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Augmented Reality Learning Media Development to Enhance Student Learning Motivation: A Systematic Literature Review

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Abstrak. This study aims to analyse the development of Augmented Reality (AR)-based learning media to increase students' motivation to learn using the Systematic Literature Review (SLR) approach. The study was conducted by selecting articles from various databases using inclusion criteria related to the form of AR implementation, the effectiveness of AR in learning, and supporting factors and barriers to its use. The results of the review show that AR media is developed in various forms, such as marker-based, markerless, interactive modules, and 3D books. Consistently, AR has been shown to increase student motivation, attention, and engagement in learning through 3D visualisation and real-time interaction. However, device limitations, the need for stable internet connections, and teachers' ability to operate technology are the main challenges to its implementation. These findings confirm that AR has the potential to be an effective, innovative learning medium, noting the need for facility adjustments, teacher training, and more systematic curriculum integration.

Keywords: Augmented Reality; Learning Media; Learning Motivation; Educational Technology.

1. Introduction

The development of digital technology in the era of the Industrial Revolution 4.0 has brought significant changes in the world of education (Fitrianti et al., 2024). This transformation requires the learning process to be more adaptive and responsive to the needs of students living in a digital environment (Siswanto, 2024). Technology-based learning media is one of the important instruments in supporting the quality of learning (Sitorus et al., 2025). Augmented Reality (AR) is one technology that has developed rapidly and is now widely used in various educational contexts.

AR technology is a form of integration between virtual objects and real environments in real-time (Lv, 2020). The integration process results in an immersive learning experience that allows students to interact with learning objects in a more concrete way (Wagner & Liu, 2021). Three-dimensional visualisation, animation, and audio-visual integration on AR provide a learning experience that is not only engaging, but also makes it easier to understand abstract concepts (Papanastasiou et al., 2019). The use of AR in learning has been proven to increase student engagement and facilitate the delivery of material more effectively.

Learning motivation is a key factor in determining the success of the learning process (Osman & Warner, 2020). AR-based learning media have great potential in increasing this motivation. The use of AR provides a powerful visual stimulus, new learning experiences, and opportunities for self-exploration (AlGerafi et al., 2023). Previous research has shown that AR contributes to increased attention, relevance, confidence, and learning satisfaction, in line with Keller's ARCS model

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(Sdravopoulou et al., 2021; Laurens-Arredondo, 2022). Positive changes in the psychological dimension have direct implications for improving student learning achievement and active participation.

The application of AR in various subjects has shown quite positive results. Subjects such as science, mathematics, biology, history, and art are part of the field of study that often utilises AR (Juliawan et al., 2024; Juwita et al., 2021; Tanto et al., 2025). The technology makes it easier for students to see body organs, study space objects, understand the scientific process, and explore historical artefacts through 3D modelling. A more tangible visual context makes the learning process more meaningful. The main obstacles in its implementation lie in the limitations of devices, teachers' ability to operate technology, and uneven internet infrastructure (Perifanou et al., 2023).

Limitations in aspects of school readiness and educator competence lead to suboptimal use of AR in learning. Most schools still rely on conventional learning media such as printed books, static images, and simple videos (Mazaimi & Scotland, 2023). This condition has an impact on decreasing the level of interest and motivation of students in learning material that is abstract or requires visual understanding (Light & Purnomo, 2025). The use of AR has the potential to be an effective solution, especially for learning materials that require strong visual representations.

Several recent studies reinforce the view that AR is effective for learning. The use of AR has been proven to be able to increase students' focus of attention compared to conventional methods (Wulandari et al., 2025). Markerless-based AR applications increase interactivity and encourage students to engage in discussions actively (Prayitno et al., 2025). International research conducted by (Zhang & Miao, 2025) Also shows that AR is effective in increasing students' engagement in learning and intrinsic motivation across various educational discourses.

