Exploring the Role of Augmented Reality in Education: Systematic Literature Review

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ABSTRACT

The development of digital technology drives innovation in education, one of which is through the implementation of augmented Reality (AR), which increases interactivity and understanding of abstract concepts in learning. This research employed a Systematic Literature Review (SLR) method using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure transparency and rigor in article selection and data analysis. Of the 3,225,372 articles reviewed, 30 journals met the research criteria, with Marker-Based Tracking as the most commonly used AR method because of its stability and accuracy. The study results showed that AR increases students' interactivity, facilitates understanding of abstract concepts, increases student engagement, improves information retention and memory, facilitates simulation and practice, develops creativity and collaboration, adapts learning to individual needs, and improves cost and resource efficiency, although it still faces challenges in the infrastructure and technical skills of teachers. Therefore, further development in AR applications at various education levels is recommended to improve understanding and adaptation to scientific developments.

Keywords: Augmented reality, learning media, marker-based tracking

1. Introduction

The dynamic development of science, especially in technology and digital, has had a great impact on progress in several sectors, one of which is the field of education. This progress certainly has an important role in the learning process related to technological developments that aim to bring innovations in learning media. One of the innovations that is increasingly developing is the use of Augmented Reality (AR) in supporting the learning process. This technology can bring us into digital elements without ignoring the reality that occurs in the real world so that it can increase the effectiveness of learning with more interactive and realistic visualizations and trials [1]. The ability of AR to integrate virtual elements into the real world is what makes AR usable to help understand learning media better through interactive simulations in the context of education [2].

The integration of technology in learning is becoming increasingly crucial to increase the effectiveness and efficiency of the teaching and learning process [3]. This Augmented Reality (AR) technology allows users to interact with digital and integrated environments without ignoring the reality that occurs in the real world, thus providing a more immersive and interactive learning experience. This Augmented Reality (AR) technology allows users to interact with digital and integrated environments without ignoring the reality that occurs in the real world, thus providing a more immersive and interactive learning experience. The use of AR in learning is increasingly widespread due to its ability to increase student engagement and enrich learning materials with more realistic and interactive visual elements [4], [5]. The implementation of AR in education has been applied in various fields, including science, medicine, engineering, and even social sciences, which have shown its effectiveness in improving the understanding of complex and abstract concepts.

However, despite its many potentials, the application of AR in education still faces various challenges. Some of the main obstacles in the implementation of AR are the lack of supporting infrastructure, high development

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Table 1: PICOC Formulations.

Population	Students, teachers, and lecturers at different educational levels
Intervention	Advantage, methods of Augmented Reality in education
Comparison	Conventional learning, traditional learning, and conventional classroom teaching
Outcomes	Improvement in student engagement, knowledge retention, interactivity, and understanding of abstract concepts
Context	Implementing Augmented Reality in formal educational institutions (high schools and universities)

costs, and resistance to change from educators. Some of the main obstacles that are often faced include high development costs, limited technological infrastructure in some educational institutions, and the lack of technical skills from educators in operating this technology [6]. Therefore, it is important to explore more deeply how the implementation of AR can be optimized in the learning environment, so that it can provide maximum benefits for students. Although various studies have discussed the implementation of AR in education, studies that specifically discuss the effectiveness of AR in improving understanding and learning skills are still limited [6]. The use of AR in learning helps trigger students' memory and skills. Therefore, this study aims to conduct a Systematic Literature Review (SLR) to identify the advantages, challenges, and effectiveness of AR in improving understanding and analytical skills in the learning process.

Although Azuma's foundational work [1] laid the groundwork for understanding the technical components and conceptual framework of augmented reality (AR), it primarily focuses on the technological aspects of AR rather than its application in educational settings. As such, there remains a significant gap in exploring how AR can be effectively utilized to enhance pedagogical strategies and learning outcomes in formal education systems [3].

Similarly, while Schmalstieg and Höllerer [2] present an extensive overview of AR principles and implementation practices, their discussion largely centers on the development and engineering aspects of AR systems. There is limited exploration of empirical studies that examine the actual impact of AR tools on student engagement, comprehension, and academic performance in real-world classrooms. This highlights a need for further research that bridges the gap between AR’s technical potential and its educational value [4].

