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Towards technology-based education: Exploration of augmented reality in e-modules for latest learning

Anggela Pratama[1], Moch. Najril[2], Namira Khosyi[3]
[1,2,3] Universitas Pendidikan Indonesia, Bandung, Indonesia
anggelapratama_@upi.edu[1], najrilfauzan@upi.edu[2], namiranasywa@upi.edu[3]

ABSTRACT

Education is an important foundation for character development and improving the quality of human resources. In the ever-evolving landscape of classroom learning, teachers play an important role as facilitators in creating innovative and student-centered learning environments. This research explores the integration of Augmented Reality (AR) into E-Modules as innovative digital teaching materials. This research uses a literature review approach to explore the role of AR in developing interactive e-modules, which aims to increase student engagement and understanding regarding abstract concepts in learning. This research collects data from relevant research results, emphasizing the role of e-modules and AR in adapting to the era of digitalization. The findings show a significant positive impact of using AR in learning, reflected in an increase in student interest by 94 percent and an increase in understanding of the material by 90 percent. In addition, aspects such as appearance components and feasibility received positive responses of 88 percent and 84 percent respectively. This research shows that the integration of AR into the E-Module has a positive effect on student participation and understanding. The positive response from students highlights the potential of AR in creating an engaging learning process.

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ABSTRAK

Pendidikan merupakan landasan penting bagi pengembangan karakter dan peningkatan kualitas sumber daya manusia. Dalam lanskap pembelajaran di kelas yang terus berkembang, guru memainkan peran penting sebagai fasilitator dalam menciptakan lingkungan pembelajaran yang inovatif dan berpusat pada peserta didik. Penelitian ini bertujuan untuk mengeksplorasi integrasi Augmented Reality (AR) ke dalam E-Modul sebagai bahan ajar digital inovatif. Pendekatan tinjauan literatur digunakan untuk mengeksplorasi peran AR dalam pengembangan e-modul interaktif yang bertujuan untuk meningkatkan keterlibatan peserta didik dalam pembelajaran dan pemahamannya mengenai konsep-konsep abstrak dalam pembelajaran. Penelitian ini mengumpulkan data dari hasil penelitian yang relevan, menekankan peran e-modul dan AR dalam beradaptasi dengan era digitalisasi. Temuannya menunjukkan adanya dampak positif yang signifikan penggunaan AR dalam pembelajaran, tercermin dari peningkatan minat peserta didik sebesar 94 persen dan peningkatan pemahaman materi sebesar 90 persen. Selain itu, aspek seperti komponen tampilan dan kelayakan mendapat respons positif masing-masing sebesar 88 persen dan 84 persen. Penelitian ini menunjukkan bahwa integrasi AR ke dalam E-Module berpengaruh positif terhadap partisipasi dan pemahaman peserta didik. Respons positif dari peserta didik menyoroti potensi AR dalam menciptakan proses pembelajaran yang menarik.

Kata Kunci: *augemented reality; pendidikan; e-modul; pembelajaran*

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INTRODUCTION

Education is a crucial foundation for character formation and improving the quality of human resources. In the context of classroom learning, teachers, as facilitators, play a central role in creating an innovative learning environment that meets the needs of students (Septikasari & Frasandy, 2018). Along with the development of the times, changes in learning paradigms, and technological advances, teachers are expected to continue to innovate in using interesting and relevant learning methods, models, approaches, and media (Mea, 2024). In this context, the use of technology, especially Augmented Reality (AR), is a significant focus in delivering technology-based education.

Teachers are not only transmitters of information, but also planners and evaluators of learning activities. The shifting learning paradigm demands the integration of technology into instructional design and the development of learning media (Rahmawati & Suryadi, 2019). In the context of chemistry learning in secondary schools, for example, students often face the challenge of abstract and difficult-to-understand concepts, which can affect their interest and learning outcomes (Jayadiningrat *et al*., 2017). The low learning outcomes of students are also influenced by one-way learning processes that focus primarily on lower-level cognitive competencies. Therefore, a more interactive learning approach that engages higher-order cognitive skills is needed. Successful learning requires the development of instructional media that align with the curriculum, are easy to use, engaging, and beneficial for students (Khaira *et al*., 2023; Lubis & Ikhsan, 2015; Rosyiddin *et al*., 2023).

