figure 4: Plugin and editor EduTech-AR

Figure 5 shows the interface of EduTech-AR application for user. Figure 5(a) shows the interface page displaying a start page that automatically shows 'loading' and then to the main menu page as shown in Figure 5(b). Figure 5(c) shows a page that displays an AR teaching video based on the target image (marker) scanned by the user. The target image provided contains all learning topics for Educational Technology subject as shown in the Figure 5(d) below. Figure 5(e) shows the page that displays information related to EduTech-AR.

(a) (b) (c)

(d) (e)

Figure 5: Interface of EduTech-AR

5. METHODOLOGY

This study applied a quasi-experimental, quantitative method. This type of experiment requires the selection of one or more outcome measures and a sample of customers or other units of analysis (Thyer, 2012). In this study, there are two groups, i.e., the treatment group and the control group. The teaching and learning method received by the control group is conventional which uses learning materials such as notes from slides or handouts. A week before the treatment, students from both groups were given a pre-test and an explanation of the implementation of this research. Then, the treatment was carried out to both groups for four weeks. Students carried out planned activities while being monitored by lecturers from time to time. The following week, both groups were given a post-test form. Scores from the pre-test and post-test were collected and compared to see the changes that occurred in the achievement levels of the students of both groups before and after receiving the treatment. In total, this study was conducted for nine weeks. Figure 6 shows the research procedure.

5.1 Research procedure

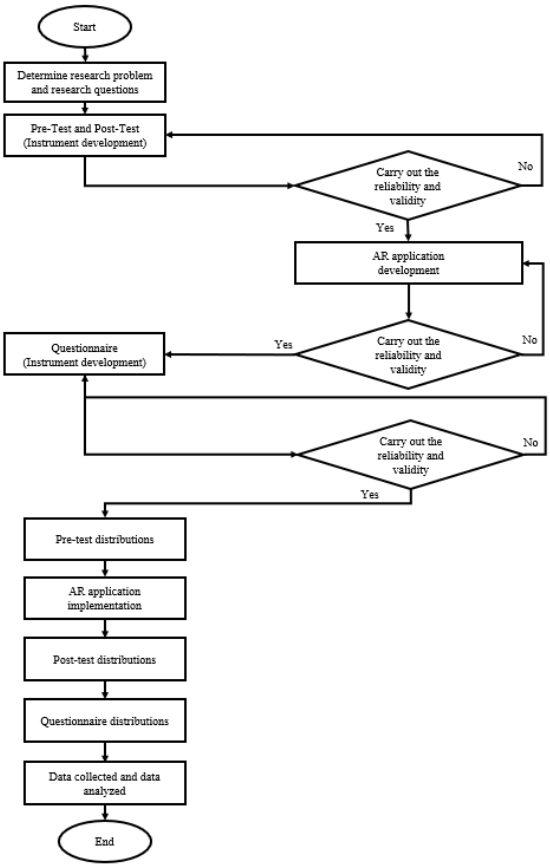


Figure 6: Research procedure

An effective way to determine sample size is needed. The population in this study is a total of 160 undergraduate students taking educational technology subjects at UTM. The number of samples selected is 56 students from two sections. A correlation coefficient is a number that indicates how closely two variables are related. The range of r values is +1.00 to -1.00. The Pearson correlation coefficient is 0.947, which is quite close to 1. This leads to the conclusion that the first score and the second score variable have a significant association. The instruments were developed to achieve the objectives in this study. This instrument also went through verification tests by experts to ensure the validity and reliability of the instrument to be carried out with the sample. The researcher distributed the pre-test form and post-test form to the sample within the stipulated period, after which the data was collected and analyzed to determine the difference in the results between the two tests conducted. After that, the questionnaire was distributed to both sample groups and the data was then collected and analyzed. A pilot study to obtain the validity and reliability of the research instrument had also been conducted. The instrument was evaluated by two experts in the field of Educational

Technology while the reliability of the instrument was tested with 15 different students from the actual study sample.