Moreover, Dunleavy *et al.* [3] demonstrate the promise of immersive AR simulations for participatory learning, yet their work is constrained to specific case studies or controlled environments. Consequently, broader investigations are needed to determine the scalability and adaptability of AR technologies across diverse educational contexts, curricula, and learner populations [5].

While Billinghurst *et al.* [4] provide a comprehensive survey of AR advancements from a human-computer interaction (HCI) perspective, the pedagogical dimensions of AR—such as instructional alignment, learner assessment, and curriculum integration—remain underexplored. There is a clear opportunity for future research to investigate how AR can be tailored to support constructivist, inquiry-based, or problem-based learning models in more effective ways [3].

Finally, Wu *et al.* [5] highlight the opportunities and challenges of AR in education, noting that most existing studies are exploratory in nature or focused on prototype testing. The lack of longitudinal studies examining the long-term impact of AR on critical thinking, collaboration, and sustained academic achievement underscores a critical research gap. This calls for more rigorous, data-driven investigations that assess AR’s efficacy as a transformative educational tool over time [4].

2. Research Method

Table 1 shows the Population Intervention Comparison Outcomes Context (PICOC) formulation used in this SLR. This study conducted a comprehensive survey of research on the implementation method of Augmented Reality as a learning medium and created a systematic review protocol research using the PRISMA (Preferred Reporting Items for Systematic Review and Meta-analysis) method. This process is classified into 4 (four) stages, namely: Determination of Eligibility Criteria, Determination of Information Sources, Literature Selection, and Data Collection.

The article selection process followed four PRISMA stages: (1) **Identification**, which involved searching major databases using specific keywords; (2) **Screening**, where duplicate and irrelevant articles were removed; (3) **Eligibility**, during which full texts were assessed based on predefined inclusion and exclusion criteria; and (4) **Inclusion**, where 35 articles were selected for final analysis

Stage 1: Article eligibility criteria. Determined by the Inclusion Criteria (IC) and Exclusion Criteria (EC), namely:

Inclusion Criteria (IC):

a. IC1: articles must be original research that has been studied and written in English and Indonesian.

b. IC2: articles published between 2020 and 2025.

c. IC3: articles aim to analyze other researchers' methods for developing Augmented Reality

Exclusion Criteria (EC):

a. EC1: Articles that do not focus on the educational applications of AR.

b. EC2: Articles with insufficient methodological descriptions or lack of clear data analysis.

c. EC3: Duplicates or retracted publications.

Stage 2: Determination of literature sources

a. Literature is searched in online databases with significant repositories for academic studies such as Google Scholar, Springer Nature, Crossref, Scopus, and IEEEXplore

b. In articles that are eligible for IC, other studies related to this study are also searched.

Stage 3: Literature Selection

a. The first determination of keywords is "Augmented Reality" and "Augmented Reality Application".

b. To explore and select titles, abstracts, and articles

c. Keywords are obtained from the results of a search for the eligibility of predetermined criteria.

d. Read articles that were not removed from the previous stage, in full or in part, to determine whether the item is eligible for further review

e. Selected articles are re-assessed to find related studies

Stage 4: Data Collection

Data was collected manually by creating a data extraction form. This study filters 3,225,372 journals based on the keyword “Augmented Reality,” and 384,938 articles based on the keyword “Augmented Reality Application” from all sources and criteria, and all articles, 95 scientific journals are eligible as reference candidates according to the title and abstract to answer the research question. After further research, only 30 selected articles were eligible for this study. Table 2 shows the data that has been collected.

This SLR provides answers to several Research Questions such as shown in Table 3

3. Results and Discussions

The first stage is discussing the results of the questions that have been determined in the Research Question. Research methods that have been carried out by previous researchers are used as references related to the topic of augmented reality design. Some methods that have been proposed by previous researchers are as seen in Table 4

From Fig. 1, there are three methods that have been proposed by previous researchers related to the design of Augmented Reality. The proposed methods are the Marker-Based Tracking method, the Markerless Tracking method, and the Head Pose Tracking method. From the three methods, software development was carried out, and

Table 2: Results of Research Journal Selection.