Learning media not only serves as a means of conveying information, but can also help students with low cognitive abilities overcome limitations of space, time, and sensory capacity. Furthermore, during the COVID-19 pandemic and the new normal learning era, learning media is key to ensuring the smooth running of the learning process, both offline and online (Sewang & Aswad, 2021). An integral part of teaching materials is modules, which are systematically and engagingly designed to achieve the desired competencies. With the development of technology and information, the emergence of interactive e-modules as an alternative to digital teaching materials offers students greater flexibility in learning independently (Sidiq & Suhendro, 2021). E-modules are electronic modules that can be accessed without direct guidance from a facilitator or teacher, allowing students to learn anytime and anywhere (Dewi *et al*., 2022; Yaniawati *et al*., 2021). According to Amril and Thahar, this e-module has advantages over regular modules, namely that it makes it easier for students to access because it can be loaded onto tablets or mobile phones. The e-module can also be easily distributed and purchased, and it allows for font size adjustments and the addition of text. Furthermore, the e-module is believed to support the literacy skills of both adults and children in school, especially children with limited literacy skills and knowledge upon entering school (Amril & Thahar, 2022).

Several studies have been conducted on e-modules as digital teaching materials, including Aulia et al.'s study entitled “Pengembangan Elektronik Modul pada Mata Pelajaran IPA Materi Pencemaran Lingkungan Berbasis Inkuiri”. The study discusses the experiences of many teachers who still rely on government-mandated teaching materials, which leads to less active students. For this reason, the development of inquiry-based e-modules is needed to increase student learning participation (Aulia *et al*., 2022). There is also research by Rahman, entitled “Efektivitas Penerapan Flipped Classroom dalam Pembelajaran Jarak Jauh di SMA Negeri 9 Makassar,” which states something similar. The research discusses the creation of e-modules for a new learning model called the flipped classroom, where students study material at home and work on problems in class. Flipped classroom learning, utilizing these e-modules, effectively enhances students' exploration of the learning material (Rahman, 2022). Finally, Murni et al.'s study, “E-Modul Tematik Interaktif: Membuat Pembelajaran Lebih Menyenangkan dengan Canva di SD,” also states that creating e-modules can improve elementary school students' abilities in a more feasible, practical, and

effective manner. The study found that the average scores of students who learned using e-modules were higher than those who were not taught using e-modules (Murni *et al*., 2024).

Based on these studies and to address the challenges of today's era, the development of interactive e-module teaching materials supported by multimedia technology is crucial. The use of AR in e-modules can be an innovative solution to increase the appeal and effectiveness of learning in this technological era. This article will further explain the exploration of AR in e-module development as a step towards technology-based education that is relevant to current developments. This article is expected to serve as a reference for readers in developing engaging learning media for students.

LITERATURE REVIEW

Education, as a primary pillar in shaping character and improving the quality of human resources, demands continuous innovation in learning methods and media. Teachers, as planners and evaluators of learning activities, play a central role in creating a learning environment that is responsive to current developments and student needs (Rahmawati & Suryadi, 2019).

Technology Integration in Learning

Today, the integration of technology into learning has become an urgent need. The role of teachers is no longer merely as information transmitters, but also requires integrating technology into learning design. The shifting learning paradigm has given rise to demands for the adoption of technology as an integral part of the learning process. The importance of technology in learning is reinforced by the finding that innovation in the learning process is inevitable (Goulart *et al*., 2022; Munna & Kalam, 2021). Transformation in education, especially in the development of learning systems and processes, has become an unavoidable necessity (Isma *et al*., 2022). Conventional learning processes that are considered irrelevant to current developments influenced by technological advances require adjustments through technological integration (Jayadiningrat *et al*., 2017). One way to achieve this integration is by utilizing technology in learning, such as multimedia presentations, video editing, and other learning media. This will demonstrate that multimedia presentations have a significant impact on student learning outcomes (Haniko *et al*., 2023). The use of multimedia for presentations not only increases the effectiveness of learning but also provides flexibility in students' understanding of concepts, utilizing sensory elements such as audio, visual, and audio-visual.

In Indonesia, the integration of information technology into learning remains an ongoing and adaptive process. The use of digital technology, such as the e-modules explored in this study, offers students opportunities to explore broader information sources, develop technology-related soft skills, and make the learning process more engaging and creative (Suryansyah & Hasanah, 2024). Therefore, exploring AR in e-modules as part of technology-based education can be an innovative step that is relevant to the demands of the times and technological developments.

