INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 13, Issue 9, (2023) E-ISSN: 2222-6990

Teachers' Perception of the Use of Augmented Reality (AR) Modules in Teaching and Learning

Suhana Mohamad & Hazrati Husnin
Faculty of Education, Universiti Kebangsaan Malaysia (UKM)
Corresponding Author's Email: hazrati@ukm.edu.my

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v13-i9/18319 DOI:10.6007/IJARBSS/v13-i9/18319

Published Date: *08* September 2023

Abstract
Augmented Reality (AR) has generally changed the flow of education and the landscape of teaching progress to digital teaching and learning methods. The developed AR module will give teachers an understanding of the approach to the use of this technology in the learning process. Therefore, this study was conducted to examine teachers' perceptions in terms of design, content and satisfaction of teachers on the use of AR modules to integrate in teaching. The research of this study includes the design and development of educational applications that involve augmented reality. Design and content aspects are derived from the Cognitive Theory of Multimedia Learning to ensure that the design content is in line with a subject. This learning module has undergone a stage of verification by experts and has been conducted to evaluate the quality of development of modules and multimedia elements that have been applied in this module. This quantitative study uses Google Form as a questionnaire instrument. A total of 78 Bestari Coordinator Teachers in the state of Terengganu were selected as respondents of the study. Data were analyzed using SPSS software version 26. The analysis found that the level of teacher perception of the design, content and satisfaction of the AR module was high (M = 4.14). As an implication, the positive perception of teachers towards the design of self-learning modules including the arrangement of information content and the layout of graphic images also shows these elements benefit them in understanding and mastering the learning material.
Keywords: Augmented Reality, Teacher Perception, Design, Satisfaction

Introduction

Nowadays, the advancement of mobile and multimedia technology plays a role in education in the form of a new approach to the learning process. This shows that the use of technology in the learning process has become a necessity in this digital age. The popularity of mobile devices such as smartphones and wireless networks among students has led teachers to use different learning materials or channels to adapt lessons at any time. Furthermore, various new technologies are being used in today's education that offer new learning models in the form of a combination of learning media and traditional technology. The AR experience is

becoming a significant trend, and it is estimated that there will be 2.4 billion augmented reality users worldwide by 2023 (Sinha, 2021).

In line with technological development, Malaysia's Education Development Plan 2013-2025 (Ministry of Education Malaysia, 2013) identifies improving teacher education and training as a key strategy for improving the quality of education in the country. One of the goals set in the plan is to ensure that teachers have quality and competent pedagogical skills in using information and communication technology (ICT) in teaching. Today, in the course of technological development, various innovations are being produced. Among the technologies that are gaining attention and becoming more popular in the world of education is augmented reality.

According to Raja & Nagasubramani (2018), the use of technology in teaching and learning shows a positive effect on student achievement and the use of technology also plays an important role in the process of transferring knowledge in the distance or remote. Teachers need to master these teaching techniques and strategies to meet the requirements of the 21st century. Among digital media's attention is the adoption of Augmented Reality (AR) technology (Kerdvibulvech & Chen, 2020). AR is a technology tool that provides digital learning to expand the latest interactive learning environment. Augmented Reality has been widely used in learning to create a better educational environment (Chen et al., 2017; Chen et al., 2019; Liu et al., 2020).

In addition, several collaborative studies are investigating various aspects of the use of augmented reality in education, from technical features to pedagogical and user aspects (Jamrus & Razali, 2021; Nordin et.al., 2021). Belani & Parnami (2020) explained that the use of AR technology in the classroom shows an increase in the aspect of student motivation and learning outcomes and has a positive effect on learning attitudes where learning outcomes become very interesting and enjoyable. This teaching approach can enhance the learning experience in the context of learning information offered to students.

Moreover, digital education is now one of the key triggers in the country's economic development. All parties need to take care of today's educational context that requires educators to have high levels of digital literacy. Furthermore, in the era of industrial revolution and technology-based teaching and learning, digital skills have become increasingly important and influential (Ayob et al., 2022). As educators, it is crucial to embrace new and creative approaches to apply educational innovation and enhance future learning. Indeed, community growth can have a huge impact on education (Kiryakova et al., 2018), As communities grow and develop, it can bring many changes and considerations for educators. Traditional approaches to education have often remained unchanged over time. However, the integration of augmented reality (AR) development technology can bring about significant enhancements to the learning process. Despite the explosion of technology and digital learning, it does not necessarily mean that conventional teaching methods in the classroom should be completely abandoned. While technology can enhance and complement traditional teaching approaches, it is important to strike a balance and leverage the strengths of both. Technology, including augmented reality (AR), is best viewed as a medium or tool that can facilitate the teaching and learning process (Yusof et al., 2022).

While new technology can play a significant role in educational advancements, the driving force behind change in the education sector is ultimately the students and the skills they need to thrive in a rapidly evolving world. Educators play a critical role in facilitating this transformation by adopting student-centered approaches, integrating real-world experiences, promoting skills development, and fostering a culture of lifelong learning. A

study by Ibili et al (2019); Marques & Pombo (2021) provide valuable insights into the impact and benefits of training for teachers in the context of teaching and learning. These studies highlight the importance of professional development opportunities for educators and how such training can meet the needs of teachers.

In line with the seventh thrust of the Ministry of Education Malaysia (MOE), which is to improve the digital education capability in schools in leading the national education system (Perimbanayagam, 2022), The development of an AR module as a guide for teachers demonstrates a commitment to improving digital education capabilities in schools. The module likely serves as a catalyst for teachers to explore new instructional approaches, experiment with AR technology, and reflect on their teaching practices. Overall, in this study, teachers' perceptions of AR modules have broad implications for understanding teacher perspectives, identifying benefits and challenges, informing pedagogical approaches, supporting professional development, encouraging collaboration, and informing policy and decision-making. It also can can benefit teachers, students, educational institutions, AR module developers, and society in general.

Therefore, this study aims to examine the views of experts on the developed modules and evaluate teachers' perceptions of the use of ar modules in terms of design, content and satisfaction by answering the following question: 1) What is the expert's view of the AR module developed based on multimedia? 2) Do AR modules enhance teachers' perceptions in the teaching and learning process in terms of design, content and satisfaction?

Literature Review

AR Technology in Education

Studies in recent years have identified three elements that define augmented reality (AR); the combination of reality and virtual, continued with interactive imagery information and running in real time (Oranç & Küntay, 2019; Garzón & Acevedo, 2019). The literature also proves that AR is enabling greater engagement in the environment of collaboration between the real and digital world. (Klimova, 2018; Garzon & Acevedo, 2019; Petrov & Atanasova, 2020).

Cieza & Lujan (2018) developed an AR mobile application that uses a marker-based system on flashcards to improve learning of vowels and numbers for children in kindergarten. By integrating AR into the study, the proficiency level in number reading increased to 22.6% and the level of vocal reading increased to 27.6% among participating kindergarten children. Constantly changing the learning environment by integrating AR inspires students' love of learning and enhances their memory, comprehension, and application

A study by Yahya (2019) examined how instructors perceive the use of augmented reality (AR) applications when teaching basic electronic circuitry. This study surveyed instructors who expressed their views and opinions about the use of AR in the context of teaching basic electronic circuits. The results show that instructors are positive about the use of AR applications in teaching basic electronic circuits and see the potential of AR to improve the effectiveness of teaching and learning and to increase student interaction and engagement, making it more enjoyable and interesting.