Source	AUGMENTED REALITY	AUGMENTED REALITY APPLICATION	CANDIDATES	SELECTED
Crossref	240.486	305.462	12	1
Google Scholar	2.880.000	35.600	37	10
Springer Nature	95.388	43.018	9	1
Scopus	200	34	31	16
IEEE Xplore	9.298	824	6	2
Total	3.225.372	384.938	95	30

Table 3: Research Questions.

ID	Research Questions	Background
RQ1	What methods have previous researchers proposed for conducting Augmented Reality Design?	Identifying methods previously proposed by researchers regarding Augmented Reality Design.
RQ2	Which research methods are most widely used to design Augmented Reality in learning?	Identifying the methods used to carry out Augmented Reality Design in learning
RQ3	What levels of education use Augmented Reality?	Identifying levels of education that use Augmented Reality.
RQ4	What are the benefits of using Augmented Reality as a learning media?	Identifying the benefits obtained from using Augmented Reality as a learning media.

the process started with the system. Then, from Fig. 1, it is clear that the Marker-Based Tracking method is most commonly used for Augmented Reality design.

Based on information from Fig. 1, it can be seen that the majority of research on Augmented Reality design applies the Marker-Based Tracking method. Previous researchers who applied the Marker-Based Tracking method in the journal [9], [13], [17], [18], [19], [31], [34] choose this method because this method is more stable in tracking objects so that only certain objects need to be recognized by the system, suitable for use as a learning medium because it is easy to implement, does not require high device specifications, and is effective in observing the structure of small objects. Here are four main reasons why some researchers choose to apply the Marker-Based Tracking method in designing Augmented Reality.

Table 5 summarizes the reasons why researchers prefer the Marker-Based Tracking method. It shows that the method is valued for its stability, ease of use, low hardware requirements, and suitability for object recognition in educational settings. Learning media is generally related to education or skills and training, previous researchers use and implement Augmented Reality at several levels of education from Elementary School to University or used for training workers such as police, pilots, and doctors of course with different focuses such as introduction, education, understanding, or for simulation. Here is the use of Augmented Reality in several levels of education and training.

Table 6 and Fig. 2 highlights how AR is used across various educational levels, demonstrating its versatility —from teaching astronomy in elementary school to complex medical simulations in university settings.

From Table 6, there are very diverse uses and implementations of Augmented Reality, ranging from Elementary School to worker training. In Elementary School students, its use is intended as visual and interactive learning in Middle School and High School students, it is useful to help understand abstract concepts such as the solar system, computer networks, and art, while in universities and training, this technology is useful to improve practical experience, technical simulations, and professional training. Based on Table 6, AR is widely used to review small objects that are constrained in accessibility and are also related to high production costs, such as dental surgery procedures, epilepsy surgery, and recognition of which, if practiced with real objects, require the availability of goods that are difficult to obtain. Large-scale objects can also be reduced in scale with AR technology, such as learning related to the solar system. AR increasingly makes it possible to study small objects that are limited in availability, making learning easier to do with a touch of AR technology and with benefits listed on Table 7.

Table 4: Literature Review Results.

