



## Augmented Reality: Impact on student engagement and learning

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### ABSTRACT

This research investigates the influence of Augmented Reality (AR) on student engagement and understanding in education. This research emphasizes how AR can enhance the learning experience by presenting interactive and meaningful content. The research methodology involved an in-depth review of the literature and theories related to AR and education. Research findings show that AR has a positive effect on student engagement, as it offers an immersive and stimulating learning experience. Additionally, AR helps deepen understanding of concepts by providing visualizations and interactive elements that aid in understanding. The study results show that AR increases students' interest in learning and improves overall learning outcomes. This research emphasizes the importance of the effective implementation of AR technology in educational settings. This highlights the benefits of using AR to create three-dimensional virtual displays and interactive learning experiences that support student understanding. This research concludes that this research shows the potential of AR to increase student engagement and improve learning outcomes in education. It is hoped that this research can positively contribute to developing innovative and effective learning methods.

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### ABSTRAK

Penelitian ini bertujuan untuk menyelidiki pengaruh Augmented Reality (AR) terhadap keterlibatan dan pemahaman peserta didik dalam pendidikan. Penelitian ini menekankan bagaimana AR dapat meningkatkan pengalaman belajar dengan menyajikan konten yang interaktif dan bermakna. Metodologi penelitian melibatkan tinjauan yang mendalam terhadap literatur dan teori-teori terkait AR dan pendidikan. Temuan penelitian menunjukkan bahwa AR memiliki efek positif terhadap keterlibatan peserta didik, karena menawarkan pengalaman belajar yang mendalam dan merangsang. Selain itu, AR membantu memperdalam pemahaman konsep dengan menyediakan visualisasi dan elemen interaktif yang membantu dalam pemahaman. Hasil studi menunjukkan bahwa AR meningkatkan minat peserta didik dalam belajar dan meningkatkan hasil pembelajaran secara keseluruhan. Penelitian ini menekankan pentingnya implementasi yang efektif dari teknologi AR dalam setting pendidikan. Hal ini mengangkat bahwa manfaat menggunakan AR untuk menciptakan tampilan virtual tiga dimensi dan pengalaman belajar interaktif yang mendukung pemahaman peserta didik. Kesimpulan dari penelitian ini adalah penelitian ini menunjukkan potensi AR untuk meningkatkan keterlibatan peserta didik dan meningkatkan hasil pembelajaran dalam pendidikan. Penelitian ini diharapkan dapat memberikan kontribusi positif bagi pengembangan metode pembelajaran yang inovatif dan efektif.

**Kata Kunci:** Augmented reality; keterlibatan peserta didik; pemahaman peserta didik; pengalaman belajar

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## INTRODUCTION

The rapid development of information technology in today's world has led to many changes in several sectors. Education is no exception to these changes. The technology used in education can help educators maximize the potential of students to gain learning experiences. One technology that is being explored and utilized in various sectors is Augmented Reality (AR). AR enables an interactive experience between the real world and a world where objects are computer-generated information (Garzón, 2021). AR is considered to have the potential to revolutionize the learning experience and have a significant impact on education, bringing many positive effects to the field of education (López-Belmonte *et al.*, 2023). Through AR, abstract concepts in subjects can be brought to life visually, helping students understand learning materials more interactively and increasing the effectiveness of learning (Tasrif *et al.*, 2020; Yusup *et al.*, 2023). Additionally, AR can be utilized to enhance virtual tours of historical sites and natural phenomena, as well as facilitate collaboration between students, thereby creating a more enjoyable and interactive learning experience (Lungu *et al.*, 2021). Adding AR elements can transform traditional textbooks into more dynamic learning resources, allowing students to access additional information and animations to support their understanding of the material.

Interactive learning using AR can improve students' memory and understanding. The use of AR can also help train practical skills, such as electronic installation and other technical skills, through realistic simulations (Takroui *et al.*, 2022). Overall, AR creates an innovative learning environment that motivates students to learn actively and helps them master educational concepts in a more in-depth and practical manner (Romano *et al.*, 2023). The use of multimedia in the learning process helps students understand and participate more actively (Sholeh *et al.*, 2021). Currently, a significant amount of literature demonstrates the potential of AR in education. AR can be used in learning geometry, spatial relationships between planets, and molecular structures. Some educators use AR to visualize abstract concepts more intuitively and improve understanding when describing object models and displaying objects, making them appear more realistic through 3D objects (Chafied, 2010; Cieri *et al.*, 2021).