The study conducted by Dalim et al (2020) focused on investigating the effectiveness of combining art and speech recognition in the learning process. They developed a teacher prototype that incorporated both elements to enhance the educational experience. The findings can have implications for enhancing the learning experience, promoting multimodal learning, fostering creativity, improving language skills, increasing student engagement and

motivation, and informing teacher professional development in utilizing these technologies effectively.

Perception

Teachers' perceptions of technology have been the subject of study throughout the year (Gargrish et al., 2021b). The study examines teacher's perceptions of technology, and the findings show that performance and effort expectations are important aspects of implementing new technology adoption. The findings can inform educational policymakers, administrators, and professional development providers in designing strategies and initiatives that support effective technology integration and address teachers' needs and concerns. According to the theory of consumer commitment and continuous use of technology, the key features that influence the use of new media by the public are the use and ease of use (Hu et al., 2020; Liu et al., 2019). By examining teachers' perceptions of technology, the study by Gargrish et al (2021b) likely contributes to understanding the factors that shape teachers' attitudes and beliefs towards technology use in education.

Raper (2018) found that teachers' perception of technology is influenced by factors such as accessibility to technology and perceived benefits when combining technology. While the study by Hendriyani et al (2019) made AR an innovative learning medium in the era of Industrial Revolution 4.0 by developing marker-based AR applications using computer hardware as training. Research findings show that perceptions of the use of Augmented Reality technology for teaching media development by English teachers are in a positive category.

A case study conducted by Yang & Mei (2018) that aims to gain a deeper understanding of students' perceptions and experiences of using augmented reality for language learning. The thematic analysis shows that overall, students have positive perceptions and attitudes towards a deeper language learning experience with AR programs. The results of the study show that the role of the teacher in the implementation process is very important and clear instructions need to be given for more effective use of AR.

Research by Azizi et al (2020) has shown that perceptions of usefulness and perceptions of ease of use are the most important factors influencing users' perceptions and satisfaction with using a new technology. Outcomes related to performance and effort expectations affect behavioral intentions to use technology. Results show that this variable is positively correlated with users' perceptions of technology use. Performance and effort expectations have an important impact on perceptions of technology use (Arain et al., 2019; Nikolopoulou et al., 2020).

Design

In developing the AR module, the multimedia elements of the cognitive theory of multimedia learning (CTML), Mayer (2002), were applied to ensure that the learning content is designed in accordance with the teaching and learning process for a subject. CTML theory described in a study by Amiruddin et al (2021) explains that the selection of CTML theory is one of the earliest strategies in a study based on design and development research (DDR).

CTML theory is often used as a multimedia design principle and offers a possible justification for the development of AR integration for education (Sommerauer & Müller, 2018). Krüger & Bodemer (2022) stated that AR learning environments can be used with visual and auditory forms of representation such as 3D visual graphics, animations, and interactive audio to create effective AR integrated learning materials to support a better learning environment.

Therefore, this theory is suitable as a framework for designing and developing AR modules for PdP purposes.

Satisfaction with AR Applications

A study conducted by Ibili et al (2019) investigated the level of adoption and intention of mathematics teachers to use an AR application called ARGTS (Augmented Reality Geometric Thinking System). This application was developed with the goal of improving students' 3D geometric thinking skills. In this study, the researchers considered several outcome variables, namely anxiety, social norms, and satisfaction. The results of the study show that perceived ease of use (PEU) has a direct influence on perceived usefulness (PU) according to the technology acceptance model (TAM). Both variables together influence satisfaction, but PEU has no direct influence on attitude. Fear was found to have a direct influence on PEU, but no influence on PU and satisfaction.

While a study by Hashim et al (2018) aims to evaluate user satisfaction based on the System Usability Scale (SUS) questionnaire on augmented reality (AR) applications for productive vocabulary using speech recognition. Interviews with experts were conducted and SUS questionnaires were given to teachers and parents of students to evaluate user satisfaction. The results showed that the research hypothesis of this study was successfully achieved in that teachers and students were satisfied with the application based on the SUS result (SUS result > 68). Since the total score SUS is 80.3, which is higher than the average, it shows that they are satisfied with the application overall.

Research Problems

Educators have begun to look for technologies that have the potential to be integrated into the classroom to help students become active learners and improve their understanding of certain topics. However, there are some issues associated with teaching and learning using digital technologies - augmented reality.

In a study by Shafeey et al (2021), lack of training and inadequate content for practice are considered challenges that create a gap among teachers in integrating technology AR into their teaching process. In addition, the study proves that the acceptance of the integration of technology AR is also influenced by the external environment resulting from organizational and institutional factors. However, they have difficulties in doing so due to lack of training and resources, as noted by (Barroso-Osuna et al., 2019).

Continuous support from the administration is very important to help teachers integrate Augmented Reality (AR) technology into their teaching and learning process more effectively. A study by Almoosa (2019) highlighted the importance of administrative support in the form of professional training and infrastructure. In this study, researchers emphasized the need for ongoing training and support for teachers to understand and integrate AR technology into learning. In addition, administrators must also ensure that adequate infrastructure, such as the hardware and software needed to implement AR, is available and functioning well in the learning environment.

In addition, research conducted by Webster & Gardner (2019) highlights the administrative system's lack of attention to teachers' technology integration needs. This research shows that administrative systems often do not prioritize and provide adequate resources for training

teachers in the use of AR technology and do not provide adequate support to address challenges that may arise in the integration process.

Other than that, quality professional development should equip teachers with the knowledge and skills they need to use AR effectively in teaching and learning (Lasica et al., 2020). This study highlights the importance of professional development related to the use of AR in the classroom. The goal of this training is to provide teachers with a comprehensive understanding of the concepts and uses of AR and to equip them with the practical skills to design and integrate meaningful AR experiences into the classroom.

Implementing augmented reality (AR) in an educational context is often considered expensive (Garzón et al., 2019). Implementing AR in education involves costs that include hardware, software, custom AR content development, and teacher training. These costs can be a significant barrier, especially for schools or educational institutions with limited budgets. in the context of teaching and learning, it is important to choose the appropriate equipment for implementing augmented reality (AR). Studies by Hanid et al (2020) emphasized the importance of choosing the right equipment for using AR in an educational context.

Nonetheless, research and development of AR has improved over several decades, and various researchers have successfully introduced AR as a relatively low-cost innovation for use in education (Abdinejad et al., 2021). This study investigated the use of AR in foreign language learning and found that AR can provide an interesting and effective learning experience at a relatively low cost. This study highlights that AR can be a cost-effective innovation to support learning in the classroom.

In an effort to improve the educational environment, the use of augmented reality (AR) has been introduced through the integration of digital technology and advanced devices. Ozdemir et al (2018) research highlights the importance of integrating digital technology with AR in the educational context. From the research, integrating AR with digital technology can increase student engagement in the learning process. AR can provide an engaging and interactive learning experience that can motivate students to actively participate in learning activities.

A study by Mahmud et al (2018) showed that one of the main barriers to the adoption of augmented reality (AR) in science teaching and learning is low pedagogical and technological confidence among teachers. Lack of understanding of how to integrate AR into classroom practice can lead to a lack of pedagogical confidence in its use. Teachers may feel they don't have enough time or technical skills to use AR effectively.