NO	Titles	Years	Methods
1	The Effect[7]	2020	Marker-Based Tracking
2	Implementation…[8]	2020	Marker-Based Tracking
3	Pengembangan…[9]	2021	Marker-Based Tracking
4	Augmented…[10]	2022	Marker-Based Tracking
5	Implementation of…[11]	2022	Marker-Based Tracking
6	Educational…[12]	2022	Markerless Tracking
7	Augmented…[13]	2023	Marker-Based Tracking
8	Enhancing…[14]	2023	Marker-Based Tracking
9	Development…[15]	2023	Marker-Based Tracking
10	Implementation of…[16]	2023	Markerless Tracking
11	Pemanfaatan…[17]	2023	Marker-Based Tracking
12	Pengembangan…[18]	2023	Marker-Based Tracking
13	Implementasi…[19]	2023	Marker-Based Tracking
14	Augmented…[20]	2024	Marker-Based Tracking
15	Smartphone…[21]	2024	Markerless Tracking
16	Ten Years…[22]	2024	Markerless Tracking
17	Application…[23]	2024	Markerless Tracking
18	Molecule…[24]	2024	Marker-Based Tracking
19	Augmented…[25]	2024	Marker-Based Tracking
20	The Use…[26]	2024	Markerless Tracking
21	Increasing…[27]	2024	Marker-Based Tracking
22	Empowering…[28]	2024	Marker-Based Tracking
23	Penerapan…[29]	2024	Markerless Tracking
24	Pemanfaatan…[30]	2024	Markerless Tracking
25	Penerapan…[31]	2024	Marker-Based Tracking
26	Implementasi…[32]	2024	Markerless Tracking
27	Penerapan…[33]	2024	Markerless Tracking
28	Pengembangan…[34]	2025	Marker-Based Tracking
29	Efficient…[35]	2025	Head Pose Tracking
30	Augmented…[36]	2025	Markerless Tracking

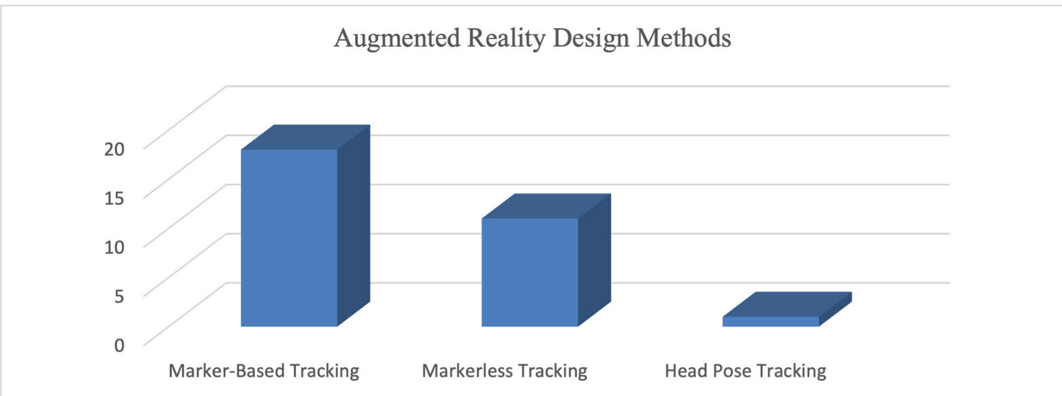

Fig. 1: Graph of the number of Augmented Reality design methods.

Table 5: Results of the Literature Review on the reasons for implementing the Marker-Based Tracking method

No	Results	Journal
1	Previous researchers used the Marker-Based Tracking Method because it has high accuracy in recognizing and displaying 3D objects so that object recognition is more stable and not distracted by other objects because the system is set to recognize certain images, symbols, or objects.	[17], [18], [34]
2	The Marker-Based Tracking method is the right choice as material for interactive and fun learning media, and can also be easily applied to books, cards, or documents without requiring complicated spatial mapping.	[9], [31]
3	Uses that do not require high specifications on the designer's device because it is lighter in terms of computing, cost-effective and easy to implement compared to Markerless Tracking because the system does not require additional sensors or LiDAR.	[19]
4	The Marker-Based Tracking method can determine the position of an object so that it does not shift, which makes it more effective in identifying small objects or documents.	[18]

Table 6: Educational Levels of Augmented Reality Use.