AR can increase student engagement and understanding because this technology allows students to interact directly with learning content visually and interactively (Hariyono, 2023). According to him, with AR, students can see various economic concepts more concretely in a real context. Additionally, AR is also claimed to facilitate collaborative learning and communication among students, enabling them to work together. A similar statement was also expressed based on the results of another study, which showed that AR has an impact on student engagement and understanding because this technology allows students to combine real-world elements with virtual elements, creating an interactive and more meaningful learning experience (Azzalea, 2023).

In abstract learning, such as mathematics, AR can be used to visualize mathematical concepts more concretely, thereby stimulating student engagement through interactive exploration. It also facilitates independent learning among students, allowing for effective collaboration. AR has a positive impact on increasing student motivation, skills, problem-solving abilities, and learning outcomes (Cahyani *et al.*, 2024). The use of AR is considered effective in improving students' skills and motivation to learn. AR is also claimed to help students understand abstract material and visualize objects in the real world. AR provides a more engaging and interactive learning experience, which can increase students' motivation to learn (Videnovik *et al.*, 2020). By visualizing objects in the real world, AR allows students to see and interact with information directly, which can help deepen their understanding.

This study will focus on the role of AR in increasing student engagement, deepening conceptual understanding, and improving learning outcomes. The objective of this study is to detail the impact of AR on student engagement by providing an informative, interactive, and meaningful learning experience. This study aims to enhance our understanding of how to effectively integrate AR into teaching, creating a

responsive and dynamic learning environment that meets the evolving needs of students in an era of continuous information technology development.

## LITERATURE REVIEW

### Augmented Reality (AR)

Augmented Reality (AR) is a technology that utilizes a webcam to blend 3D and 2D objects with the real world, enabling users to perceive virtual objects as integrated into the physical environment. This helps students understand concepts and theories by encouraging them to think conceptually and enhancing their reflection (Aryani *et al.*, 2019). AR is a technology that allows users to see a combination of virtual objects and the real world in real-time. In addition, other researchers have defined AR as an interaction between humans and computers, resulting in a situation where virtual objects are added to the real environment and can be viewed in real-time through a video camera or computer (Tomi & Rambli, 2013). AR has been used as an addition to existing traditional teaching methods, integrating text, 3D graphics, video, and audio into the real-time environment of learners (Cai *et al.*, 2020).

Tools such as books and cards can contain markers that will trigger AR. These main tools include AR-based books that bridge the digital and real worlds and are well-received by digital-native learners, such as “The Future is Wild: The Living Book.” Another tool is AR Note, a system that enables note-taking in a virtual notebook, recognized for its efficiency and support for graphic content and information retrieval within notes. Systems like these can improve student engagement and learning habits (Belda-Medina & Marrahi-Gomez, 2023). Technological advances continue to increase the application of AR in education. Educators and researchers are developing new teaching methods to make learning more accessible. The prevalence of mobile devices facilitates the widespread adoption of AR in education. As predicted by industry experts, future technological advances will likely improve the quality and effectiveness of AR-based educational content, further integrating AR into educational practices (Marrahi-Gomez & Bella-Medina, 2022).

### E-learning

E-learning is a learning process that uses information technology as a medium for delivering material and facilitating interaction between teachers and students. In e-learning, students can study independently by utilizing various learning resources available on online platforms. They can also interact with educators and fellow students through discussion forums or live chat, enabling effective communication even in distance learning (Maatuk *et al.*, 2022). The main advantage of e-learning is its flexibility in terms of time and place. Learners can access learning materials at any time and from anywhere according to their needs. This allows individuals with busy schedules or those in remote locations to continue their studies without having to be physically present in class (Valverde-Berrococo, 2020).

E-learning also allows learners to study at their own pace and according to their own learning styles, making the learning process more efficient and effective. With e-learning, learners can also develop independent skills in finding information and solving problems. They not only rely on the material presented by educators but can also find additional learning resources relevant to the topic being studied (Baabdullah *et al.*, 2022). This makes the learning process more interesting and varied, and can improve students' problem-solving and critical thinking skills (Alwahtani & Rajkhan, 2020). However, despite its many advantages, e-learning also faces several challenges. One of them is the lack of internet access in some areas, which can prevent students from participating in online learning. Additionally, not all students possess the necessary technological skills to participate effectively in e-learning. Therefore, efforts need

to be made to enhance the accessibility and technological capabilities of students, enabling them to maximize the benefits of e-learning (Al-Rawashdeh, 2021).