Research by Fauzi et al (2019) shows that most teachers do not support the use of augmented reality (AR) due to a lack of knowledge in using digital applications. Lack of access to adequate resources and training on the use of AR can be a barrier for teachers in developing their digital literacy skills. These limitations can hinder their ability to integrate AR into classroom practice. Some teachers may be more inclined to use conventional teaching methods that they have mastered and are familiar with. However, research also shows that it is recognized that adapting AR through the resulting three-dimensional visualization can promote better understanding among students

Methodology

The research method used is based on design and development research (DDR), which is empirical (Richey & Klein, 2007). Richey & Klein (2007) stated that the application of the DDR approach is very systematic and includes the process of design and development and evaluation, which is based on empirical studies. In this study, DDR type 1 was used to design an AR module specifically for teachers and to evaluate the effectiveness of the module. The

Type 1 DDR approach includes three main phases: i) requirements analysis, ii) design and development, iii) implementation and evaluation. Therefore, in this study, the three phases were linked to the process of the model ADDIE. These phases focus on the process rules that were implemented during the development and evaluation of this module.

Requirements Analysis Phase

In this phase, the researchers have distributed a questionnaire instrument, adapted from the study of Hendriyani et.al (2013) with a few amendments to ensure that the items are in line with the current scope of the study. However, in this research paper, this phase will not be discussed further.

Design and Development Phase

In this phase, an educational application based on augmented reality has been designed to be included in a module that will be used by teachers. The researchers will design and develop an AR module suggested by expert's view and also guided by the needs analysis data that has been implemented. Teachers only need to download the Unity AR application on a mobile device, get a marker on page 58, RBT Year 4 textbook (as shown in Figure 1) and internet requirements. Therefore, to see the results of the AR content, the teacher needs to scan the pictures found in the Year 4 RBT textbook. The process of designing and developing this module is divided into 2 parts, namely the module and the evaluation instrument.

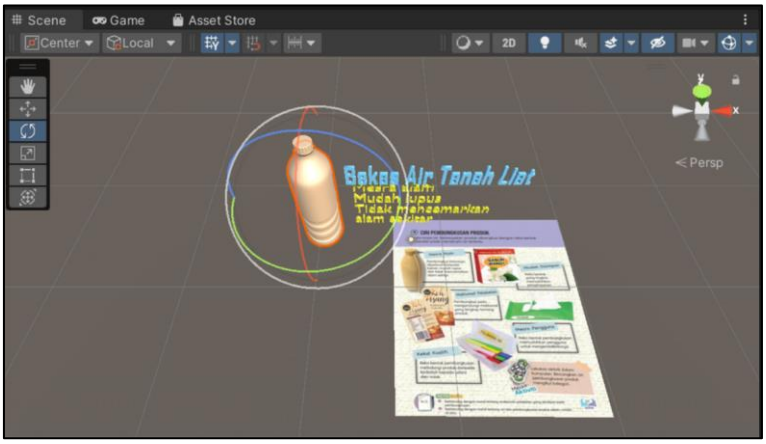

Figure 1: RBT textbook page 58

i. Module

The first stage is to determine the design and content of the module to be produced taking into account the principles of multimedia in cognitive and multimedia learning theory or CTML such as segmenting, contiguity, dual mode, coherence. The second stage is the determination in terms of module content based on the topics in the selected textbook.

Finally, the AR module prototype is applied through the Canva platform (see in Figure 2)

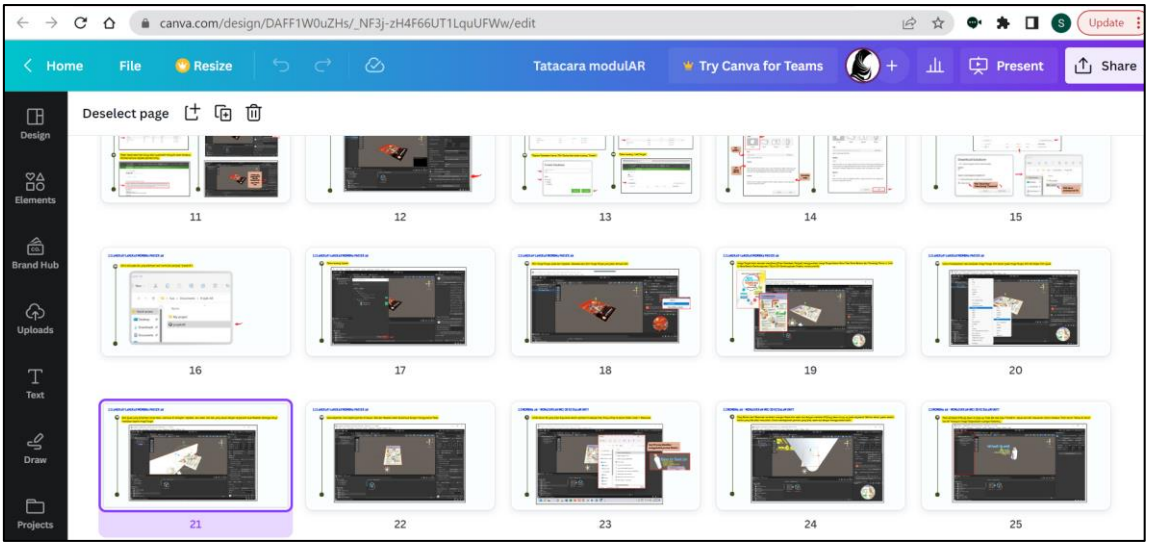

Figure 2: AR module prototype in Canva

ii. Evaluation instruments

An AR module evaluation questionnaire instrument which is the content element of the module AR, was created to obtain expert evaluation of the design and content of the module. These data are important to ensure that the developed module meets the objectives of the study. Four experts with technology and multimedia skills with more than 10 years of experience consisting of a lecturer from Universiti Malaysia Terengganu, a Chief Assistant Director of the Education Resources and Technology Sector of the Terengganu State Education Department, Assistant District Officer of the Kuala Terengganu District Education Office and a teacher from SK Mengabang Telipot will be involved in instrument validation. Expert views are analyzed based on frequency and percentage only. Table 1 shows the expert profile used in responding to the expert questionnaire. To obtain effective research results, the researchers ensure information about the experts, such as the experts' positions, the experts' experience in the field of study related to the researcher's study.

Table 1
Expert profile summary

Name	Position and department	Experience
Expert 1 (E1)	Prof. Madya Ts., Lecturer, UMT	17 years
Expert 2 (E2)	Chief Assistant Director, SSTP JPNT	36 years
Expert 3 (E3)	Assistant District Officer, PPD Kuala Terengganu	14 years
Expert 2 (E2)	Teacher, SK Mengabang Telipot	36 years

Evaluation Phase

A set of questionnaire instruments was used in this study to examine teachers' perceptions of the use of the AR module, adapted from Sural (2018) with slight amendments to ensure that the items are in line with the scope of the current study and was distributed to 78

respondents consisting of teachers appointed as Bestari Coordinator Teachers serving in the State of Terengganu. This teacher questionnaire instrument contains 24 questions divided into four parts. The questionnaire as a whole was also reviewed by four experts involved to ensure the validity of its content. Questionnaire data was analyzed descriptively using SPSS version 26. Table 2 shows a summary of the research design according to the research question.

Table 2
Summary of the study by phase

Phase	Research Question	Instrument	Respondent	Data Analysis
Requirement Analysis	What elements are needed to develop AR module?	Questionnaire	32 teachers	Mean and percentage
Design and Development	What is the expert's view of the AR module developed based on multimedia?	AR module user manual Questionnaire	4 experts in techology and multimedia skills	Agree & Do not Agree, percentage
Evaluation	Do AR modules enhance teachers' perceptions in the teaching and learning process in terms of design, content and satisfaction?	Questionnaire	78 Bestari Coordinator Teachers	*MEAN, Frequency*

Findings

AR Module Design and Development Phase

The developed AR module has several criteria to be evaluated. The findings from this quantitative analysis were used to determine the first research question, which is about expert views on AR modules development in terms of design and content construct. The construct validity will be validated by all experts. The experts also evaluated the teacher's questionnaire to obtain the validity of the questionnaire before it was distributed to the study respondents. The following subtopics will explain on the research instruments validation.

