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AUGMENTED REALITY (AR)-BASED LEARNING ON PHYSICAL EDUCATION LEARNING OUTCOMES

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ABSTRACT

This study aims to evaluate the effectiveness of Augmented Reality (AR)-based learning in improving physical education outcomes among junior high school students. Using a quantitative approach with a pretest–posttest design, the research involved 32 students who received AR-assisted instruction on basic basketball movements. The assessment instruments covered cognitive, affective, and psychomotor domains. The findings revealed a significant improvement from pretest to posttest scores, with the N-Gain value categorized as effective. The use of AR provided an immersive learning experience through three-dimensional visualization, enhancing students' motivation, engagement, and conceptual understanding. The discussion highlights that AR supports active learning in line with constructivist and socioconstructivist theories, while also offering opportunities to strengthen motor skills through interactive simulations. Nevertheless, the implementation of AR still faces challenges such as limited teacher competence and technological infrastructure. These findings underscore the potential of AR as an innovative learning medium to improve the quality of physical education. The implications of this study include the need for teacher training and the development of adaptive technology-based learning models.

INTRODIUCTION

Physical education plays a fundamental role in supporting the physical, cognitive, social, and emotional development of students. As an integral part of the school curriculum, physical education aims not only to improve physical fitness, but also to develop motor skills, critical thinking skills, character, and social cooperation. Recent studies indicate that physiological factors such as physical fitness, haemoglobin levels,

and nutritional status contribute significantly to academic achievement and physical education learning performance (Zhang & Yu, 2022).

This shows that physical education is closely related to physical development and function, including the influence of bodily substances on students' academic abilities. An individual's physical condition, particularly body mass index and aerobic capacity, has a significant contribution to learning performance and movement skills in physical education, as both influence the endurance, coordination and efficiency of students' movements (Pranata, 2017) .It can be seen that in addition to having a direct influence, nutrition also has a significant influence (Cahyadi & Kurniawan, 2023).In line with this, the development of digital technology has also brought about pedagogical innovations that support learning effectiveness. Changes in physical activity patterns due to social and technological developments require innovation in physical education learning approaches to remain relevant, adaptive, and able to increase student participation in a sustainable manner (Didi ,et al 2022). One innovation that is increasingly being integrated is Augmented Reality (AR), which, according to (Shen et al., 2023), can reduce cognitive load, improve understanding of complex material, and enrich the learning experience through interaction between the real world and digital content.

In recent years, AR has gained widespread attention as a learning medium capable of providing immersive, interactive, and multimodal experiences for learners (López-Belmonte et al., 2022). Emphasise that the use of AR in learning can increase student motivation and commitment to learning through the presentation of more interesting and visually rich material. Similarly,(Hmoud et al., 2023) report that the implementation of AR in biology learning for secondary school students significantly increases student engagement and attention. The advantage of AR lies in its ability to present visual, auditory, and kinesthetic interactions simultaneously, thus accommodating a variety of student learning styles (Zatarain-Cabada et al., 2023). (Marini et al., 2022) also showed that the use of AR can strengthen critical thinking skills and conceptual understanding through clearer spatial representation and motion visualisation, an aspect that is highly relevant to physical education learning.

However, the reality on the ground shows that PE learning at the secondary school level is still dominated by conventional teacher-centred approaches, with minimal variation in methods and a tendency towards monotony. Various studies criticise traditional learning methods, which are often ineffective in facilitating active student participation and fail to adapt to their increasingly complex learning needs. (Casey &

Goodyear, 2015) emphasise that traditional teaching approaches tend to limit student engagement and provide insufficient opportunities for practice and feedback, resulting in suboptimal psychomotor skill development. On the other hand, research by (Hrušová et al., 2024) shows that the blended learning model in physical education can increase motivation, engagement, and overall learning effectiveness. The integration of physical activities with interactive digital materials provides a more adaptive and engaging learning experience compared to conventional methods, thereby supporting the achievement of movement skills and conceptual understanding in a more optimal way.

The main problem that arises in this context is the low effectiveness of PJOK learning due to the limitations of the traditional approach. The lack of variety in methods and the lack of interactive technology in learning causes students to have low levels of engagement, decreased motivation, and difficulty in understanding basic sports techniques correctly. This situation is exacerbated by the lack of utilisation of digital technology, particularly AR, in teaching basic basketball movements, even though this technology has great potential to strengthen the learning process through accurate and interactive movement visualisation.