The Role of Teachers as Learning Facilitators and Innovators

The teacher's role as a facilitator in creating a pleasant educational environment has a significant impact on the development of students' creativity. A well-designed environment not only provides physical comfort but also stimulates students' creative thinking, in accordance with the principles of independent learning promoted by the Ministry of Education and Culture (Mustaghfiroh, 2020). In their role as facilitators,

teachers can create learning spaces that are interesting, stimulating, and actively involve students, making them more likely to be engaged in the learning process (Rosarian & Dirgantoro, 2020).

Furthermore, the role of teachers as learning innovators is also manifested through the use of Android-based interactive learning media. This innovation not only proves effective in providing more engaging learning but also addresses the issue of educational accessibility (Ariani *et al*., 2023). By opening wider access to learning resources, particularly through technology, teachers can bridge the gap between students with limited access and those with greater access. The variety of learning methods implemented by teachers is key to realizing their role as learning innovators. The use of varied methods not only makes students more active but also helps avoid boredom, making the learning process more dynamic and relevant. (Alga *et al*., 2024). The factors mentioned together have contributed to increasing the effectiveness of learning, especially in the context of technology-based education, which continues to develop.

The Role of Learning Media in Effective Learning

In the context of the important role of instructional media in achieving effective learning, communicative interaction between teachers and students becomes the primary focus. Communication processes involving one-way, two-way, and multi-way communication are considered practical approaches in stimulating students' interest in learning (Putri, 2023). This communication fosters an environment where students are not merely passive recipients of information but are actively engaged in the learning process. The importance of using interactive learning media is increasingly emphasized in the era of Industry 4.0, particularly among the millennial generation, who prefer engaging with media through Android applications. (Firmadani, 2020). Therefore, teachers are expected to adopt interactive media such as our class app, Ruang Guru, and Quipper. The use of these media not only reflects a response to current developments but also accommodates the learning needs of students who are more responsive to technology.

The role of teachers in responding to technological advances is becoming increasingly vital. Teachers are not merely transmitters of information, but also facilitators and innovators who understand students' learning preferences and styles. Therefore, adopting interactive learning media is not merely an option, but a key factor in creating effective learning that is aligned with current developments and student needs (Hamadi *et al*., 2021; Treve, 2021; Tulaskar & Turunen, 2022). By understanding the role of learning media as a catalyst for interaction and active learning, education can be more responsive to the dynamics of the technological era.

Augmented Reality (AR) in E-Modules as an Alternative Digital Teaching Material

In responding to changing times, innovation in learning is crucial, particularly through the development of digital materials that address the challenges of secondary school learning. Several studies have shown that students' 4C skills (Critical Thinking, Creative, Communication, and Collaborative) are influenced by teacher dominance in the learning process and a lack of student-centered thinking and interaction activities (Iryani, 2020). Therefore, a strategic step was taken by developing digital materials for teaching using AR integrated with the Contextual Teaching and Learning (CTL) model.

The lack of alignment between the design of learning activities by teachers and the 2013 curriculum, particularly in encouraging students to be more active in the learning process, is the basis for developing AR-based digital materials that are integrated with the CTL model (Mantasia & Jaya, 2016). Findings from previous research indicate that digital materials for AR teaching, when integrated with the CTL model, are

considered valid and practical in improving students' 4C skills. This aligns with previous research findings that suggest the use of digital materials can improve students' 4C skills (Sriyanto, 2021).

Despite technical constraints related to smartphone specifications in Indonesia, such as limited camera capabilities, processors, and storage space, previous research indicates that students respond positively to the use of AR in learning (Mardian *et al*., 2023). This suggests that the application of AR in e-modules has significant potential to overcome the challenges of conveying an understanding of abstract material. With this digital material application, students are not only encouraged to explore and expand their understanding of the learning material but also allowed to develop their critical thinking, creativity, communication, and collaboration skills. Thus, AR in e-modules opens up new alternatives as innovative digital teaching materials that are responsive to the needs of 21st-century education (Azhar *et al*., 2024).

METHODS

This research uses a library research approach to support the exploration and development of the concept of "Towards Technology-Based Education" with a focus on the application of Augmented Reality (AR) in E-Modules for the latest learning. According to Prastowo in his book entitled “Metode Penelitian Kualitatif dalam Perspektif Rancangan Penelitian,” library research is defined as a type of research that aims to collect data or information through the use of materials such as books, magazines, documents, articles, and other sources. The type of data collected and reviewed pertains to research results relevant to the study of the role of technology in supporting distance learning.