No	Educational level	Purposes	Journals
1	Elementary school	Learning the solar system, Education through interactive games, Introduction to human body organs, Visualization of biological concepts	[10], [19], [31]
2	Junior high school	Learning the solar system, learning ablution movements, learning physics, learning science	[7], [8], [9], [16]
3	Senior High School	Introduction to computer networks, Learning musical instruments, Learning molecules and compounds, Understanding computer systems	[18], [24], [33], [34]
4	University/Training	Weather training, Learning electrical circuits, Visualizing industrial processes, Dental surgical procedures, Teaching accounting principles, Understanding radiation therapy, Investigation training, Introduction to social distancing, Epilepsy surgical navigation	[11], [20], [21], [23], [26], [27], [35], [36]

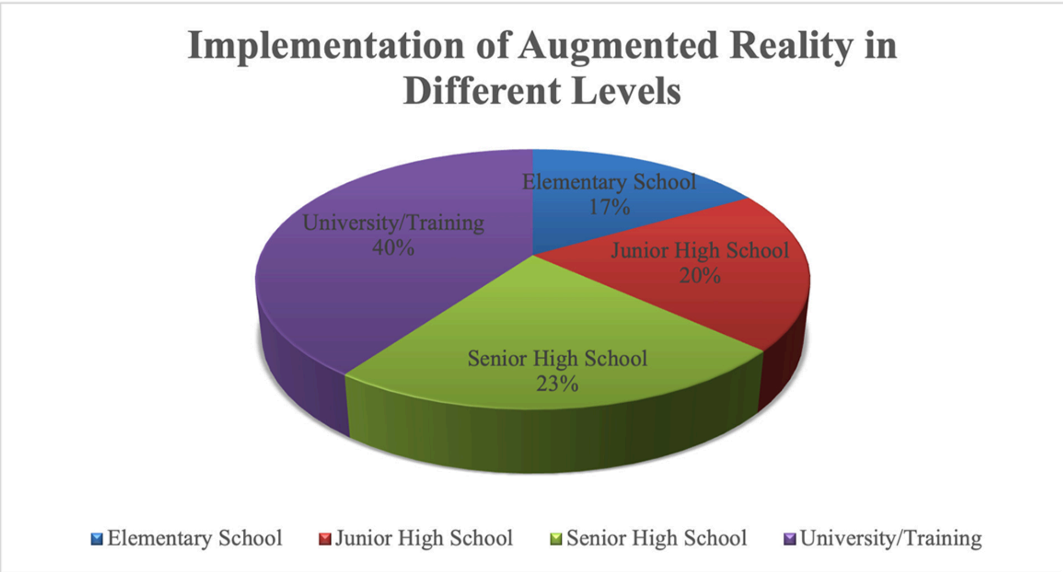

Fig. 2: Implementation of Augmented Reality in Different Levels.

A visualization of co-occurrence matrix is given in Fig. 3. Analysis of 30 articles provides results that Augmented Reality learning with object visualization is the most widely used, the implementation allows students to describe their imagination to be more real. This makes learning with AR more interactive and not monotonous, which affects students' thinking abilities, which are not all the same, so that with AR students do not feel pressured, and teachers do not need to repeat the simulation process several times, which is not time-effective. The different thinking abilities of students are increasingly the background for one of the reasons AR technology must be developed, because with flexible learning, students can learn and adjust the speed and learning method that suits them. In AR technology, visuals are displayed more than text, which is suitable for the current generation of students

Table 7: Benefits of Using Augmented Reality.

No	Benefits	Journals
1	Increasing Interactivity	[31]
2	Facilitates Understanding of Abstract Concepts	[9], [34]
3	Improve Retention and Memory	[31]
4	Saving Costs and Resources	[21], [26], [36]
5	Increasing Student Engagement	[20], [37]
6	Facilitates Simulation and Practice	[13], [27]
7	Developing Creativity and Collaboration	[19]
8	Adapting Learning to Individual Needs	[34]