These findings show that AR has great potential in improving the quality of learning. However, the majority of research remains partial, focused on the development of specific products, and has not provided a comprehensive mapping of AR implementation development across existing studies. Systematic studies using the Systematic Literature Review (SLR) approach remain limited, especially in the context of education in Indonesia. Information on the development trends, benefits, and challenges of AR implementation remains scattered and has not been comprehensively analysed.

This research gap shows the need for a systematic literature review to map the development of AR in learning. Systematic studies can help identify development patterns, technological variations, effectiveness in increasing learning motivation, and obstacles experienced in their implementation (Hussien et al., 2019). This information can provide a comprehensive overview for educators, media developers, and policymakers in optimising the use of AR in the educational environment.

This study seeks to fill this gap through an SLR approach that aims to collect, select, and analyse relevant articles on the use of AR in learning. The SLR process allows researchers to synthesise findings in an objective, structured manner. In addition, an in-depth analysis of various articles can be the basis for formulating recommendations for more effective AR implementation.

The formulation of the problem in this study focuses on three main aspects. The first focus concerns the form and model of AR-based learning media development over the last five years of research. The second focus concerns the effectiveness of AR in increasing students' motivation to learn. The third focus examines the challenges, barriers, and supporting factors in implementing AR across various learning contexts. These three focuses provide clear direction for the process of collecting and analysing research data.

This study aims to describe the implementation of AR in learning, analyse its role in increasing students' motivation to learn, and identify obstacles and recommendations for its implementation in education. The results of the research are expected to provide theoretical contributions to the development of AR in education and practical recommendations for its implementation, addressing teachers, media developers, and educational institutions.

2. Methods

This study uses a Systematic Literature Review (SLR) approach to examine research results on the development and application of Augmented Reality (AR) in learning. SLR was chosen because it can provide a structured, comprehensive, and objective mapping of knowledge based on relevant scientific articles (Andreini & Bettinelli, 2017). The SLR process follows systematic steps that include article identification, selection based on specific criteria, thematic analysis, and synthesis of research results (Cabrera & Cabrera, 2023).

The data collection process began with searching for articles in various national and international databases, including Google Scholar, ERIC, ScienceDirect, and Garuda. The search was conducted using several keywords, including "augmented reality in education", "AR-based learning media", "learning motivation with AR", and "AR learning engagement". The articles found were then checked for suitability with the research topic based on titles, abstracts, and keywords.

Inclusion criteria are established to ensure the relevance of the analysed articles. Eligible articles are those that: (1) were published in the last five years, (2) discuss the implementation of AR in the context of learning, (3) outline the impact of AR on student motivation or learning engagement, and (4) use AR media development or test methods. Exclusion criteria are set to avoid articles that do not meet the study's needs, such as those lacking empirical data, not focusing on learning, or not available in full text.

The selection process is carried out through three stages of screening, namely title screening, abstract screening, and complete content review (Cabrera & Cabrera, 2023). Each article that passed the screening stage was then analysed thematically, based on the study's focus, the development model used, the form of AR implementation, the results of the learning motivation test, and the obstacles to the application of AR in learning.

The data analysis technique uses a content analysis approach. Each article is coded to identify key findings and patterns. The analysis stage produced three thematic categories, namely: (1) the form and model of AR implementation in learning, (2) the effectiveness of AR in increasing learning motivation, and (3) the challenges and supporting factors of using AR in various educational contexts. These three categories are used as the basis for compiling a synthesis of research results.

The validity of the research is maintained through the source triangulation technique, which involves comparing results from various articles by different researchers to ensure consistency of the findings. Methodological triangulation is also achieved by comparing product development studies, experimental studies, and evaluative studies that examine the implementation of AR. The results of the analysis were arranged narratively to provide a comprehensive picture of AR's contribution to learning.