5.2 Data analysis

Analysis was conducted based on the data obtained from the pre-test and post-test for the control group and the treatment group. According to Astuti et al., (2021), the signed modified Wilcoxon Signed-Rank Test is used to determine whether two sets of data are different, whether observations before and after treatment are comparable, and whether a treatment is effective. The data obtained from this study were initially analyzed using the Statistical Package for Social Science (SPSS) software. Further analysis is required, utilizing a non-parametric test, specifically the Wilcoxon Signed-Rank Test. This choice is based on the observation that the data distributions of the post-test control and treatment groups are not normal and, therefore, considered non-normal.

6. RESULTS AND FINDINGS

6.1 Analysis of student's level of achievement for the subject educational technology

Table 4: Analysis of student's level of achievement for pre-test control and treatment group

Score Pre-test Treatment Group Score Pre-test Control Group	
Z	- 0.764[b]
Asymp. Sig. (2-tailed)	0.445

To evaluate the effectiveness of the Augmented Reality application, we have conducted an Augmented Reality application experiment related to its use for undergraduate students in Educational Technology at UTM. The Wilcoxon Signed-Rank test was used to determine whether two data sets were different, whether pre- and post-treatment observations were comparable, and whether a treatment was effective. According to Table 4, it is clear that there is no significance difference between the achievement level of undergraduate students for control and treatment group before intervention ($p > 0.05$).

Table 5: Analysis of student's level of achievement for post-test control and treatment group

Score Post-test Treatment Group Score Post-test Control Group	
Z	- 4.636[b]
Asymp. Sig. (2-tailed)	0.001

Although the pre-test scores of this study did not show a significant difference between the two groups, it was the opposite in the post-test of this study. As shown in Table 5, the results indicate that students in the treatment group had better learning achievement than those who were taught conventionally. According to Table 5 it is clear that there are significant differences between the achievement level of undergraduate students for control and treatment group after intervention ($p < 0.05$).

6.2 Analysis of the perception of undergraduate students using augmented reality applications

Table 6: Analysis of overall students' perceptions towards the use of augmented reality application.

Aspect	**Overall Mean**	**Mean Interpretation**
Knowledge level of Augmented Reality application	3.71	High
The effectiveness towards the use of Augmented Reality application	4.37	Very high
Perception towards the use of Augmented Reality application	4.02	High

Based on the table 6, the level of knowledge of the Augmented Reality application achieved a mean value of 3.71 (high), the effectiveness of the use of the Augmented Reality application with a mean value of 4.37 (Very high) and the student's perception of the use of the Augmented Reality application had a mean value of 4.02 (High). Referring to this data, the level of effectiveness towards the use of Augmented Reality applications is the highest and the level of knowledge of Augmented Reality application is the lowest. Mean interpretation shows that students' perception of the effectiveness of using Augmented Reality applications is at a high level.

7. DISCUSSION

Based on the discussion for this study, the effectiveness of using Augmented Reality applications in the Educational Technology subject is evident. Referring to the analysis that has been carried out, there is a significance difference between the achievement level of undergraduate students for control group before and after intervention. According to research Fahrudin et al., (2021), a conventional notion is a learning process in which the teaching and learning process is very repetitious and verbal, as well as a teaching and learning process that is centred on the teacher. Students rely on the teacher to determine whether or not an answer is correct. Children that have this kind of encounter may have a limited perspective. As a result, kids are not exposed to quality and excellent sources of information. The conventional approach may be defined as a learning approach that is more focused on the teacher, communication is more one-way from the teacher to the students, and the learning technique is more focused on concept mastery rather than competence. Not only that, students passively receive information; learning is very abstract and theoretical and does not rely on the reality of life; students' study time is mostly used to work on homework, listen to the teacher's lecture, and complete the exercises individually (Dewi, 2018). However, some research claims that there is a distinction in the impact of employing Augmented Reality (AR) on student learning outcomes, with academic achievement being the evaluated outcome. Researchers discovered that compared to students who do not utilise AR, those students have greater levels of algorithmic design expertise and algorithm efficiency (Ou Yang et al., 2023). Additionally, a study by Cao et al.,(2023) demonstrates that AR-assisted education fosters more positive results in higher learning accomplishment when compared to traditional approaches.

