12 (2) (2025) 374 - 381

Journal of Physical Education, Health and Sport

https://journal.unnes.ac.id/journals/jpehs

The Effect of Augmented Reality (AR) on Students' Motor Educability in Football Learning

Aulia Azzahra[1]✉, Asep Sumpena[2], Sufyar Mudjianto[3]

Physical Education Health and Recreation, Faculty of Sport Health and Education, Indonesian University of Education, Indonesia[123]

History Article

Received Desember 2025
Approved Desember 2025
Published vol 12 no 2 2025

Keywords

Augmented Reality; Motor Educability; Football Learning

Abstract

Physical education in schools requires strategies that can improve not only motor skills (motor ability) but also motor educability, namely the ability of students to understand, imitate, and adapt to new movements efficiently. However, conventional learning in soccer games is often hampered by limited visualization of techniques and low student motivation. Augmented Reality (AR) technology offers a solution through interactive visualization and real-time feedback that can enrich the sensorimotor processing process. This study aims to analyze the effect of AR-based learning using Active Arcade on improving students' motor educability compared to conventional learning. The study used a quasi-experimental design with a pretest–posttest control group model on 134 students of Junior High School 14 Bandung ($n = 67$ experimental; $n = 67$ control). Motor educability was measured using the Iowa Brace Test (21 items ; validity 0.92; reliability 0.96). The intervention lasted for five learning sessions. Data analysis used normality, homogeneity, paired sample t-test , and ANOVA to test the treatment effect by controlling for pretest scores ($\alpha = 0.05$). The results showed that both groups experienced significant improvement between pretest and posttest ($p < 0.001$). However, the AR group showed a higher and more stable average improvement than the control group. ANOVA test indicated a significant difference in posttest scores after controlling for the pretest ($F(1,132) = 4.996$, $p = 0.027$), indicating that AR-based learning resulted in better motor educability than conventional learning. These findings confirm that AR is effective in enhancing visual processing, motor attention, and student engagement, thus optimally enhancing movement learning abilities. Therefore, AR is recommended as an innovative approach in physical education, particularly for materials requiring precise and interactive understanding of movement techniques.

How to Cite

Azzahra, A., Sumpena, A., & Mudjianto, S. (2025). The Effect of Augmented Reality (AR) on Students' Motor Educability in Football Learning. Journal of Physical Education, Health and Sport, 12 (2), 374-381.

✉ Correspondence Author:
E-mail: aulia.azzahra14@upi.edu

p-ISSN 2354-7901
e-ISSN 2354-8231

INTRODUCTION

Physical education instruction in secondary schools plays a strategic role in developing students› motor skills and physical capacity. In the context of soccer, the learning process aims not only to develop skilled technical skills but also to build readiness for continuous movement learning. However, conventional learning practices still face several major obstacles, such as limited visualization of movement techniques, a lack of exercise variety, and low student engagement and motivation to actively practice (Liang et al., 2023) . These conditions implicate students› low ability to understand, imitate, and adapt movements effectively.

Augmented Reality (AR) -based approaches are increasingly being used to improve the quality of physical education. AR technology allows students to observe three-dimensional, interactive movement demonstrations, making the learning process more concrete and engaging. AR is very effective in supporting skill-based learning, including motor skills, because it facilitates 3D immersion of movement and provides a more interactive learning experience (Bacca et al., 2014). Through realistic visualizations and structured feedback, AR has been shown to improve technical understanding, increase motivation, and accelerate motor skill achievement (Chen et al., 2017; Pérez-Muñoz et al., 2024) . AR can improve students› conceptual understanding, motivation, and interaction, and is effective for motor learning because it provides clearer and more concrete visualization of movements (Akçayır & Akçayır, 2016). Several studies have also shown that AR-based learning results in significant improvements in basic motor skills compared to conventional media such as videos or live demonstrations (Liang et al., 2023; Pratama et al., 2022).

However, most of these studies still focus on the end result of basic motor skills (motor ability), namely how well someone performs a movement after training. The majority of studies still focus on improving the end result of specific motor skills (product-oriented), such as passing accuracy or shooting power. Meanwhile, research investigating the impact of AR on the learning process itself (process-oriented), particularly on the construct of motor educability , is still very limited (Sırakaya & Sırakaya, 2020).

However, there is a more fundamental but rarely researched aspect: motor educability , which describes an individual›s ability to learn new movements quickly and efficiently. Motor educability is not simply a skill, but rather an internal capacity to receive instructions, process sensorimotor information, and adapt movement patterns quickly (Arlioni et al., 2021) . In other words, someone with high motor educability will more easily understand and imitate new movements, even with relatively short training times.

Motor educability influences the skills and abilities of students themselves, which can be seen from student development. Motor educability is important in relation to motor skills in students to learn new motor skills towards the development of student abilities (Panji et al., 2020) . Motor educability is important in relation to learning movement so it is necessary in physical education learning for the development of student learning. From the analysis, it can be said that Motor Educability influences the learning process of students, therefore it is necessary to teach so that the development of student motor educability is good (Zubaida & Lestari, 2021) .