The stages in this literature review are detailed as follows: first, the researcher selects a research topic to be studied, with an emphasis on the concept of technology-based education and the use of AR. Second, an article search is conducted, and research articles are selected that align with the study topic, with a focus on the use of AR in learning. The next stage involves analyzing and synthesizing the sources found in relation to the study topic. This research not only uses theoretical sources but also explores empirical data that supports the exploration of the use of AR technology in distance learning. Fourth, the results of the analysis and synthesis are organized, developed, and concluded in accordance with the research topic, emphasizing the role of libraries in supporting the understanding and application of AR technology in E-Modules.

Furthermore, the paper is structured systematically, following the research topic structure, and provides comprehensive conclusions. Therefore, this literature review serves not only as a theoretical foundation for the research framework but also as a data source that provides in-depth insights into AR exploration in current learning contexts.

RESULTS AND DISCUSSION

In response to the changes of the modern era, innovation in learning has become essential, particularly through the development of digital materials that address learning challenges in secondary education. The rapid advancement of technology has significantly impacted the field of education, one of which is making learning delivery more innovative and interactive. Moreover, the widespread use of technology in everyday life has encouraged the emergence of more diverse learning methods. One example of utilizing technology as a learning medium is Augmented Reality (AR). AR is a technology that integrates two- or three-dimensional virtual objects into a real-world environment, allowing these virtual objects to be viewed in

real time (Einsthendi *et al*., 2024). Integrating AR in E-Modules as an alternative innovative digital teaching material is a strategic step in optimizing learning.

Although technical challenges related to smartphone specifications in Indonesia remain, previous research has shown that students respond positively to the use of AR in learning. This indicates that the application of AR in e-modules has significant potential to overcome the barriers to transferring understanding of abstract material. With this digital learning application, students are not only encouraged to explore and expand their understanding of the learning material but also allowed to develop their critical thinking, creativity, communication, and collaboration skills (Sari & Alfiyan, 2023).

The following is presented in **Table 1:** a literature study in the form of articles regarding the use of AR in e-modules as an alternative digital teaching material:

Table 1. Literature Study of Articles

No	Writer	Article Title	Contents of The Article
1.	(Harahap *et al*., 2024)	Pengembangan Modul Kimia Berbasis Teknologi Augmented Reality pada Materi Hakikat Ilmu Kimia	An augmented reality-based chemistry module, created through a storyboarding process, complete with colorful illustrations, has proven to be feasible and practical for use in chemistry learning. This is evidenced by assessments from material and media experts, with scores above 86%, as well as assessments from students and teachers, with scores above 87%. They stated that this augmented reality-based chemistry module provides valid and practical material.
2.	(Allo & Suhendra, 2022)	Development Of an E-Module Using Augmented Reality In Physics Teaching At The High School Of Manokwari Regency	An augmented reality-based e-module for physics was created to facilitate learning at SMA Negeri 1 Manokwari. This e-module is considered important because it can provide students with an understanding of physics sub-topics through videos, animations, and other virtual experiences. The e-module was deemed valid, effective, and practical to use, and can improve students' physics learning outcomes. This is evident in the increased post-test scores of students after being taught using the augmented reality-based physics e-module.
3.	(Riyanti *et al*., 2022)	Student Needs Analysis for The Development of Augmented Reality Integrated E-Modules about Particles in Science Learning.	This article presents the results of a survey on the needs of students and teachers regarding the creation of an augmented reality-based e-module for science learning in schools. The survey results indicate that students struggle to learn about atoms, ions, and molecules, as well as other material properties. Students also feel that teachers teach the material in an uninteresting way, so they agree and strongly support the creation of this augmented reality-based e-module. Students want the e-module to be accessible from their Android phones because it can facilitate access and understanding of science materials. In addition, teachers are also willing to implement this augmented reality-based e-module to create more effective learning.
4.	(Saputra & Octavia, 2024)	E-module Assisted by Augmented Reality with a Discovery Learning Model on Virus Material to Increase Scientific	An augmented reality-based e-module on viruses has proven suitable for integration into biology learning activities. This conclusion was drawn from assessments conducted by media and materials experts, biology teachers, and student feedback, all of which yielded high scores and deemed the e-module highly practical. The e-

No	Writer	Article Title	Contents of The Article
		Literacy and Learning Independence for Class X High School Students	module was also effective in enhancing students' literacy skills and promoting independent learning habits.
5.	(Saputri & Asrizal, 2023)	Needs Analysis for the Development of Digital Teaching Materials With Augmented Reality for Optical Instrument Materials	This article discusses the need to create augmented reality-based teaching materials in physics learning at MAN 1 Padang City. The results of the study indicate that many students are no longer interested in using printed teaching materials, particularly since these materials are considered outdated in the current learning context and curriculum. Student grades are also categorized as low, especially in the optical instrument material, because students lose interest and motivation. The learning objectives designed by teachers often fail to account for the varying levels of student ability. Based on these various reasons, it is concluded that the development of digital teaching materials based on augmented reality is essential for both students and teachers.