Besides, analysis of student's level of achievement for treatment group before and after intervention shows that there is a significance difference between the achievement level of undergraduate students for treatment group before and after intervention. This is consistent with the study by Herman et al., (2023) one of the factors that can improve learning outcomes is the use of learning media. Based on the study, it can be concluded that the use of learning media with Augmented Reality (AR) is effective in learning because students can see for real and directly imagine the results of the learning process. Augmented Reality learning media helps students visualize abstract concepts through the structure of an object for better understanding . According to the results of the study by Nordin et al., (2022), teaching materials designed with enhanced Augmented Reality technology have a positive effect in increasing the motivation of university students towards completion of their studies. Besides, based on the findings of the study by Amalia et al., (2023) it can be concluded that there is a positive impact on the use of holograms in the learning process. The researcher stated that Augmented Reality- combining holograms with learning videos can improve students' critical thinking skills. This is because students are able to focus during the learning process and digital 3-dimensional objects are able to help convey information to students to make learning easier.

AR is a multimedia-enhanced technology. According to the research by Santos et al., (2016) visualising knowledge in a context-rich environment utilising AR can assist students in making a meaningful connection between the content and the real world. This encourages more thorough knowledge as well as more cues to recall. The cognitive process of integrating new information with current knowledge is aided by the presence of multimedia. By eliminating or adding features, they can make the artwork more abstract or contextual. In the case of AR, the environment is provided, and the author of AR learning content must make innovative use of it. According to Gopalan et al., (2018) many aspects were used in the development of an effective AR project. Previous AR projects' features are classified based on multimedia elements such as text, audio, images, video, and animation, as well as three-dimensional models (3D) as supplementary elements. Meanwhile, the presentation mode and sensory modality viewpoints are centred on the learner's information

processing system and presume that humans process information through sight and hearing. Although the definition of multimedia focuses on the presentation of information and the use of sensory modalities to understand information, delivery media is also vital for efficiently delivering content. As a result, AR has been introduced so that students may see what they have learnt and what they need to study. Consequently, AR technology has lowered the barriers to multimedia learning that uses aural and visual resources rather than words and images. According to Mohd Fadzil & Mohd Noor, (2023) an Augmented Reality application that applies multimedia elements can have a positive impact on the students' learning environment, especially in face-to-face or mobile learning.

AR is another technology that may be accessible via mobile technology. According to research by Rahmat et al., (2023) mobile-based technology has the potential to improve education using AR. The study discovered that students who utilised mobile Augmented Reality in the implementation study had greater learning accomplishment criterion than students who used textbooks. Students claim that using mobile Augmented Reality technology in learning subjects makes the learning environment more engaging, makes it simpler for students to understand concepts by incorporating visual 3D simulations, creates a fun learning environment, and affects learning achievement. Furthermore, it was mentioned by Sung et al., (2016) that mobile technology has a significant potential to enable more innovative instructional methods. At the same time, this pattern in educational methods may aid not only in subject matter acquisition, but also in the development of communication, problem solving, creativity, and other high-level talents in students.

Next, analysis of student's level of achievement for pre-test for control and treatment group before the intervention shows that there is no significance difference between the achievement level of undergraduate students for control group before the intervention. According to research by Maulana et al., (2020) the pre-test scores for the control group and the treatment group were not significantly different from one another. Besides, a study by Pham, (2023) also that indicates that the findings demonstrate that pre-test scores for the control group and the treatment group are not significantly different from one another because presumably students in the control and experimental groups have the same level of knowledge. Analysis of student's level of achievement for post-test for control and treatment group after the intervention shows that there is a significant difference between the achievement level of undergraduate students for control group after the intervention. The findings of the study, according to Anugerah et al., (2023) demonstrate that students who use Augmented Reality application have a notable improvement. The analysis performed, which demonstrates the significant differences between the experimental group and the control group, serves as proof of this. The findings of the study demonstrate that the use of Augmented Reality improves learning outcomes. It can be argued that Augmented Reality media is proven to have an impact on student learning outcomes based on study by Danti et al., (2023). The presentation of research results and the discussion of previous research in their study, supports the claim. The learning outcomes for students who use Augmented Reality application also showed notable improvement. The use of Augmented Reality application can as well help students develop their critical-thinking and creative-imagination skills apart from providing stimuli that can help them learn more effectively.