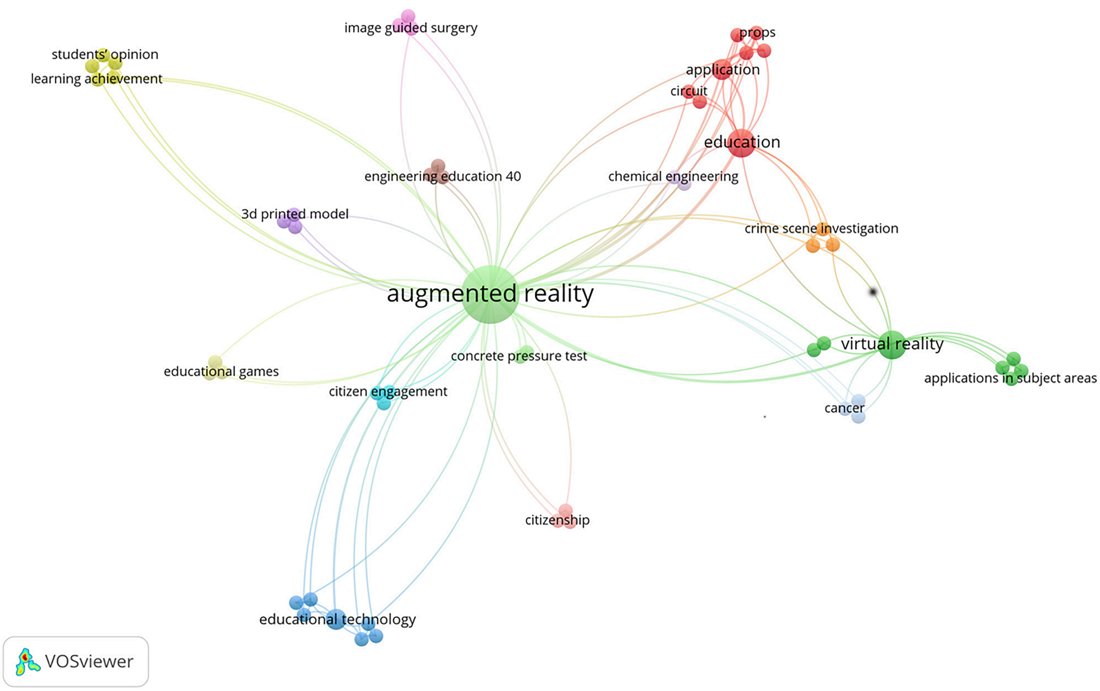

Fig. 3: Co-Occurrence Network

whose interest in reading is mostly lacking and is starting to be replaced by instant technology. Studies on learning media using AR have been conducted at several levels of education. This research is still limited in scope. However, researchers have a focus on learning in higher education or universities, although in addition to universities, AR implementation is also applied to elementary, middle, and high schools/vocational schools.

The use of teaching materials in higher education, especially in learning topics related to abstract matters or objects with limited accessibility, is often still constrained by the lack of laboratory facilities so that they still use conventional theories that are limited to books, while students in higher education are required to be able to carry out simulations or practices as professionals because they will be faced with the world of work so that they require compatibility and skills in their respective fields. The many technological tools that are now easily accessible should be used to integrate these limited objects so that innovation becomes a learning medium that is not only interesting and interactive, but also stimulates students' way of thinking and can improve their abilities because of the simulations from AR.

From the research results, several AR technologies in higher education are implemented in countries other than Indonesia. In Indonesia itself, the use of AR is still limited to elementary, junior high, and high school education. Things that need to be considered for students in Indonesia who must also develop AR technology. In higher education, there will be a lot of complex learning materials, if only theory is used to study it, then objects such as 3D images cannot be visualized and imagined by students. The benefits of this AR technology have a great influence on learning, some of the most influential are increasing student interest and motivation, because they can directly simulate, so that it is not boring, and can see objects in detail because AR can help make the object modeling process easy to understand.

Many studies have implemented the positive impacts of AR, but there are still some aspects that require further research related to its effectiveness. Although research on the use of Augmented Reality (AR) as a learning medium continues to be updated, some studies have not yet conducted comparisons on students with different learning styles such as visual, auditory, or kinesthetic [38]. Different learning styles affect their ability to understand learning. Augmented Reality based on 3D objects utilizes attractive visuals to increase student interaction, research generally only analyzes in general without knowing the learning style of the student, whether they are visual, audio, or kinesthetic learners. Further research is needed to assess the effectiveness of this method in various learning environments.