3. Results

The literature search yielded several articles relevant to developing Augmented Reality (AR)-based learning media to increase students' motivation to learn. Using inclusion and exclusion criteria, several articles were analysed to identify AR implementation patterns, characteristics of the developed media, and findings related to learning motivation. The selection stage is carried out by

filtering the article's title, abstract, and full content so that only those that meet the criteria are further analysed.

The results of the analysis show that research on AR in learning generally focuses on developing marker-based and markerless mobile AR applications and AR interactive books. AR is implemented across subjects such as science, mathematics, history, and religious education. AR media is developed using software such as Unity, Vuforia, Blender, and Spark AR.

The general findings of the SLR identified three main groups of outcomes, namely:
(1) variations in the form of AR media development,
(2) AR's contribution to learning motivation, and
(3) obstacles encountered during implementation.

Concise information on all the analysed articles is presented in the following table.

Table 1. Summary of SLR Results Articles on the Use of AR in Learning

No.	Author & Year	Research Context	AR Shape	Key Results	Challenge
1	(Toha & Panggayuh, 2024)	Science Class VII	*Marker-based AR*	Improve focus and engagement in learning	Limitations of student devices
2	(Malihah et al., 2025)	Elementary Mathematics	*Markerless AR*	Students are more active when manipulating 3D objects	Poorly trained teachers
3	(Aldeeb et al., 2024)	General education	Mobile AR	Strengthen students' intrinsic motivation	Unstable internet connection
4	(Haka et al., 2025)	High School Biology	Android-based AR	Makes it easier to understand anatomical concepts	Insufficient phone specifications
5	(Sutjiningtyas et al., 2025)	History of Indonesia	Android-based AR	Increase interest in visual learning	The development time is quite long
6	(Ratu & Talakua, 2024)	Junior High Mathematics	AR to build space	Students have an easier time understanding 3D concepts	Lack of teacher training
7	(Sa'diyah et al., 2025)	High School Physics	AR Simulation	Strengthen attention and motivation to learn	Device compatibility constraints
8	(Tarigan, 2025)	Elementary School	AR digital module	Foster learning engagement	There is no support for school infrastructure
9	(Hasibuan et al., 2025)	Religious education	Digital book-based AR	Increase interest in Reading and exploration	Quite heavy applications on low-end cellphones
10	(Andrian et al., 2023)	Multimedia SMK	AR 3D products	Learning outcomes have increased significantly	Limited laboratory availability

The analysis of the article shows that AR is developed in several primary forms, namely marker-based, markerless, mobile applications, AR books, interactive AR modules, and AR simulations. Most studies use Unity and Vuforia as development platforms. AR is used primarily to visualise three-dimensional objects and provide an interactive learning experience.

Data from the analysed articles showed an increase in learning motivation, as indicated by greater attention, activity, visual interest, and exploration interest. AR can present a more engaging learning experience than conventional media, especially with abstract materials.

The most common obstacles include limited devices, teachers' inability to operate AR, lack of training, and limited infrastructure, such as internet connections and computer labs. Compatibility constraints are also a factor that affects the success of AR implementation.

4. Discussion

Implementation of Augmented Reality in Learning

The implementation of Augmented Reality (AR) in learning across various studies shows a paradigm shift from static media to interactive, immersive, and visually oriented media. These characteristics make AR one of the most relevant technologies for 21st-century learning needs. AR media allows students to observe learning objects in three dimensions with an adjustable viewing angle. This kind of learning experience contributes to the formation of stronger mental representations, especially in abstract material. The findings of the SLR show that most AR media were developed to meet those needs.

The concept of AR implementation has a strong theoretical foundation in constructivism. AR technology provides a space for students to build knowledge through hands-on experience with virtual objects projected into a real environment. The theory of constructivism states that students learn optimally when they are actively involved in the process of exploration and manipulation of objects (Piaget, 2013). AR fulfils this principle through real-time interaction, allowing students to change perspective, zoom in, or rotate virtual objects to understand their structure and function better. The compatibility between constructivist theory and AR characteristics explains why AR is increasingly being adopted in research on learning media development.