Based on the discussion above, it can be deduced that the effectiveness of using Augmented Reality application in Educational Technology subject is evident. According to Johar et al., 2018) to some extent, the use of technology in education has opened new avenues in teaching and learning methods, in addition to assisting teachers in changing their delivery methods and approaches, besides making the teaching and learning process more exciting and participatory. This module features various multimedia elements to generate a more pleasurable learning method among students, especially in grasping challenging components. Using Augmented Reality has the advantage of considerably encouraging and improving students' learning accomplishment, despite several problems encountered throughout the development and application of AR in education (Akçayır et al., 2017). According to Rodzian et al, (2023), Augmented Reality can also be used as a self-learning tool that is very easy to be employed by students of all ages, and the learning process becomes very interesting and can be improved with the presence of interactivity and the involvement of the students themselves. Furthermore, the use of learning materials is very helpful in increasing the students' motivation to give full concentration to their learning due to the existence of 3-dimensional models that are available.

8. CONCLUSIONS

This study shows that there is a significant difference for students in the control group and the treatment group before and after the intervention by using Augmented Reality application learning approach compared to conventional learning. This is explained through the conceptual framework that has been developed which includes the Cognitive Theory of Multimedia Learning as the basis of theoretical reference that is combined with elements of Augmented Reality and the elements of Educational Technology. The findings of this study can further strengthen the Cognitive Theory of Multimedia Learning which emphasizes the need to structure multimedia teaching practices and use more effective cognitive strategies to help students learn more effectively. By using Cognitive Theory of Multimedia Learning, the study demonstrates that AR application improves cognitive abilities that help students organize information in a more orderly and systematic manner. Based on this study, the findings show that students in the treatment group achieved better than the control group. This explains that the intervention carried out has been able to improve students' skills and achievement in problem solving strategies in the subject of Educational Technology by using Augmented Reality application.

The findings of this study indicate that using Augmented Reality application in conjunction with the Cognitive Theory of Multimedia Learning approach to learning educational technology topics can boost student accomplishment. The Augmented Reality application, which is a technology associated with the Fourth Industrial Revolution, has been shown to be capable of attracting the interest and motivation of students in learning sessions. Furthermore, this programme can help students study a tough topic in a more enjoyable and effective manner. The use of Augmented Reality application in learning Educational Technology topics can boost students' interest and motivation in the course, as well as make it simpler to retain the subject's information. The material offered to students can be presented in a more user-friendly manner using technology, allowing them to have a more concrete learning experience. Many countries are making significant investments in the integration of technology into the education system in order to ensure quality education delivery and to equip their citizens to meet the needs of a modern society. A variety of ideas, methods, and technologies can be employed in education, particularly in situations that are unseen, intangible, or difficult. This educational technology breakthrough promotes and enriches education by overcoming the shortcomings of traditional techniques.

This Augmented Reality application is one of the teaching aids that teachers and students can use during teaching and learning sessions. This programme can assist teachers by providing mobile learning capabilities that can be utilised in class, outside of class, or anywhere and at any time. Learning strategies utilising Augmented Reality application with the deployment of Cognitive Theory of Multimedia Learning in the field of Educational Technology can be seen to have a good impact in enhancing students' interest and comprehension of the issue. The researcher also was able to identify the level of knowledge, effectiveness, and students' perceptions of Augmented Reality application through a study done to determine the knowledge, effectiveness, and students' perceptions of Augmented Reality application. Researchers can utilise this to repair or improve existing functionalities in Augmented Reality application, allowing them to better assist students in increasing efficiency and ensuring the learning experience in the use of Augmented Reality application is more fascinating and effective.

Limitation

Based on the research findings collected from the participating experts and students, there are various limitations that may be listed as a guide for future investigations. The limitation here is that the study is limited to undergraduate students at UTM who study Educational Technology. As a result, the findings of this study cannot be generalized to the knowledge, effectiveness, and perception of Augmented Reality application in other subjects or places.

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