Source: 2024 Research

From the reviews of the articles above, it is clear that the development of AR-based teaching materials or e-modules is indeed necessary and has the advantage of applying to various subjects. Students find learning using e-modules practical (Harahap *et al*., 2024). The use of AR as a learning medium encourages interest in learning, facilitates understanding of the material, and encourages students' interest in learning (Usmaedi *et al*., 2020).

AR-based e-modules are considered important because they can provide students with an understanding of how to learn sub-materials through videos, animations, and virtual experiences (Allo & Suhendra, 2022). Utilizing AR in learning activities can encourage students to enhance their understanding of the material provided, as they tend to have a greater ability to grasp certain concepts with the aid of visualizations on digital media (Kuswinardi *et al*., 2023). The use of AR provides an opportunity to create a more engaging learning process, as the addition of digital elements will motivate students to participate more actively in the learning process (Sari & Ningsih, 2020). In addition, the many distractions that students might encounter in class can also be overcome if teachers succeed in creating learning media that prioritize student appeal.

The creation of AR-based e-modules is supported by students' difficulties in understanding the material and their desire to access it readily, thereby enhancing learning effectiveness. It will also serve as a facility to meet the personal needs of students, as it is designed according to the level of understanding of each individual and offers solutions that prioritize individual needs in the field of education (Riyanti *et al*., 2022; Wahyuanto, 2022). So that teachers can effectively encourage students to create a conducive learning situation.

This AR-based e-module yields high scores for students, enhancing their literacy and independent learning habits, and enables them to delve deeper into and better understand the material provided by the teacher (Saputra & Octavia, 2024; Socrates & Mufit, 2022). Utilizing AR in the learning process can encourage students to collaborate with their surrounding environment, thereby fostering interactions and collaborative skills (Ningsih & Sari, 2024). The positive use of AR will encourage students to improve their social and collaborative skills towards their surrounding environment (Sutanto *et al*., 2022). This can certainly provide the main benefit of preparing students to face the demands of collaboration in the real world.

The need for AR-based teaching materials arises from the declining interest and motivation of students to learn through printed materials, low student grades, and the inaccuracy of teachers in designing learning objectives (Saputri & Asrizal, 2023). The use of AR in the learning process can make it easier for teachers to tailor learning to the individual needs and preferences of students, allowing them to present personalized learning according to the varying levels of student understanding (Kuswardi *et al*., 2023). Students' interest and motivation in learning can also increase because the learning process can significantly enhance student involvement. AR elements receive a positive response, as they provide a more engaging learning experience, thereby encouraging students to become more engaged in teaching and learning activities (Kuswardi *et al*., 2023).

Given the significant impact of AR utilization, its use in learning provides an opportunity to create engaging learning processes, enhance material understanding, meet students' individual needs, and foster collaboration with the surrounding environment. However, this utilization must be accompanied by improvements in adequate technological facilities and infrastructure, as well as teacher training, so that AR can be optimally utilized in teaching and learning activities. Therefore, with this research, it is hoped that teachers in the millennial era can increase their creativity and innovation in developing learning media to keep pace with technological developments.

CONCLUSION

Based on the research results and discussion, it can be concluded that integrating Augmented Reality (AR) into E-Modules as digital teaching materials in secondary schools has a positive impact on increasing student participation and understanding in learning. The increasingly rapid existence of technology has provided an impetus for presenting innovation and interactivity in learning schemes. The results of student responses show a high level of positivity towards the use of AR in learning. Student interest in learning increases, while the ease of understanding the material becomes easier. Other aspects, such as display components and implementation, also received positive responses. The literature review conducted in this study also reinforces these findings, highlighting that the use of AR in learning can significantly enhance student engagement and activity. Therefore, the use of AR in learning offers great potential to create an engaging and immersive learning process because it will meet the personal needs of students, and encourage social and collaborative skills.

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