The forms of AR implementation found in the study include marker-based AR, markerless AR, mobile AR applications, and 3D AR books. Marker-based media is widely used due to its ease of development and high compatibility with mobile devices. Markerless AR media provides greater convenience for students because it does not require a fixed trigger image, enabling more flexible classroom use. Study (Prasetya & Anistyasari, 2020) Found that markerless AR provides a more natural learning experience because students can place virtual objects anywhere in the classroom environment. This phenomenon shows that the choice of AR type is influenced by the learning objectives, the context of use, and the developer's technical capabilities.

Literature analysis also shows that AR is used for various purposes, such as visualising organs in biology, displaying spatial structures in mathematics, conducting simulations in physics, and introducing historical artefacts in social studies. Each implementation follows the same pattern: the use of AR to bridge the gap between theory and reality. (Satuti & Atmojo, 2025) concludes that AR serves as a bridge between abstract concepts and authentic experiences, thereby reducing the misconceptions that usually arise in students. These findings are consistent with the results of the study (Prit Kaur et al., 2022), which confirm that AR improves the quality of conceptual understanding through the integration of dynamic visualisations.

The application of AR is also related to situated learning theory, which emphasises the importance of authentic context in the learning process. AR can present environmental simulations

that resemble real conditions, allowing students to learn scientific phenomena in context. Study (Ms & Yanti, 2025) Shows that students who learn to use AR show better understanding because they can relate the subject matter to more concrete visual experiences. AR applications in history learning, for example, can bring students to representations of events or buildings that are difficult to present in the classroom physically.

SLR analysis shows that the success of AR implementation does not depend solely on the quality of the media developed. This success is also influenced by infrastructure readiness, teachers' technology literacy, and students' level of technology adaptation. The lack of support for AR on mobile devices is a significant obstacle in many studies. This obstacle arises in the study (Takrouri et al., 2022) Who found that some students were unable to operate AR due to hardware limitations. These barriers affect the effectiveness of AR implementation in schools and underscore the need for adequate support for technology integration.

Teachers' role in implementing AR is a decisive factor. The use of AR requires teachers who can manage technology-based classrooms and understand how AR software works. Teachers must be able to play the role of facilitators, guiding students in exploring virtual objects. Study (Mujianto et al., 2024) Emphasising that teachers' digital competence significantly influences the success rate of using AR technology in learning. Teachers who are not familiar with technology often struggle to facilitate learning for students, so AR media is not used to its full potential.

The studies analysed in the SLR also show that implementing AR requires careful planning for learning. AR media cannot be effective if used only as a visual add-on, without integration into learning objectives, learning scenarios, and evaluation. AR integration must be adjusted to learning outcomes, student needs, and material delivery strategies. This perspective is reinforced by research (AlGerafi et al., 2023) This affirms that the success of AR in learning lies in pedagogical integration, not just in technological sophistication.

An interpretation of the overall findings suggests that the implementation of AR has great potential for modern learning, but its success is contingent on context. Aspects of technology, pedagogy, and user readiness must be considered simultaneously. AR not only serves as a visual aid but also as a medium for experiential learning. The quality of the experience is highly dependent on media design, technology selection, device readiness, and teachers' competence in utilising AR.

The Impact of Augmented Reality on Students' Learning Motivation

The use of Augmented Reality (AR) in learning significantly impacts students' motivation. Analysis of various studies shows that AR can influence students' psychological dimensions by increasing attention, interest, participation, and curiosity. The realistic visual characteristics of AR and direct interaction with digital objects create a more engaging learning experience than conventional media. This immersive experience is in line with the concept of experiential learning, which states that students learn more effectively when engaging in meaningful hands-on experiences (Kolb, 2014).