## Students' Engagement

Student engagement refers to the quality and quantity of students' psychological state, encompassing cognitive, emotional, and behavioral reactions to the learning process, as well as academic and social activities both in and outside the classroom, to achieve optimal learning outcomes. It also includes students' sense of ownership of the school, acceptance of school values, and behavioral components related to participation in school activities. Student engagement is also a manifestation of motivation as seen through actions, cognition, and emotions (Fikrie, 2021). Student engagement is critical for various reasons. Student engagement can increase their motivation to learn. When students feel involved in the learning process, they tend to be more motivated to learn and achieve good results.

Student engagement can also improve their understanding of the subject matter. When students are actively involved in the learning process, they have a greater opportunity to understand the concepts being taught. Student engagement can also increase interaction between students and educators, as well as among fellow students. This can create a more collaborative and supportive learning environment (Mukaromah & Mulawarman, 2018). However, several factors can impact the level of student engagement. One of them is the quality of interaction between educators and students. Educators who can create a fun and supportive learning environment tend to increase student engagement. Additionally, factors such as an engaging curriculum, innovative teaching methods, and support from schools and parents can also influence the level of student engagement in the learning process. Student engagement is a crucial aspect of the learning process that can significantly influence learning motivation, subject matter understanding, student-educator interaction, attendance rates, graduation rates, and the overall school environment (Ansyar *et al.*, 2023).

## Students' Understanding

Student comprehension refers to the level of understanding and acceptance of information that students receive during the learning process. This includes the ability of students to understand, interpret, and apply the subject matter presented by educators. Student comprehension is important because it enables students to master the learning material more effectively (Sari, 2020). Student comprehension also includes the ability of students to relate new information to their existing knowledge, as well as the ability to restate the information in a way that they understand. Student comprehension has a significant impact on their learning outcomes. Students who understand the learning material well tend to achieve better learning outcomes (Rosyiddin *et al.*, 2023). Therefore, educators need to continuously encourage and support students so that their understanding of the subject matter can improve. Thus, student understanding is not only a goal in the learning process but also a key factor in achieving optimal learning outcomes for students (Usanto, 2022).

In the context of the research presented, student understanding is measured through student learning outcomes, which reflect the extent to which students can understand and apply the subject matter presented (Kholifah *et al.*, 2020). Various factors also influence student understanding in the learning process. One of them is the student's learning style. Each student has a unique learning style, including visual, auditory, and kinesthetic. Educators need to understand students' learning styles in order to deliver learning materials appropriately and improve students' understanding (Khaira *et al.*, 2023). Additionally, learning motivation also affects students' understanding of the material. Highly motivated learners tend to understand learning materials more easily because they are more focused and diligent in their studies

(Pratama, 2021). Learners' understanding can also be enhanced through the effective use of teaching methods. The use of varied and engaging teaching methods can help students better understand the material. Additionally, interaction between students can also enhance their understanding. Group discussions, collaborative projects, and other group activities can help students reinforce their understanding of one another and deepen their comprehension of the subject matter (Aeni *et al.*, 2022).

## METHODS

This research method uses a literature review or literature study, which involves incorporating theories related to the issue being studied. A literature review or literature study is a necessary activity in research, especially academic research, whose primary purpose is to develop theoretical aspects and practical benefits. This research is entirely based on a literature review or literature study. Therefore, the nature of this research is library-based. The data collected and analyzed are derived from literature and other documentary materials, including journal articles and relevant media that are still under research. This study collects two types of data: primary data and secondary data. The data collection technique used in this study is a literature review, which involves searching for data related to the discussion in the research title chosen by the researcher.

This study collects relevant information through various methods, including literature research, internet research, and internet searches. The data analysis technique involves research conducted deductively using qualitative analysis techniques, which means drawing specific conclusions from general theories and inductively connecting specific facts from the event, then concluding the specific to the general. The methods used to collect relevant information in this study included literature research, bibliographic research, and internet searches. The data analysis techniques used were deductive and inductive analysis. Deductive analysis is carried out by drawing specific conclusions from general theories. In contrast, inductive analysis is carried out by connecting specific facts from the event, then concluding from the specific to the general.