A common solution offered by previous studies is the need for pedagogical innovation by integrating digital technology into physical education learning. Technology-based approaches, particularly AR, are considered to have high potential to overcome the limitations of conventional methods. AR provides three-dimensional visual simulations that allow students to observe sports techniques in more detail, improve their understanding of movements, and improve skill execution through multisensory engagement. This immersive learning experience is believed to increase students' intrinsic motivation, in line with the findings (Miao et al., 2024) that the perception of learning variation support contributes to students' adaptive motivation in physical education.

Furthermore, previous research shows that integrating AR into physical education can provide specific solutions to various pedagogical issues. (Darmawan et al., 2024) found that AR significantly improves biomotor abilities and conceptual understanding through rich and interactive visual presentations. Additionally, (Sun & Khamcharoen, 2025) proved that a blended learning model combining AR with conventional instruction can improve basic basketball skills, including dribbling and passing. AR enables more efficient and effective delivery of material, as it provides opportunities for students to practise techniques independently with clear visual guidance.

In the context of learning theory, visual and symbolic approaches have a strong foundation in cognitive development theory, which emphasises the importance of visual representation in the learning process, especially for secondary school students. Visual representation helps students understand the structure of movements and the relationships between the components of sports techniques. Furthermore, recent research shows the relevance of technology-based learning in strengthening students' knowledge construction. A systematic review of the use of Augmented Reality shows that AR can create interactions between digital and real elements that increase engagement and a deeper understanding of concepts. Meanwhile, a study by oleh (Yaseen et al., 2025) confirms that adaptive learning technology with real-time feedback and personalised content can increase student engagement and motivation, thereby encouraging a more active learning process in a technology-based environment.

Although AR has demonstrated various pedagogical advantages, recent research continues to highlight a number of gaps in its implementation. (Lampropoulos et al., 2022) shows that despite AR's great potential, its application in education still faces obstacles such as limited teacher training, lack of technological infrastructure, and schools' unpreparedness to consistently integrate digital devices. Furthermore, previous studies have not extensively evaluated the long-term impact of AR use on students' sports skills and learning motivation. Thus, there is an urgent need to explore more systematically how AR can be effectively integrated into physical education learning, particularly in the context of basic basketball movements.

Based on this gap, this study aims to evaluate the effectiveness of Augmented Reality-based learning in improving physical education learning outcomes, particularly in basic basketball movements for junior high school students. This study provides novelty through the integration of AR technology into physical education learning as an innovative alternative medium that is adaptive to student needs and in line with the demands of educational technology development. By testing the hypothesis that AR is more effective than conventional methods, this study is expected to expand the academic literature on technology-based pedagogy and provide an empirical basis for the development of a more modern, interactive, and relevant PJOK learning model for 21st-century students.

RESEARCH METHODS

This study employed a quantitative approach with an experimental approach utilizing simple linear regression analysis. The objective was to determine the effect of augmented reality (AR)-based learning on physical education learning outcomes in basketball. This approach was used to measure the influence between AR-based learning variables as independent variables and student learning outcomes as dependent variables. Through quantitative data analysis using a regression approach, this study examined the influence and effectiveness of AR-based learning before and after implementation on improving student learning outcomes.

The implementation of Augmented Reality-based learning was carried out through several steps: (1) the teacher introduced an AR application containing a model of basic basketball movements; (2) students accessed the application via mobile devices; (3) students scanned markers to display 3D animations; (4) the teacher guided students through the movement practice based on the simulation; and (5) students reflected on the movement results.

The study was conducted in the even semester at SMP Negeri 1 Langsa, Aceh Province. The population consisted of 320 students from 10 eighth-grade classes. The sampling technique used was random stratified sampling, with a lottery drawn to determine which classes would be included in the study. Prior to the drawing, the researcher determined the minimum sample size using the MC-Clave formula. The results obtained showed a standard error (SE) of 0.37, with an SE value <2.0, indicating that the sample size was homogeneous and representative of the population. This was 32 eighth-grade students, taking into account student readiness and engagement in physical education learning.

The research measurements included:

1) Learning outcome assessment: pretest and post-test to measure cognitive, affective, and psychomotor aspects.
2) Observation sheets: used to record student engagement during learning.