The three-dimensional visualisation displayed by AR provides intense visual stimulation that increases attention, one of the main factors in learning motivation. Students are more likely to focus when the material is presented as animations or 3D objects that can be rotated and enlarged. Findings from the study by (Verdiatmoko & Pinandita, 2025) show that the use of AR in spatial learning increases students' attention by up to twice that of static images. Similar findings were also reported by (Sa'diyah et al., 2025), which show a significant increase in learning concentration when AR is used to present physics concepts.

Students' intrinsic motivation has also increased due to AR's ability to offer interactive learning experiences. ARCS Theory (Keller, 2009) Affirming that the combination of visually appealing, material relevance, and experiences that provide confidence can increase intrinsic motivation. The AR media analysed in this study have characteristics that support the ARCS model.

Students not only observe the material but also explore, experiment with, and manipulate virtual objects. These activities encourage students to be more active in seeking information, understanding concepts, and maintaining interest in learning throughout the learning process.

Students' curiosity has increased significantly in AR-based learning. Students are encouraged to explore the material further because AR brings up visual phenomena not encountered in traditional learning. Research (Uno, 2024) Revealed that students showed a higher interest in learning science material when AR media was used. Their motivation increases through hands-on interaction that makes students feel involved in the process of scientific discovery. The use of AR in history has also shown positive results, as noted by (Sutjiningtyas et al., 2025) This emphasises students' heightened curiosity when exploring historical buildings and artefacts through virtual objects.

Increasing motivation through AR not only affects the affective aspect but also students' perception of the material's ease. This perception refers to the perceived ease of use theory in the Technology Acceptance Model (TAM), which states that technology that is easy to use increases students' tendency to accept it as a learning tool (Silva, 2015). Most studies analysed show that AR media is considered easy to use by students, thereby increasing their comfort with learning. The success of this technology acceptance provides an additional contribution to increasing motivation and readiness to learn.

Increased learning motivation through the use of AR directly contributes to learning outcomes. Various studies prove that motivation is a strong predictor of students' academic achievement. The relationship is underlined by (Zulfa et al., 2025) Who found that students who learned to use AR showed improved understanding of concepts and higher evaluation scores than students who used regular media. AR applications provide students with the opportunity to understand concepts in depth through visual and interactive experiences, thereby enhancing learning effectiveness.

External factors are an important part that affects students' learning motivation when using AR. The limitations of devices, teachers' ability to facilitate AR-based learning, and school infrastructure also determine the extent to which AR can motivate students. These obstacles often affect students' access to AR media and can reduce motivation if the learning experience is not optimal. Research (Ningrum et al., 2025) Shows that students without qualified devices face limitations in accessing AR, which reduces their motivation to learn. Similar conditions were also conveyed by (Najjar & Oktasari, 2023), noting that the load of AR apps on specific mobile devices slows down the learning process and lowers student comfort.

The overall analysis shows that AR has great potential to increase students' motivation to learn through engaging learning experiences, powerful visuals, and direct interaction with virtual objects. This potential can be achieved optimally if supported by device readiness, teacher technology literacy, and the right learning strategy. AR provides an opportunity to create more meaningful, engaging, and contextual learning for digital-generation students, thereby improving the overall quality of learning.

5. Conclusion

This study concludes that Augmented Reality (AR) has great potential in increasing students' learning motivation. Various studies show that AR is delivered through marker-based, markerless, mobile apps, and interactive books, all of which provide visual and immersive learning experiences. These characteristics can increase students' attention, interest, engagement, and curiosity, especially with abstract materials. Such increased motivation contributes to a better understanding of concepts and learning outcomes.

The success of AR implementation is greatly influenced by device readiness, teachers' abilities, and the availability of school infrastructure. The use of AR requires proper pedagogical integration so that it is not only an additional medium but actually supports learning outcomes. The results of this study provide a theoretical and practical basis for the development of AR media, as well as

recommendations for teachers, developers, and schools to consider both technical and pedagogical aspects in their applications.

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