## RESULTS AND DISCUSSION

### Basic Concepts of Augmented Reality (AR)

AR is a technology that combines computer-generated elements with the real world, creating an interactive experience that enriches users' perception and interaction with their environment. In education, AR can be used to display digital information, such as 3D models, videos, or animations, superimposed on the physical world, allowing students to learn more effectively (Nadela *et al.*, 2022). AR technology enables users to view virtual content that appears in the real world, combining two- or three-dimensional virtual objects within a real three-dimensional environment, and projecting these virtual objects in real-time. Using a smartphone or glasses, users can view dynamic changes in their environment and access content and media nearby (Ramandani, 2022).

The use of AR in education has great potential to improve students' understanding of complex subject matter. This technology enables more realistic and concrete visualization, making it easier for students to understand abstract concepts that are difficult to explain using conventional methods (Wong *et al.*, 2021). For example, in science lessons, AR can be used to visualize molecular structures or the solar system, providing a more immersive and interactive learning experience. Additionally, AR supports collaborative learning, where students can work together to solve problems or explore materials together, creating a more enjoyable and effective learning environment (Wen, 2021). The integration of AR in education is believed to strengthen student engagement, increase learning motivation, and ultimately contribute to better learning outcomes.

## The Impact of Augmented Reality (AR) on Student Engagement and Understanding

The use of AR in learning environments has been proven to have a significant positive impact on student engagement and understanding. A series of studies have emphasized the enormous benefits of applying AR in economics education. These include increased student engagement, a deeper understanding of general concepts, the development of logical thinking, further holistic literacy experiences, and enhanced creativity through collaboration. Similarly, these studies also demonstrate that effective and efficient general learning applied through AR technology can stimulate student participation and enthusiasm, while also enhancing overall literacy effectiveness (Hariyono, 2023).

Various studies show that the use of AR in learning economics, early childhood education, Mandarin, and history can increase student engagement, conceptual understanding, interest in learning, and learning efficiency. For example, the application of AR in economics learning can increase student engagement, enhance conceptual understanding, provide in-depth learning experiences, and foster collaborative creativity. The use of AR in history learning has also been shown to improve student understanding, as evidenced by the use of AR-based HISAPP media for research. Therefore, it can be concluded that the use of AR in the learning environment has a positive impact on student engagement and understanding (Yuniawatika *et al.*, 2023).

Additionally, focusing on AR operations to understand complex material has proven to be highly effective. For example, specific exploration of AR operations in studying eye system material shows that scientists have made significant progress in understanding abstract material (Amir Alkodri *et al.*, 2020). Performing AR operations in this environment not only provides a more realistic visual dimension but also creates a more in-depth and interactive literacy experience (Widiasih *et al.*, 2023). With this series of positive findings, it can be concluded that the use of AR in literacy is not merely a technological discovery but an effective tool for increasing student engagement and overall understanding. By continuing to integrate AR technology into literacy approaches, tutors can create new opportunities to foster a dynamic, interactive literacy environment that supports the in-depth growth of students.

## Improving Material Comprehension with Augmented Reality (AR)

The use of AR technology in education clearly shows its positive impact on student engagement and understanding. Various studies show that the use of AR in the learning process not only increases student engagement but also improves conceptual understanding, interest in learning, and overall learning effectiveness (Purwanto & Kurniawan, 2023). As a specific example, the application of AR in economics learning has successfully created a dynamic learning environment that enhances student engagement and deepens their learning experience through innovative methods. In addition, in history learning, AR has also proven to be an effective tool for improving student understanding by providing an extra dimension to historical material through interactive visualization. (Mar'atullatifah & Ratnasari, 2023).

For example, the integration of AR in economics learning can result in increased student engagement, deeper conceptual understanding, a more memorable learning experience, and enhanced collaborative creativity. This phenomenon is evident in research results that demonstrate the success of applying AR in history learning, specifically through the use of AR-based HISAPP media, in enhancing student understanding (Yuniawatika *et al.*, 2023). Research shows that AR has a positive impact on student comprehension levels, reflected in increased engagement and improved learning quality. Additionally, these findings indicate an increase in student comprehension of various subjects, including mathematics (Larasati & Widiasari, 2021). This confirms that AR is not only effective in improving learning in specific fields but also has the potential to support improved cross-disciplinary comprehension.