Design Elements of AR Module

This section will focus on the validity of module design surveys from the expert view. After the module is created and developed, firstly, it sent to the supervisor for review before being submitted to the validity expert for evaluation. Then, the module was sent to four experts as describe in Table 1. These experts are chosen to validate how each instrument measures each

contrast represented in this study. Therefore, the researchers provided each expert with a complete copy of the module AR and a set of teacher questionnaires to review, evaluate, and suggest improvements to the developed module. A calculation of content validity follows:

$$\frac{\text{total expert score}}{\text{maximum score}} \times 100\% = \text{validity of survey}$$

Table 3 shows that the overall validity of the AR module is high and which is 0.96. The coefficient of construct validity based on the individual validity components reported by the experts ranged from 0.82 to 1.0. Russell's (1974) formula was used in this study to calculate the content validity of each rater's performance. A module can be considered content valid if the validity scores are above 70% (Tuckman & Waheed, 1981). Thus, the researchers found that all the ratings given by the experts resulted in a 100% response, except for P4's comment, which was 82% (see Table 4).

Table 3
Validators for Module Design Survey

No.	Expert	Percentage Design Validity Form	Coefficient	Expert view
1	P1	100%	1.0	Accepted
2	P2	100%	1.0	Accepted
3	P3	100%	1.0	Accepted
4	P4	82%	0.82	Accepted
	Overall Percentage	**96%**	**0.96**	**Accepted**

In total, there are 11 criteria included in the module design section AR, as shown in Table 4. All four experts agree that the cognitive theory of multimedia learning is applied. Thus, with these multimedia elements, the module is suitable for teachers to use when creating learning materials with augmented reality.

Table 4
AR module design elements

No.	Item	Expert			
		P1	P2	P3	P4
1	The visuals of each page used are attractive and clear.	√	√	√	√
2	The visuals used in each page are clear.	√	√	√	√
3	The language and writing used in this module is easy to understand.	√	√	√	√
4	Arrangement of modules (layout) according to regular or segmented steps (segmentation principle).	√	√	√	√
5	Use of graphics appropriate to the content of the module.	√	√	√	√
6	Appropriate font type and size and easy to understand.	√	√	√	√
7	Use of simple sentences.	√	√	√	√
8	The words used in this module are spelled correctly.	√	√	√	√
9	The explanatory text is placed close to the graphic in accordance with the contiguity principles.	√	√	√	√
10	The presentation of media along with information is according to the principles of multimedia in dwimode.	√	√	√	√
11	The 3D graphics used show the real image of the object.	√	√	√	√

Based on the results of the analysis, all experts agreed with all the items mentioned by the researchers, except for item 5, for which expert 4 suggested improvements as shown in Table 5.

Table 5
Expert comments for item 5

Item	Expert	Comment
5	P4	pseudocode/flow chart is suggested for the Unity installation work process starting from the AR embedding step into the project

Based on expert views, Table 6 is the expert's comments and recommendations on the design of the AR module that has been developed.

Table 6
Expert comments for AR Module design

Bil.	Expert	Comments
1	P1	Overall, interesting and easy to use
2	P2	Simple and attractive design
3	P3	An interesting module covering every principle of multimedia learning

Content Elements of AR Module

Part B in Table 7 requires experts to evaluate the content of the AR module as to whether or not it is appropriate for use. Each content specified in the module content validity form is described in detail below:

Table 7
AR module content criteria

No.	Item	Expert			
		P1	P2	P3	P4
1	The topics in this module are in line with the objectives of the module.	√	√	√	√
2	The content of this module achieves the training objectives.	√	√	√	√
3	The content of this module is appropriate for the target group.	√	√	√	√
4	The modules provided are easy to understand.	√	√	√	√
5	This module displays learning content only according to coherence principle.	√	√	√	√
6	The Unity software used is open source and compatible.	√	√	√	√
7	The installation process of Unity software is taught step by step in detail.	√	√	√	√
8	A description of how to use the software is clearly indicated.	√	√	√	√
9	Markers are easy to use by the teacher.	√	√	√	√
10	Marker works well.	√	√	√	√

√: Agree X: Disagree

There are several elements that must be assessed by the experts based on the content of the module AR, compiled in the expert validation form. Each criterion is explained and evaluated using a content validity calculation. Table 8 shows the validity assessment analysis of the content of the module AR. The overall results of the validity test of the AR module show that the determined coefficient of content validity is high and is 0.9.

Table 8
Validity analysis of AR Module content

Bil.	Expert	Content Validity Percentage	Elements	Expert view
1	P1	100%	1.0	Accepted
2	P2	100%	1.0	Accepted
3	P3	100%	1.0	Accepted
4	P4	80%	0.8	Accepted
	Overall percentage	**90%**	**0.9**	**Accepted**

As a result of the results of the expert validation form, all experts accepted the activities performed except for one expert who suggested improvements to the content of the AR module. Table 9 shows the experts' comments on the activities in the developed module AR. Table 10 shows the suggestions for improvement for all experts.

Table 9
Expert comments for the activities implemented

Item	Expert	Comment
3 & 6	P4	Check whether the Unity software is open source or not. Adaptation of the module content to the target group. The recommendations must be clear for the target group of beginners and advanced users

Table 10
Expert's view of AR Module Content

No.	Expert appraiser	Improvement suggestions
1	P1	Overall attractive and easy to use
2	P2	Congratulations for developing an AR module and a good innovation to the department
3	P3	Good content is consistent with the content referenced in the textbook
4	P4	Using language that is easy to understand along with descriptions and the use of appropriate images ● Recommendation: It is also necessary to explain the source of the Vuforia package in addition to the Unity program and create a work order diagram for the installation work process of the Unity program and the AR embedding steps in the project.

Evaluation Phase

The evaluation phase involved 78 Bestari Coordinator Teachers from 8 districts in Terengganu State to test the use of the AR module.

Respondent Demographic Analysis

Based on the findings of the study in Table 11, the majority of respondents (56.4%) are female teachers while male teachers are (43.6%). Of the total number of teachers, 29.5% indicated that they had teaching experience between 16-20 years, followed by 19.2% with teaching experience between 1-5 years and as many as 14.1% of teachers had teaching experience between 6-10 years. While the lowest percentage is from teachers who have more than 20 years of teaching experience which is 12.8%. This shows that the number of teachers who have experience using AR or have known about AR is more or less equivalent.

Table 11
Distribution of Respondents According to Gender, Age and Teaching Experience

Item	**Frequency, *f***	**Percent, %**
Gender		
Male	34	43.6
Female	44	56.4
Age (year)		
21 - 30	11	14.1
31 - 40	24	30.8
41 - 50	28	35.9
51 - 60	15	19.2
Teaching Experience (year)		
1 - 5	15	19.2
6 - 10	11	14.1
11 - 15	19	24.4
16 - 20	23	29.5
> 20	10	12.8

Teacher's Perception of AR Module Design

Table 12 below shows a summary of the findings of the analysis of teachers' perceptions of the AR module design.