This study aims to determine the effect of Augmented Reality (AR)-based learning using the Active Arcade application on improving students› motor educability in learning soccer games compared to conventional methods with. Active Arcade offers the opportunity to incorporate gamification elements by awarding points or medals to students for achieving specific targets, further increasing participation. This platform, accessible on Android and iOS devices, supports collaborative activities, where students can work together in groups to complete specific in-app missions, such as overcoming obstacles or time-bound challenges. (Rafiandi et al., 2025)

Unlike previous studies that assessed improvements in basic motor skills as the primary measure, this study focused on motor learning ability itself. This approach is important because motor learning ability reflects the fundamental capacity that determines how quickly students can master and understand new movements. If AR technology can enhance students› visual processing and motor perception, then improvements in motor learning ability become a more representative indicator of the effectiveness of technology-based learning .

Based on initial observations at Junior High School 14 Bandung, many students still have low motor skills due to a lack of visual understanding of correct movements. The novelty of this study is its emphasis on motor educability, or the capacity to learn through methods, instead of the more typical emphasis on particular motor outcomes. This offers a new perspective in the area of enhanced reality-based physical education research. Therefore, this study aims to test whether AR-based learning can improve students› motor educability skills in soccer learning.

Research on the use of AR in physical education has increased significantly in recent years. In general, research results show that AR can improve students› motivation, movement comprehension, and motor performance. For example, research by (Neldi et al., 2025) found that AR was used in sports teaching (basketball), and the use of AR can improve skill acquisition, performance, and increase student motivation and engagement thanks to real-time feedback, enhanced visualization, and an immersive learning environment. This increases the efficiency of learning basic sports techniques by providing accurate visual feedback.

In the context of soccer, AR has been shown to improve the understanding of basic movement patterns such as dribbling, passing, and ball control (Pratama et al., 2022) . Furthermore, (Pérez-Muñoz et al., 2024) showed that the use of AR can reduce technical errors by clarifying movement details. However, these studies generally assess final motor skills, not motor learning capacity or motor educability. According to the Cognitive-Load Theory approach (Sweller et al., 2019) , appropriate visualization can reduce cognitive load so that learners are more focused on understanding movement patterns. Therefore, if movement demonstrations are provided through AR technology that displays 3D virtual models, the process of internalizing movement can be more efficient.

Skills in playing soccer are closely linked to basic motor skills such as movement accuracy, balance, agility, and eye-foot coordination, which are important indicators of motor developmental abilities. Research shows that students who regularly participate in soccer training experience significant improvements in motor coordination and balance control compared to students who do not participate (Biino et al., 2023) . This supports the argument that soccer not only hones specific sport skills but also improves fundamental abilities in learning new movements, which is the primary focus of this study.

Research specifically evaluating the impact of AR on motor educability is still very limited. (Sırakaya & Sırakaya, 2020) emphasized that although AR increases engagement in motor learning, very few studies have measured how this technology affects students› internal motor learning capacity. This represents a research gap and justifies the importance of this study .

The hypothesis proposed in this study is that after controlling for pretest scores, the group that learned with AR assistance had a higher average post-test motor educability score than the group that used conventional methods. H0: After controlling for pretest scores, there is no difference in the mean motor educability posttest scores between the AR group and the conventional method group. H1: After controlling for pretest scores, the AR group has a higher mean motor educability posttest score than the conventional method group.

METHOD

This study employed a quantitative approach using the Quasi-Experimental Design method with a pretest-posttest design with a non-equivalent control group in two different classes. This design was chosen because it suited the learning conditions in schools, where classes could not be completely randomized. The researchers used random class selection (cluster random sampling) to determine the experimental and control groups.

The research design used the Pretest–Posttest Control Group Design model with two groups, namely the experimental group that received AR-based learning with the Active Arcade application and the control group that followed conventional soccer learning. The study was conducted for 5 face-to-face sessions (pretest – 3 times treatment – posttest) with a duration of 35 minutes/session, a frequency of 1 time per week as commonly applied in the Physical Education curriculum in secondary schools (Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2016), under the supervision of 1 Physical Education teacher and 1 research assistant.

The study sample consisted of n = 134 students divided into two equal groups, the experimental group (n = 67) and the control group (n = 67). The age range of participants was 13–14 years (mean ≈ 13.5 years). The gender composition of the sample was 61 males (45.52%) and 73 females (54.4%). Inclusion criteria: participants were physically healthy, able to participate in sports activities, and attended at least 80% of the intervention sessions. Students with injuries or medical conditions that prohibited physical activity were excluded from the sample. All research procedures were approved by the school (Junior High School 14 Bandung). Parents/guardians of each participant signed informed consent; participants provided verbal assent before the measurements. Data were collected and stored anonymously.