## Challenges and Solutions in the Implementation of Augmented Reality (AR)

The application of AR technology in the context of learning is not without a number of challenges that need to be overcome. One of the main challenges is the development of adequate AR applications, which requires a deep understanding of educational needs and appropriate design (Rezaldi *et al.*, 2023). In overcoming this, the use of the Multimedia Development Life Cycle (MDLC) has been proposed as an effective solution. MDLC helps guide the AR application development process by ensuring that the content produced is relevant and useful in the context of learning. In addition, the integration of AR with hardware is also an obstacle that needs to be overcome. The proposed solution is the application of technologies such as Vuforia, which can be used to create interactive AR learning applications. This technology not only supports object and image recognition, but also provides the possibility to present learning content in a more interesting and dynamic way (Mardian *et al.*, 2023).

Although its benefits have been proven, the application of AR in education is not without challenges. One of the main obstacles is the need for appropriate hardware and software, accompanied by implementation costs. The right solution to mitigate these challenges lies in the application of markerless AR, which can identify objects in the real world without relying on markers. In addition, the transition to a digital era in Indonesia also poses other obstacles to the widespread application of AR, particularly in the judicial system (Lastian & Tampinongkol, 2023). Examples include its application in the development of AR headsets for surgical procedures, its integration into the marketing industry, and its role in promoting cultural heritage (Febrianet *et al.*, 2015).

The availability of appropriate content is also a significant challenge. To overcome this, the development of Android-based AR applications for mathematics learning materials has been proposed using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. This model provides a structured framework to ensure that AR learning content is not only in line with the curriculum but also effective in facilitating the understanding of complex concepts (Zen *et al.*, 2023). The importance of training for educators in implementing AR in the learning process cannot be ignored. Therefore, initiatives to provide adequate training to educators need to be strengthened to ensure the effective use of this technology in the classroom (D'Amato *et al.*, 2022).

## Discussion

Based on the results of research on the influence of AR in education, it was found that this technology can have a significant positive impact on student engagement and understanding. AR allows students to interact with learning content visually and interactively, providing a more in-depth and meaningful learning experience (Erwis *et al.*, 2024; Li & Liu, 2023). Through the integration of technology, abstract concepts can be visualized more clearly, making it easier for students to understand the material being taught. The use of AR has also been shown to increase students' interest in learning, which has a positive impact on improving their learning outcomes. The implementation of AR in learning also opens up opportunities to create a more collaborative learning environment (Scavarelli *et al.*, 2021). Students can work together to explore new concepts, which not only increases their engagement in the learning process but also helps them develop critical thinking and problem-solving skills. In various learning contexts, AR helps strengthen students' understanding of complex material, such as mathematics, science, and history, by providing concrete and interactive visualizations (Abdullah *et al.*, 2022).

The application of AR technology is not without challenges. Limitations in the availability of AR-enabled hardware and a lack of training for educators are obstacles to its implementation. However, solutions such as the use of the MDLC development model and the integration of technologies such as Vuforia can help

overcome these obstacles (Dede *et al.*, 2021). Thus, despite several challenges, AR has great potential to improve the quality of learning at various levels of education, providing a more effective, innovative, and engaging learning experience.

## CONCLUSION

The use of AR technology in learning environments has been proven to have a significant positive impact on student engagement and understanding. Similarly, these studies also show that the effective and efficient application of general learning through AR technology can stimulate student engagement and enthusiasm while improving overall literacy effectiveness. AR operations that focus on understanding complex material have proven to be successful. Performing AR operations in this environment not only provides a more realistic visual dimension but also creates a more immersive and interactive reading and writing experience. Thus, the use of AR in learning can be an innovative solution to improve the quality of learning, especially in deepening students' understanding of complex material. By providing a more engaging, interactive, and memorable learning experience, AR can be an effective tool in supporting the achievement of better learning outcomes. Various studies show that the use of AR in the learning process not only increases student engagement but also improves conceptual understanding, interest in learning, and overall learning effectiveness. It can be concluded that the use of AR in literacy is not just a technological discovery but an effective tool for increasing student engagement and overall understanding. Research shows that AR has a positive impact on student comprehension levels, reflected in increased engagement and improved learning quality. Therefore, it can be concluded that the use of AR in the learning environment is not just a technological trend but a positive evolution that makes a real contribution to the quality of education by increasing student engagement and comprehension. The proposed solution is to implement technologies such as Vuforia, which can be used to create interactive AR learning applications. This technology not only supports the recognition of objects and images but also offers the possibility of presenting learning content in a more interesting and dynamic way. The application of AR in learning media has succeeded in creating three-dimensional virtual objects, creating an interactive learning experience, and supporting student understanding.

## AUTHOR'S NOTE

The author declares that there are no conflicts of interest related to the publication of this article. The author confirms that the data and content of the article are free from plagiarism.

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