The data analysis technique used in this study was simple linear regression analysis to test the contribution of the independent variables, followed by the normalized gain (N-gain) formula, a data analysis test aimed at determining the effectiveness of implementing a learning model or method. Learning outcome data was analyzed using the N-Gain formula to determine student score improvement. The N-Gain formula:

$$\text{N-Gain} = \frac{Final\ Score - Initial\ Score}{Ideal\ Score - Initial\ Score}$$

Table 1. Interpretasi N-Gain

Presentase (%)	Interpretation
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Moderately Effective
> 76	Effective

RESULTS AND DISCUSSION

Results

Based on the pretest results, the average learning outcome score for eighth-grade students at SMP Negeri 1 Langsa was 47. After implementing game-based learning, the average post-test score increased to 84.5. Using the N-Gain formula, the score was 0.70, or 70%, which is considered quite effective.

This improvement demonstrates the effectiveness of augmented reality-based learning on students' physical education learning outcomes. Table 1 presents the pretest and post-test results:

Table 2. Average Results of Pretest and Post-test Learning Outcomes

No	Test Type	Average Score
1	Pretest	47
2	Posttest	84,5
	N-Gain	0,70 (70%)

Thus, the N-Gain score obtained is in the high category and indicates that the applied learning model is quite effective in improving student learning outcomes. The data distribution is illustrated in the following diagram.

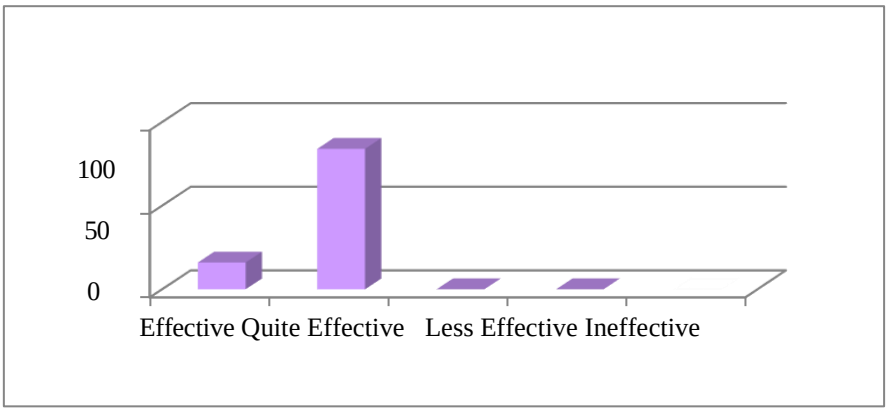

Figure 1. Histogram of Data Distribution

From the histogram data distribution above, it can be seen that 84% has a fairly effective effect on physical education learning outcomes, 16% has an effective effect on

physical education learning outcomes, none has a less effective effect, and none has an effective effect on physical education learning outcomes through the application of augmented reality-based physical education learning to school students.

Discussion

Research findings indicate that Augmented Reality (AR)-based learning has a significant positive impact on improving student learning outcomes in physical education, particularly in basic basketball movements. The increase in scores from pretest to post-test, as shown in the previous table, reflects that AR contributes to improving students' cognitive, affective, and psychomotor aspects. The mechanism of this improvement can be explained through a constructivist theoretical framework, which states that learning occurs optimally when students are actively involved in the process of constructing knowledge through direct interaction with the learning environment (Mokmin & Rassy, 2022) AR provides a multidimensional environment where students can manipulate visual objects, understand movement representations more concretely, and conduct in-depth exploration of the sports techniques being studied.

Previous studies have also found that AR can improve the quality of motor learning through realistic motion visualization, immediate feedback, and tactile representations that help students gradually build motor understanding. This is relevant to the results of this study, which show that student engagement increases significantly when AR is used in learning. Three-dimensional visualization allows students to capture technical details that are difficult to achieve through conventional methods. Basic motor skills such as dribbling and passing can be observed and practiced repeatedly with consistent visual guidance, as stated by (Sun & Khamcharoen, 2025), which confirms that the combination of AR and a blended learning approach improves the quality of fundamental skill achievement in sports. Mastery of sports skills is greatly influenced by biomotor abilities, especially muscle strength, which can be developed optimally through structured training and learning that emphasizes visualization of correct movement techniques (Rahmat et al., 2025)

The correlation between this research's findings and constructivist and socioconstructivist learning theories further strengthens the argument that AR is an effective medium for physical education learning. According to Piaget, active learning occurs when students interact directly with environmental stimuli to construct understanding) AR provides an exploratory space that allows students to interact with

movement simulations through visual, auditory, and kinesthetic perception. Meanwhile, Vygotsky's socioconstructivist theory emphasizes the importance of social interaction in learning. (Sepulveda-Valenzuela & María, 2020) supports this idea by demonstrating that collaborative learning experiences in AR environments have the potential to improve academic achievement by strengthening interaction and communication between students.