One of the most significant advantages of Augmented Reality (AR) in education lies in its capacity to improve students' conceptual understanding, especially of abstract and complex topics. Traditional instructional methods often rely heavily on textual and two-dimensional visual materials, which may not effectively convey the dynamics of certain subjects such as molecular structures, astronomical phenomena, or human anatomy. AR bridges this gap by enabling learners to interact with three-dimensional, dynamic representations in real time. This spatial interaction helps students form more accurate mental models, making it easier to grasp intricate processes and relationships. For instance, in chemistry education, AR can allow learners to manipulate virtual molecules, observe their interactions, and visualize chemical bonds and reactions that would otherwise be invisible. Similarly, in physics or biology, AR can model forces, structures, or body systems in ways that enhance understanding and retention. These benefits are supported by empirical studies that show significant improvements in learning outcomes when AR is used to supplement instruction in STEM disciplines [39], [40]. Such findings highlight AR's role not merely as a technological novelty, but as a pedagogical tool capable of transforming abstract knowledge into concrete learning experiences.

AR-based educational tools significantly enhance student motivation and engagement by introducing interactive, game-like learning environments. Unlike traditional learning materials, AR applications often incorporate elements of gamification, storytelling, and real-time feedback, which are proven to increase students' attention and enthusiasm for learning. The immersive nature of AR allows learners to be actively involved in their educational experiences, stimulating curiosity and fostering a sense of exploration. This is particularly impactful for younger students or those with lower intrinsic motivation, who may otherwise struggle to remain focused in conventional settings. Studies show that AR not only increases student interest but also improves participation and persistence in learning tasks [41], [40]. As engagement is a key predictor of academic achievement, these findings suggest that AR can play a pivotal role in cultivating deeper and more sustained learning experiences.

AR supports collaborative learning by facilitating shared experiences in both physical and virtual spaces. Through AR-enabled activities, students can engage in team-based problem-solving, discussion, and exploration. Such interactions foster peer-to-peer learning, social communication skills, and the development of shared knowledge construction. For example, multi-user AR environments allow learners to co-manipulate virtual objects or participate in scenario-based learning simulations that demand cooperation. This enhances students' understanding not only of academic content but also of teamwork and communication strategies. Research has demonstrated that collaborative AR applications increase learner satisfaction and performance, particularly when tasks are designed to require input from multiple users [39], [41]. These benefits make AR a valuable asset in group learning contexts, such as classroom projects, STEM labs, and peer-led workshops.

When properly designed, AR can reduce learners' extraneous cognitive load and enhance information retention by presenting content in a multimodal and contextually meaningful manner. By integrating visual, auditory, and kinesthetic stimuli, AR allows students to process information more effectively without overwhelming their working memory. For instance, rather than relying solely on text to explain a scientific process, an AR application can visually demonstrate the sequence of steps with interactive overlays, reducing the need for abstract reasoning. This multimodal presentation aligns with cognitive load theory, which emphasizes the importance of balancing cognitive demand during instruction. Empirical studies have shown that AR-enhanced learning environments improve students' focus and memory retention while maintaining high levels of comprehension [40], [39]. Consequently, AR represents a promising solution to address the challenges of cognitive overload, particularly in complex subject areas.

Augmented Reality (AR) has become a promising tool in special education, especially for learners with Autism Spectrum Disorder (ASD) and other developmental disabilities. Recent research has demonstrated that AR can significantly improve social skills, such as conflict resolution and friendship development, through interactive platforms like AR picturebooks [41]. These tools provide engaging and context-rich environments where students can practice social interactions in safe, repeatable scenarios. Furthermore, a decade-long review of AR applications in special education highlighted its positive impact on communication, engagement, and long-term competitiveness in the job market for students with special needs [40]. As a result, AR fosters inclusive learning by offering personalized, accessible content that meets the unique needs of diverse learners.

The integration of AR with Artificial Intelligence (AI) and the Internet of Things (IoT) significantly enriches educational experiences by enabling adaptive and context-aware learning environments. AI enhances AR systems by personalizing content and providing intelligent feedback based on learner performance, while IoT devices allow real-time data collection and interaction with physical environments. This synergy supports immersive learning scenarios that mirror real-world applications, such as smart lab simulations or personalized virtual tutors [39], [41]. These integrated systems represent a forward-thinking shift in digital pedagogy, opening pathways for more intelligent and responsive educational ecosystems.