Table 12

Analysis of Teachers' Perceptions of AR Module Design

No.	Item	1	2	3	4	5	Mean *M*	*SD*
1	The display of text and diagrams in this module is clear.	0 (0.0%)	0 (0.0%)	2 (2.6%)	18 (23.1%)	58 (74.4%)	4.72	0.507
2	This module has a smooth transition from one view to another.	0 (0.0%)	0 (0.0%)	2 (2.6%)	21 (26.9%)	55 (70.5%)	4.68	0.522
3	The module has clear instructions for use.	0 (0.0%)	0 (0.0%)	2 (2.6%)	25 (32.1%)	51 (65.4%)	4.63	0.537
4	This module contains information and guidance for building the AR base project.	0 (0.0%)	0 (0.0%)	0 (0.0%)	22 (28.2%	56 (71.8%)	4.72	0.453
5	The interface design and presentation of the module looks attractive.	2 (2.6%)	7 (9.0%)	12 (15.4%)	42 (53.8%)	15 (19.2%)	3.78	0.949
6	This module shows the steps to build AR materials in detail.	3 (3.8%)	5 (6.4%)	18 (23.1%)	43 (55.1%)	9 (11.5%)	3.64	0.911
7	I managed to import the prepared 3D image into Unity.	1 (1.3%)	8 (10.3%)	7 (9.0%)	50 (64.1%)	12 (15.4%)	3.82	0.864
8	The user manual using Canva helps me use this module	0 (0.0%)	5 (6.4%)	10 (12.8%)	47 (60.3%)	16 (20.5%)	3.95	0.771

	better.							
9	This module provides various visual and multimedia elements such as text, interesting graphics.	0 (0.0%)	0 (0.0%)	0 (0.0%)	54 (69.2%)	24 (30.8%)	4.31	0.465
Overall Mean, *M* = 4.25, Standard Deviation, *SD* = 0.664								

(Level of Interpretation: Low = 1.00 - 2.34, Medium = 2.35 - 3.67, High = 3.68 - 5.00)

In this study, the level of teachers' perception of AR module design was measured by 9 items. Table 11 shows that all items have a high score except one item has a medium score. The results of this study show that item 1, which is “The display of text and diagrams in this module is clear.” and item 4, which is "This module contains information and guidance for building the AR base project." recorded the highest mean (*M* = 4.72, *SD* = 0.507). While item 6 which is "This module shows the steps to build AR materials in detail." recorded the lowest mean (*M* = 3.64, *SD* = 0.911). However, most teachers have extensive technology knowledge and are familiar with AR technology. 97.5% of teachers indicated that the writing and diagrams in this module are clear and 78% responded that this module provides information and instructions for creating basic AR projects. This is supported by a study conducted by Shafie et al (2019), whose findings show that technological knowledge is important for increasing technology adoption among teachers and mastering the integration of technology in the classroom. Overall, it shows that the score of the level of teacher's perception towards the design of the AR module (*M* = 4.25, *SD* = 0.664) is at a high level.

Teacher's Perception of AR Module Content

Table 13 below shows a summary of the findings of the analysis of teachers' perceptions of the content of the AR module.

Table 13
Analysis of Teachers' Perceptions of AR Module Content

No.	Item	1	2	3	4	5	Mean, *M*	*SD*
1	I know about AR technology.	4 (5.1%)	2 (2.6%)	4 (5.1%)	8 (10.3%)	60 (76.9%)	4.51	1.066
2	I have knowledge of Unity software.	6 (7.7%)	1 (1.3%)	5 (6.4%)	11 (14.1%)	55 (70.5%)	4.38	1.176
3	I used to use Unity software.	10 (12.8%)	1 (1.3%)	5 (6.4%)	6 (7.7%)	56 (71.8%)	4.24	1.397
4	I can build an AR easily.	1 (1.3%)	7 (9.0%)	10 (12.8%)	48 (61.5%)	12 (15.4%)	3.81	0.854
5	I can use this module as a self-learner.	0 (0.0%)	8 (10.3%)	10 (12.8%)	49 (62.8%)	11 (14.1%)	3.81	0.807
6	The content of this module is organized systematically.	0 (0.0%)	5 (6.4%)	7 (9.0%)	53 (67.9%)	13 (16.7%)	3.95	0.719
7	I successfully produced my own AR material for learning purposes.	5 (6.4%)	12 (15.4%)	25 (32.1%)	19 (24.4%)	17 (21.8%)	3.40	1.177

(Level of Interpretation: Low = 1.00 - 2.34, Medium = 2.35 - 3.67, High = 3.68 - 5.00)

In this study, the level of teachers' perception of AR module content was measured by 7 items. Table 13 shows that 6 items have a high score, while another item has a medium score. The results of this study show that item 1, which is “I know about AR technology.” recorded the highest mean (*M* = 4.51, *SD* = 1.066). Followed by item 2 which is "I have knowledge of Unity software." (*M* = 4.38, *SD* = 1.176) and item 3 which is "I used to use Unity software." (*M* = 4.24, *SD* = 1.397). While item 7 which is "I successfully produced my own AR material for learning purposes." recorded the lowest mean (*M* = 3.40, *SD* = 1.177). From this analysis, based on the analysis of item 5, most teachers (84.6%) understand module content and can use modules independently. They are also knowledgeable about appropriate and consistent methods and strategies to use during instruction. A study by Scherer et al (2021) concluded that teachers' content knowledge enables them to perform tasks or procedures related to content learning. The study concluded that content knowledge improves teachers' understanding of what they are doing. Overall, the mean value of teachers' perceptions of the AR module for the content elements (*M* = 4.01, *SD* = 1.028) is at a high level.

Teachers' Perception of Satisfaction using AR Modules

Table 14 below shows a summary of the findings of the analysis of teachers' perceptions of satisfaction using the AR module. The level of teachers' perception of satisfaction using the AR module was measured by 4 items. The results of the analysis in Table 13 for the element of satisfaction also show a high mean for each item except for item 3 which is at a medium level. From the results, it shows that item 1, which is "I successfully installed the Unity software based on the AR module." recorded the highest mean (*M* = 4.64, SD = 0.624). Followed by item 2 which is "I enjoy using this AR module." (*M* = 4.56, *SD* = 0.656) and item 4 which is "I would recommend this module to a friend" (*M* = 3.95, *SD* = 0.701). While item 3 which is "I am excited to be able to build my own AR material through the steps shown in this module." recorded the lowest mean (*M* = 3.38, *SD* = 1.084). The analysis data also showed that 70.5% of respondents agreed to recommend this module to other teachers. Based on the hypothesis shown in a study by Hashim et al. (2018) which evaluates user satisfaction based on the System Usability Scale (SUS) questionnaire showing that the SUS score obtained is above average. This shows that they are satisfied with the overall application. However, the overall element of teacher satisfaction using the AR module (*M* = 4.13, *SD* = 0.766) is at a high level.

Table 14
Analysis of Teachers' Perceptions of Satisfaction using the AR Module

No.	Item	1	2	3	4	5	Mean *M*	*SD*
1	I successfully installed the Unity software based on the AR module.	0 (0.0%)	0 (0.0%)	6 (7.7%)	16 (20.5%	56 (71.8%)	4.64	0.624
2	I enjoy using this AR module.	0 (0.0%)	1 (1.3%)	4 (5.1%)	23 (29.5%)	50 (64.1%)	4.56	0.656
3	I am excited to be able to build my own AR material through the steps shown in this module.	6 (7.7%)	10 (12.8%)	18 (23.1%)	36 (46.2%)	8 (10.3%)	3.38	1.084
4	I would recommend this module to a friend	0 (0.0%)	5 (6.4%)	6 (7.7%)	55 (70.5%)	12 (15.4%)	3.95	0.701
Overall Mean, *M* = 4.13, Standard Deviation, *SD* = 0.766								

(Level of Interpretation: Low = 1.00 - 2.34, Medium = 2.35 - 3.67, High = 3.68 - 5.00)

Overall, analysis of the data in Table 15 revealed that the Design element had the highest mean score of 4.25. The satisfaction element received a mean of 4.13, followed by the content element with a mean of 4.05. Thus, the average mean for teachers' perceptions of the AR module is 4.14 and is considered a high interpretive value. This shows that the AR module has a good perception level. Therefore, design, content, and satisfaction contribute to teachers' perception with a high mean value. Normality was tested with statistical tests for skewness and kurtosis. The value of both tests must be between the values of -1.96 and +1.96. Based on the statistical results in Table 14, for the construct Design, the value of skewness = -0.741, kurtosis = 0.672. For the construct Content, the data results show skewness = -1.400, kurtosis = 1.544. For the construct Satisfaction, the skewness = -0.603, kurtosis = -0.263. Thus, it was found that all skewness and kurtosis values are in the range of +-1.96 and all three elements are normally distributed.