The combination of these two theoretical frameworks explains why AR is effective in improving students' conceptual understanding and motor skills. Interaction with virtual objects enables representational learning that helps students understand the relationships between movement components holistically. The multimodal aspects of AR, which include dynamic visual imagery and instant feedback, support sensorimotor understanding, which is crucial in physical education learning. This is in line with the view put forward by (Kamarainen et al., 2013), who stated that multimodal interactions in AR have the potential to activate various forms of intelligence, thereby enriching students' learning experiences.

The use of AR in physical education learning has shown significant increases in student engagement and motivation. Engaging visualizations and AR's ability to create immersive learning experiences spark students' curiosity and enrich their interaction with the learning material. This is supported by research (López-Belmonte et al., 2022), which explains that AR increases student learning commitment through the presentation of more engaging and meaningful content. In this research, students appeared more active in following instructions, imitating movements, and understanding the logic of sports techniques through digital simulations presented by AR technology.

Students' intrinsic motivation also increased when they felt successful in understanding and correctly performing movements through clear visual guidance. This finding is supported by research (Hmoud et al., 2023), which found that the use of AR in science learning significantly increased student engagement, and research (Zatarain-Cabada et al., 2023), which stated that AR can accommodate diverse learning styles, resulting in a more personalized and adaptive learning experience. This increased motivation directly impacted learning outcomes, as reflected in improved student posttest scores.

Although AR offers numerous advantages, its implementation in physical education learning is not without challenges. One major obstacle is teachers' lack of technical and pedagogical understanding in utilizing AR technology. Many teachers feel inadequately

competent to integrate AR into their lessons, leading to resistance or distrust in the technology's effectiveness. This finding is supported by (Mokmin & Rassy, 2022), who stated that limited teacher training and experience are often the biggest barriers to implementing AR technology.

In addition to teacher competency challenges, infrastructure issues such as hardware and software availability, AR application compatibility, and limited school budgets also impact the success of AR implementation. These obstacles result in low frequency of AR use in learning and prevent many schools from fully adopting this technology. These challenges highlight the need for more progressive educational policy support, including the provision of professional training, technological facilities, and dedicated budgets to encourage broader AR adoption.

Teachers play a central role in the success of AR implementation in learning environments. Teachers' perceptions of the technology's usefulness and ease of use are important factors influencing their decision to adopt AR in their teaching practices. Research (Jang et al., 2021) found that teachers are more likely to adopt AR technology if they perceive it to be easy to use and relevant to learning objectives. In this study, participating teachers reported that using AR made the learning process more efficient and adaptive.

Furthermore, research (Volioti et al., 2022) showed that evaluating AR usability significantly impacted teachers' readiness to integrate this technology. Teachers who had positive experiences in AR trials were more prepared and confident to use it in their lessons. This finding is supported by (Huang & Liu, 2024), who explained that positive perceptions regarding AR use experiences foster teachers' openness to technological innovation in physical education.

The results of this study confirm the findings of several previous studies showing that AR not only improves students' test scores but also strengthens conceptual understanding and the overall learning experience. (Rafiun et al., 2025) found that the use of AR significantly improves students' motor learning skills because this technology is able to provide clear movement visualizations, immediate feedback, and opportunities for repeated practice in a safe and interactive virtual environment. Furthermore, (Jang et al., 2021) explained that AR in physical education is able to integrate visual representations and real-time movement demonstrations, thus making it easier for students to understand basic sports techniques and improving the quality of practical learning. Both emphasized

that AR has great potential to strengthen the movement learning process and overcome the limitations of conventional methods.

The findings of this study also align with studies by (Arici et al., 2021) and (Serin, 2022) which showed that AR technology can increase students' motivation to participate in physical activities and learn sports skills. Thus, these findings reinforce the view that AR has the potential to be a transformative learning medium.

CONCLUSIONS AND SUGGESTIONS

Augmented Reality-based learning has proven quite effective in improving physical education learning outcomes for students at SMP Negeri 1 Langsa, particularly in basketball. The high N-Gain value indicates that this approach is able to address the problem of student engagement in conventional learning. The use of AR enriches students' learning experiences, improves understanding of basic movements, and encourages active engagement throughout the learning process.

As a recommendation, physical education teachers are encouraged to begin integrating AR technology as part of innovative learning media. Schools are also expected to provide support in the form of training on technology use and the provision of adequate equipment. Further research can be directed at exploring the use of AR in other physical education materials, as well as assessing its effectiveness at higher education levels for broader and more measurable benefits.

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