AR facilitates contextual and situated learning by embedding digital content within real-world settings or simulations, which enhances conceptual understanding through direct experience. Students can engage in virtual field trips, conduct augmented laboratory experiments, or explore historical sites with layered digital information. This approach supports experiential learning theories by situating knowledge within meaningful contexts, making learning more relevant and memorable [40], [42]. As such, AR helps bridge the gap between theoretical knowledge and practical application, particularly in disciplines that benefit from spatial and environmental interaction.

In vocational and technical education, AR is instrumental in delivering realistic, hands-on training without the risks or costs associated with physical environments. By simulating complex tasks in medical, engineering, and mechanical domains, AR allows learners to practice and refine skills through repeated, safe interaction with virtual tools and equipment. These simulations enhance learners' confidence, procedural knowledge, and performance, making AR an effective solution for workforce readiness and technical certification programs [43], [44]. As industries increasingly demand skilled professionals, AR offers scalable and immersive training alternatives that align with real-world requirements.

The successful implementation of AR in education is closely tied to teacher readiness and professional development. Educators must possess not only the technical skills to operate AR tools but also the pedagogical understanding to integrate them meaningfully into instruction. Studies emphasize the need for structured training programs that build digital competencies and instructional design strategies for AR-enhanced learning [41], [45]. Investing in teacher preparation ensures that AR applications are used effectively to support curriculum goals and foster learner engagement, rather than serving as mere technological novelties.

Despite its pedagogical advantages, AR adoption faces significant challenges related to cost and accessibility. Developing high-quality AR content and acquiring compatible hardware can be financially prohibitive, especially for under-resourced schools. Additionally, issues such as poor internet connectivity and lack of infrastructure limit the feasibility of AR use in rural or economically disadvantaged regions [46], [47]. To democratize AR in education, stakeholders must address these disparities through policy support, funding, and the development of low-cost, scalable solutions that broaden access for all learners.

As AR technologies collect and process large amounts of user data, ethical and privacy concerns become paramount. Ensuring the protection of students' personal information, obtaining informed consent, and delivering age-appropriate content are critical to responsible AR implementation. Furthermore, educators must be aware of the psychological impacts of immersive experiences and avoid overexposure to virtual stimuli [48], [49]. Establishing clear ethical guidelines and privacy safeguards is essential to building trust and maintaining the integrity of AR-based educational systems.

4. Conclusions

The results of this study can be a reference for further research on augmented reality design and can identify effective and efficient methods according to the objectives of the augmented reality design needed. Several methods have been developed to design Augmented Reality. The most popular method according to this study is Marker-Based Tracking. With its advantages and effectiveness, Marker-Based Tracking is very suitable for use in designing Augmented Reality for learning materials. The limitations of this study are the survey conducted in this paper between 2020 and 2025 (ongoing), so that in subsequent studies, researchers can add duration to improve accuracy and quality and describe several methods to be combined to obtain stronger and more useful research. Based on the findings of various studies in the field of Augmented Reality (AR), especially those related to learning media, several things are suggested for the future: Increasing Research in the field of higher education, especially professional training: More research and development is needed in the use of AR in the scope of higher education to improve understanding and adaptation to scientific developments.

CRediT Authorship Contribution Statement

Passion T. G. Sianipar: Conceptualization, Methodology, Software, Resources, Writing – Original Draft, Visualization. **Wilonotomo:** Resources, Writing – Review & Editing, Supervision. **Priati Assiroj:** Validation, Formal analysis, Resources, Writing – Review & Editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data sharing is not applicable as the data are secondary data drawn from already published literature.

Declaration of Generative AI and AI-assisted Technologies in The Writing Process

The authors used generative AI to improve the writing clarity of this paper. They reviewed and edited the AI-assisted content and take full responsibility for the final publication.

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