Table 15
Summary of the findings of the analysis of teachers' perceptions of the AR module

No.	Construct	Total Item	*M*	*SD*	*Skewness*	*Kurtosis*	Level of Interpretation
1	Design	9	4.25	0.456	-0.741	0.672	High
2	Content	7	4.05	0.752	-1.400	1.544	High
3	Satisfaction	4	4.13	0.564	-0.603	-0.263	High
	Overall	**21**	**4.14**	**0.591**			**High**

Discussion

The experts' assessment of the validity of the AR module revealed that all experts agree with the objectives included in the design of the AR module. Based on the design of the AR module, all reviewers agreed with the design of this AR module. From a cognitive point of view, this AR module contains 3D images and animations. According to a study by Serin (2020), the use of videos, images, and animations is suitable for students who have schematic and visual thinking to enhance comprehension and improve learning because this multimedia cognitive stimulation enables rapid learning. This is also supported by a study by Salinas (2017) who conducted a study on mathematics and geometry instruction through AR in which it supports lifelong learning, develops three-dimensional thinking skills, and enables meaningful learning. As for the experts' opinion on the content of the AR module, all experts agree that the content of the subtopics used meets the learning objectives. The developed AR module benefits teachers. This is because the developed AR module uses a language that is easy for teachers to understand. The experts also believe that the developed AR module is interesting and can help teachers because it incorporates the principles of multimedia learning. However, the experts also give suggestions by mentioning some elements that need to be changed and no elements that should be removed. Suggested elements that should be changed include avoiding overlapping diagrams or images and specifying the appropriate audience of respondents.

The results obtained through an online questionnaire survey aimed to identify teachers' perceptions of AR modules in terms of design and content. The results of the analysis obtained in Table 12 show the teachers' responses to the design items that explain their familiarity with AR technology and their existing knowledge of AR technology. The results show that teachers consider themselves knowledgeable enough about AR technology and have the ability to learn more about AR technology to integrate it into their teaching and learning process.

Seufert et al (2021) also recommended teachers to be professionally competent to systematically deliver technology-assisted learning and instructional design for students, as well as realizing the value of technology as a catalyst to support further learning. Similarly, as stated by Klimova (2018), the digital competence of teachers can be improved through a series of ICT courses attended related to AR technology.

The data in Table 13 shows that more than half of the teachers know about AR technology. Since the Covid-19 pandemic hit, teachers have been urged to plan teaching strategies for Online Distance Learning (ODL). Due to this situation, teachers have improved their technological knowledge to be adapted in the learning content during ODL learning. Furthermore, most teachers responded that they have knowledge and have used the Unity software.

Apart from that, the teachers also agreed that by being guided by the AR module, they can easily build Augmented Reality materials as content that is in line with the requirements of the syllabus. However, there is data showing a very small percentage of feedback from teachers who successfully produce their own AR materials for learning purposes, but the average teacher agrees saying that this AR Module has been organized systematically and it can be assumed that the teacher has agreed to have thoughts to apply AR technology to be integrated in teaching and learning.

Their expertise in technological knowledge that meets the content requirements of the curriculum specification can help them organize a better teaching approach with a specific AR integration for certain topics of the subject. For example, Bonafini & Lee's (2021) qualitative study examines teachers' prospects in using appropriate technology when the use of the preferred technology can reinforce a previously described assessment approach. Technology integrated into learning content is seen as a supportive tool to strengthen teachers' understanding of certain things.

Additionally, by allowing the use of AR in teacher teaching methods, it has the potential to provide better acceptance among teachers to the use of technology in teaching and learning without changing the subject of predetermined content (Barrow et al., 2019). In summary, the teacher's assumption of AR control can be improved if they are familiar with the application. Therefore, it is important to provide in terms of training and facilities to be encouraged by the opportunity to increase readiness among teachers in receiving the use of the AR in teaching and learning.

Recommendation

Based on some of the limitations of the study that have been identified, some suggestions for further research should also be discussed. Among the suggestions for further research is a sample of the findings of this study obtained from 78 GPB teachers from selected schools in the State of Terengganu. Therefore, further studies recommend using a larger sample size and involving other teachers in a wider area so that the findings can be generalized to a wider scope.

The second suggestion relates to the research design. In this study, the researchers did not establish a control and experimental group among the samples, so the results of the study show that the perception of the module AR depends solely on the existing knowledge, demonstration through the video tutorials provided, and independent use of the module AR. Therefore, further research is needed to study acceptance and perception of AR integration among teachers taking into account the difference setting involving the test between the control group and the experimental group.

Finally, the researchers propose to expand the to increase teachers' and students' perceptions of usefulness and usability in relation to the virtual objects produced. The reason for this is that in the AR module, the researchers only show access to AR materials created only through the Android application. Therefore, for further research, it is suggested to improve the AR module through Apple (IOS). This needs to be considered so that smartphone users have the same access to augmented reality technology.

Conclusion

In conclusion, this study examines the potential of new technologies such as AR in the world of education. More specific to this study is the impact of AR module design and development to identify expert views and perception levels among teachers. The content validity findings of this AR Module have also been given a high coefficient value by the selected experts. In terms of teachers' perceptions, the findings also show that teachers are very receptive and feel the usefulness of AR modules for learning. In fact, all parties should accept and be ready to face the shift and change in national education and join hands to realize the government's wishes. The rapid explosion of technology has made it difficult to implement new teaching methods in education. It is hoped that the AR module will continue to be developed and applied for the integration of AR in the teaching and learning process at all levels of the school for the cultivation of a continuous learning culture.

References

Abdinejad, M., Talaie, B., Qorbani, H. S., & Dalili, S. (2021). Student Perceptions Using Augmented Reality and 3D Visualization Technologies in Chemistry Education. *Journal of Science Education and Technology*, 30(1), 87–96. https://doi.org/10.1007/s10956-020-09880-2

Ali, D. F., & Julkifleh, E. (2022). Kesahan Dan Kebolehpercayaan Pembangunan Modul Interaktif Berasaskan Teknologi Augmented Reality Bagi Kursus Pembinaan Bangunan Ii. Available at: http://dx.doi.org/10.17576/ajtlhe.1401.2022.07. AJTLHE Vol. 14, No. 1, June 2022, 78-93

Almoosa, N. (2019). Barriers to the adoption of augmented reality in K-12 education: A case study in Saudi Arabia. *International Journal of Education and Development using Information and Communication Technology* (IJEDICT), 15(3), 79-94.

Amiruddin, A. Z., Halim, Z. A., & Zainuddin, N. (2021). Teoritis Reka Bentuk dan Pembangunan Kursus Bahasa Arab Dalam Talian. *Teoritis Reka Bentuk Dan Pembangunan Kursus Bahasa Arab Dalam Talian*, 4, 1–13. http://insaniah.umk.edu.my/journal/index.php/insaniah/article/download/148/53

Arain, A. A., Hussain, Z., Rizvi, W. H., & Vighio, M. S. (2019). Extending UTAUT2 toward acceptance of mobile learning in the context of higher education. *Universal Access in the Information Society*, 18(3), 659–673. https://doi.org/10.1007/s10209-019-00685-8

Ayob, N. H., Aziz, M. A., & Ayob, N. A. (2022) 'Bridging the digital divide: Innovation policy and implementation in Malaysia', *International Journal of Academic Research in Business and Social Sciences*, 12(8). doi:10.6007/ijarbss/v12-i8/14554.

Azizi, S. M., Roozbahani, N., & Khatony, A. (2020). Factors affecting the acceptance of blended learning in medical education: application of UTAUT2 model. *BMC Medical Education*, 20(1), 1–9. https://doi.org/10.1186/s12909-020-02302-2

Barroso-Osuna, J., Gutiérrez-Castillo, J. J., Llorente-Cejudo, M. C., & Ortiz, R. V. (2019). Difficulties in the incorporation of augmented reality in university education: Visions from the experts. *Journal of New Approaches in Educational Research*, 8(2), 126–141. https://doi.org/10.7821/naer.2019.7.409

Belani, M., & Parnami, A. (2020). Augmented reality for vocational education training in K12 classrooms. In 2020 *IEEE International Symposium on Mixed and Augmented Reality Adjunct* (ISMAR-Adjunct) (pp. 317-320). IEEE.

Barrow, J., Forker, C., Sands, A., O'Hare, D., & Hurst, W. (2019). Augmented reality for enhancing life science education. VISUAL 2019-*The Fourth International Conference on Applications and Systems of Visual Paradigms*, 1(1), 1–7.

Bonafini, F. C., & Lee, Y. (2021). Investigating Prospective Teachers' TPACK and their Use of Mathematical Action Technologies as they Create Screencast Video Lessons on iPads. *TechTrends*. https://doi.org/10.1007/s11528-020-00578-1

Challenor, J., & Ma, M. (2019). A review of augmented reality applications for history education and heritage visualization. *Multimodal Technologies and Interaction*, 3(2), 39.

Chen, P., Lan, X., Cheng, W., & Huang, R. (2017). A review of using Augmented Reality in Education from 2011 to 2016. In *Lecture notes in educational technology* (pp. 13–18). Springer Nature. https://doi.org/10.1007/978-981-10-2419-1_2

Chen, Y., Wang, Q., Chen, H., Song, X., Tang, H., & Tian, M. (2019). An overview of augmented reality technology. *Journal of Physics*, 1237(2), 022082. https://doi.org/10.1088/1742-6596/1237/2/022082

Cieza, E., & Lujan, D. (2018). Educational Mobile Application of Augmented Reality Based on Markers to Improve the Learning of Vowel Usage and Numbers for Children of a Kindergarten in Trujillo. *Procedia Computer Science*, 130, 352–358. https://doi.org/10.1016/j.procs.2018.04.051

Dalim, C. S. C., Sunar, M. S., Dey, A., & Billinghurst, M. (2020). Using augmented reality with speech input for non-native children's language learning. *International Journal of Human-computer Studies*, 134, 44–64. https://doi.org/10.1016/j.ijhcs.2019.10.002

Fan, M., and Antle, A. N. (2020) 'An English language learning study with rural Chinese children using an augmented reality app', *Proceedings of the Interaction Design and Children Conference* [Preprint]. doi:10.1145/3392063.3394409.

Fauzi, A., Ali, K. N., & Amirudin, R. (2019b). Evaluating students readiness, expectancy, acceptance and effectiveness of augmented reality based construction technology education. *International Journal of Built Environment and Sustainability*, 6(1), 7–13. https://doi.org/10.11113/ijbes.v6.n1.309

Gao, F., Li, L., and Sun, Y. (2020) 'A systematic review of mobile game-based learning in STEM education', *Educational Technology Research and Development*, 68(4), pp. 1791–1827. doi:10.1007/s11423-020-09787-0.

Garzón, J., & Acevedo, J. (2019). Meta-analysis of the impact of Augmented Reality on students' learning gains. *Educational Research Review*, 27(April), 244–260. https://doi.org/10.1016/j.edurev.2019.04.001

Gargrish, S., Sharma, B., Tuli, N. Y., Mantri, A., & Modgil, A. (2021b). Augmented Reality Applications in Education: Teachers Opinion. *Social Science Research Network*. https://doi.org/10.2139/ssrn.3833872

Hanid, M. F. A., Said, M. N. H., & Yahaya, N. (2020). Learning strategies using augmented reality technology in education: Meta-analysis. *Universal Journal of Educational Research*, 8(5 A), 51–56. https://doi.org/10.13189/ujer.2020.081908

Hashim, N. C., Majid, N. A. A., Arshad, H., & Obeidy, W. K. (2018). User Satisfaction for an Augmented Reality Application to Support Productive Vocabulary Using Speech Recognition. *Advances in Multimedia*, 2018, 1–10. https://doi.org/10.1155/2018/9753979

Hendriyani, Y., Effendi, H., Novaliendry, D., & Effendi, H. (2019). Augmented reality sebagai media pembelajaran inovatif di era revolusi industri 4.0. *Jurnal Teknologi Informasi dan Pendidikan*, *12*(2), 62-67.

Hu, S., Laxman, K., & Lee, K. (2020). Exploring factors affecting academics' adoption of emerging mobile technologies-an extended UTAUT perspective. *Education and Information Technologies*, 4615–4635. https://doi.org/10.1007/s10639020-10171-x

Ibili, E., Resnyansky, D., & Billinghurst, M. (2019). Applying The Technology Acceptance Model To Understand Maths Teachers' Perceptions Towards An Augmented Reality Tutoring System. *Education and Information Technologies*, 24(5), pp. 2653–2675. doi:10.1007/s10639-019-09925-z.

Jamrus, M. H. M., & Razali, A. B. (2021). Acceptance, Readiness and Intention to Use Augmented Reality (AR) in Teaching English Reading among Secondary School Teachers in Malaysia. *Asian Journal of University Education*, 17(4), 312. https://doi.org/10.24191/ajue.v17i4.16200

Johnson, D., Damian, D., & Tzanetakis, G. (2019). Evaluating the effectiveness of mixed reality music instrument learning with the Theremin. *Virtual Reality*, *24*(2), 303–317. https://doi.org/10.1007/s10055-019-00388-8

Kerdvibulvech, C., & Chen, L. (2020). The Power of Augmented Reality and Artificial Intelligence During the Covid-19 Outbreak. In *Lecture Notes in Computer Science* (pp. 467–476). Springer Science+Business Media. https://doi.org/10.1007/978-3-030-60117-1_34

Klimova, A., Bilyatdinova, A., & Karsakov, A. (2018). Existing Teaching Practices in Augmented Reality. *Procedia Computer Science*, 136(January), 5–15. https://doi.org/10.1016/j.procs.2018.08.232

Kiryakova, G., Angelova, N., & Yordanova, L. (2018). The Potential of Augmented Reality to Transform Education into Smart Education. DOAJ (DOAJ: *Directory of Open Access Journals*. https://doi.org/10.18421/tem73-11

Kruger, J. M., & Bodemer, D. (2022). Application and Investigation of Multimedia Design Principles in Augmented Reality Learning Environments. *Information (Switzerland)*, 13(2). https://doi.org/10.3390/info13020074

Laine, T. (2018) 'Mobile Educational Augmented Reality Games: A Systematic Literature Review and two case studies', *Computers*, 7(1), p. 19. doi:10.3390/computers7010019.

Lasica, I., Meletiou-Mavrotheris, M., & Katzis, K. (2020). Augmented Reality in Lower Secondary Education: A Teacher Professional Development Program in Cyprus and Greece. *Education Sciences*, 10(4), 121. https://doi.org/10.3390/educsci10040121

Liu, Q., Geertshuis, S., & Grainger, R. (2020). Understanding academics' adoption of learning technologies: A systematic review. *Computers and Education*, 151(September 2019), 103857. https://doi.org/10.1016/j.compedu.2020.103857

Macariu, C., Iftene, A., & Gifu, D. (2020). Learn chemistry with augmented reality. *Procedia Computer Science*, 176, 2133–2142. https://doi.org/10.1016/j.procs.2020.09.250

Mahmud, A. R., Yusoff, M. M., Mohamad, A. S., & Salam, S. (2018). Teachers' perception on the use of augmented reality in supporting science teaching and learning. *Journal of Fundamental and Applied Sciences*, 10(3S), 497-515.

Marques, M. and Pombo, L. (2021) 'Teachers' experiences and perceptions regarding mobile augmented reality games: A case study of a teacher training', *INTED2021 Proceedings* [Preprint]. doi:10.21125/inted.2021.1865.

Marques, M. M., & Pombo, L. (2021). The impact of teacher training using mobile augmented reality games on their professional development. Education Sciences, 11(8). https://doi.org/10.3390/educsci11080404

Mayer, R. E. (2002). Cognitive theory and the design of multimedia instruction: An example of the two-way street between cognition and instruction. *New Directions for Teaching and Learning*, 2002(89), 55–71. https://doi.org/10.1002/tl.47

McNaughton, D. B., & Cowell, J. M. (2018). Using methods of data collection. Advanced Public and Community Health Nursing Practice: Population Assessment, Program Planning and Evaluation, Second Edition, 38, 127–153.
https://doi.org/10.1891/9780826138446.0006

Ministry of Education Malaysia. (2013). *Malaysia Education Blueprint 2013 - 2025*. Retrieved from https://www.moe.gov.my/menumedia/media-cetak/penerbitan/dasar/1207-malaysia-education-blueprint-2013-2025/file

Nikolopoulou, K., Gialamas, V., & Lavidas, K. (2020). Acceptance of mobile phone by university students for their studies: an investigation applying UTAUT2 model. *Education and Information Technologies*, 4139–4155. https://doi.org/10.1007/s10639-020-10157-9

Nordin, N., Nordin, M. N. R., & Omar, W. (2021). REV-OPOLY: An Immersive Augmented Reality Board Game Experience. *Multidisciplinary Applied Research and Innovation*, 2(3), 282–285. Retrieved from https://publisher.uthm.edu.my/periodicals/index.php/mari/article/view/5130

Oranc, C., & Kuntay, A. C. (2019). Learning from the real and the virtual worlds: Educational use of augmented reality in early childhood. *International Journal of Child-Computer Interaction*, 21, 104–111. https://doi.org/10.1016/j.ijcci.2019.06.002

Ozdemir, M., Sahin, C., Arcagok, S., & Demir, M. K. (2018). The Effect of Augmented Reality Applications in the Learning Process: A Meta-Analysis Study. *Eurasian Journal of Educational Research*, 74, 165-186. https://dergipark.org.tr/en/pub/ejer/issue/42528/512469

Pantelic, A., & Vukovac, P. D. (2017). The Development of Educational Augmented Reality Application: a Practical Approach. ICERI2017 Proceedings, 1(November), 8745–8752. https://doi.org/10.21125/iceri.2017.2399

Parmaxi, A., and Demetriou, A. A. (2020). Augmented reality in language learning: a state-of-the-art review of 2014–2019. *J. Comput. Assist. Learn.* 36, 861–875. doi: 10.1111/jcal.12486

Perimbanayagam, K. (2022). MOE to focus on seven main thrusts. *New Straits Times*. https://www.nst.com.my/news/nation/2022/12/861081/moe-focus-seven-main-thrusts

Petrov, P., & Atanasova, T. (2020). The Effect of Augmented Reality on Students' Learning Performance in Stem Education. Information, 11(4), 209. https://doi.org/10.3390/info11040209

Pricilia, A., Abdurrahman, A., and Herlina, K. (2020) "Teacher expectation towards interactive multimedia integrated with STEM in learning physics: Preliminary study on geometry optic learning material," *Journal of Physics: Conference Series*, 1572(1), p. 012065. Available at: https://doi.org/10.1088/1742-6596/1572/1/012065.

Raja, R., & Nagasubramani, P. C. (2018). Impact of modern technology in education. *Journal of Applied and Advanced Research*, S33–S35. https://doi.org/10.21839/jaar.2018.v3is1.165

Richey, R. C., & Klein, J. (2007). *Design and Development Research: Methods, Strategies, and Issues*. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers

Shafeey, G. A. al, Modi, M., & Lakulu, B. (2021). Challenges Analysis for Using Augmented Reality in Education: A Review. *International Journal of Science and Research*, 10(3), 466–471. https://doi.org/10.21275/SR21306183154

Shafie, H., Majid, F. A., & Ismail, I. S. (2019). Technological pedagogical content knowledge (TPACK) in teaching 21st century skills in the 21st century classroom. Asian Journal of University Education, 15(3), 24–33. https://doi.org/10.24191/ajue.v15i3.7818

Scherer, R., Howard, S. K., Tondeur, J., & Siddiq, F. (2021). Profiling teachers' readiness for online teaching and learning in higher education: Who's ready? *Computers in Human Behavior*, 118(October 2020), 106675. https://doi.org/10.1016/j.chb.2020.106675

Seufert, S., Guggemos, J., & Sailer, M. (2021). Technology-related knowledge, skills, and attitudes of pre- and in-service teachers: The current situation and emerging trends. *Computers in Human Behavior*, 115, 106552. https://doi.org/10.1016/j.chb.2020.106552

Sinha, S. (2021) Augmented reality (AR) in education: A staggering insight into the future, *eLearning Industry*. Available at: https://elearningindustry.com/augmented-reality-in-education-staggering-insight-into-future.

Sommerauer, P., & Muller, O. (2018). Augmented reality in informal learning environments: Investigating Short-term and Long-term Effects. *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2018-January, 1423–1430. https://doi.org/10.24251/hicss.2018.176

Webster, A. R., & Gardner, J. (2019). Aligning technology and institutional readiness: the adoption of innovation. *Technology Analysis & Strategic Management*, 31(10), 1229–1241. https://doi.org/10.1080/09537325.2019.1601694

Yang, S. and Mei, B. (2018) 'Understanding learners' use of augmented reality in Language learning: Insights from a case study', *Journal of Education for Teaching*, 44(4), pp. 511–513. doi:10.1080/02607476.2018.1450937.

Yahya, S. S. (2019). Penggunaan Aplikasi Augmented Reality dalam Topik Litar Asas Elektronik (The Use of Augmented Reality Application in Basic Electronic Circuit Topic). https://itlj.utm.my/index.php/itlj/article/view/34

Yasmin, Z. (2018), *EDUINNOVATION: Inovasi Pendidikan dalam Era Revolusi Industri 4.0*. Fakulti Pendidikan UKM

Yusof, A. S., Jima'ain, M. T., Ab. Rahim, S., & Abuhassna, H. (2022). Implementation of augmented reality (AR) in Malaysian Education System. *International Journal of Academic Research in Business and Social Sciences*, 12(10). https://doi.org/10.6007/ijarbss/v12-i10/15367