The instrument for measuring motor educability is the IOWA Brace Test, which consists of 21 items of coordinative movement, with a validity level of 0.92 and a reliability of 0.96 listed in Table 1. Each item is scored: 2 (successful on the first attempt), 1 (successful on the second attempt), and 0 (two failed attempts). The motor educability assessment categories are shown in Table 2, Motor Educability Level Criteria.

Before treatment, both groups were given a pretest to measure the ability to determine the initial motor educability of students using the IOWA Brace Test instrument consisting of 21 coordinated movement items. Next, treatment was given during the predetermined intervention period, where the experimental group carried out movement activities through several Active Arcade features relevant to fundamental soccer movements such as Quick Steps , Target Kicks , Lateral Movement , and Reflex Training . Meanwhile, the control group, the learning process was carried out conventionally, namely through demonstrations of basic techniques by teachers, repeated practice (drill-based), and providing verbal feedback for movement errors. In addition, students practiced basic soccer skills such as passing, dribbling , and ball control, as is the practice of physical education in general in schools. After the treatment session was completed, both groups took a posttest with the same instrument to see changes in motor abilities objectively. All research procedures were carried out with educational ethical standards, including school approval, parental permission letters, and ensuring that participants were in good health and attended at least 80% of the learning sessions.

The instrument used was the IOWA Brace Test (validity = 0.92 and reliability = 0.96)

The research data were analyzed using parametric statistical tests, namely the normality test, homogeneity test, paired sample t-test to determine the improvement in each group (pretest– posttest), and ANOVA to test for significant differences between the experimental group and the control group by controlling for initial scores. The analysis was carried out using SPSS version 26 software with a significance level (α) of 0.05. The analysis results data are presented in the form of mean ± standard deviation (mean ± SD) for each group, as well as adjusted means and 95% confidence intervals (CI95%) of the ANOVA results.

Table 1. IOWA BRACE TEST, which consists of 21 test items.

Item	Duration
One FootTouch Head	5 s
Side Leaning Rest	5 s
Graspevine	5 s
One Knee Balance	5 s
Stork Stand	5 s
Double Heel Click	1 rep

Table 2. Criteria for Motor Educability Level

Category	Value Range
Very good	> 42
Good	31 –34
Currently	24 –30
Not good	20 –23
Very less	< 19

RESULTS AND DISCUSSION

Based on the analysis of Motor Educability data on eighth-grade students at Junior High School 14 Bandung, consisting of the experimental and control groups, the following findings were obtained. In general, there was an increase in Motor Educability scores in both groups after participating in the learning process during the research period. However, the increase in the experimental group showed a more significant change. significantly higher compared to the control group.

The experimental group, which received Augmented Reality (AR)-based soccer learning through the Active Arcade application, showed a greater increase in the average Motor Educability score from the pretest to the posttest. This indicates that the use of AR-based learning media can increase the effectiveness of movement internalization through clearer movement visualization and more accurate feedback. Meanwhile, the control group that followed conventional learning in the form of live demonstrations by the teacher, repeated basic technique exercises (drill-based practice), and verbal feedback also showed improvement, but at a lower level.

Table 3. Normality Test (Kolmogorov-Smirnov)

	Statistics	df	Sig.	Information
Pre.Control	0.120	67	0.84	normal
Post.Control	0.140	67	0.072	normal
Pre.AR	0.095	67	0.091	normal
Post.AR	0.127	67	0.079	normal

Based on **Table 3**, the normality test in this study was conducted using the Kolmogorov–Smirnov test on the pretest and posttest data in the control and experimental groups. The results of the analysis show that all significance values (Sig.) are above 0.05. In the pretest data of the control group, a significance value of 0.084 was obtained, while in the experimental group it was 0.091. Furthermore, in the posttest data of the control group, the significance value was 0.072 and in the experimental group it was 0.079. Because all Sig. values are > 0.05, it can be concluded that the pretest and posttest data in both groups are normally distributed. Thus, the assumption of normality is met so that parametric analysis such as the t-test and ANOVA can be used in the next analysis stage.

Table 4. Test of Homogeneity of Variances (Lavene's Test)

		Lavene Statistics	df1	df2	Sig.	informa-tion
Pre	Based on mean	0.013	1	132	0.908*	significant
	Based on median	0.009	1	132	0.925*	significant
	Based on median & with adjusted df	0.009	1	131,994	0.925*	significant
	Based on trimmed mean	0.012	1	132	0.913*	significant
Pre	Based on mean	3,490	1	132	0.064*	significant
	Based on median	3,290	1	132	0.072*	significant
	Based on median & with adjusted df	3,290	1	129,564	0.072*	significant
	Based on trimmed mean	3,386	1	132	0.068*	significant

Table 5. Paired Sample Statistics

	Mean	Standard Deviation	Std. Error Mean	Informa-tion
Pre. Control	27.00	7,009	0.856	Significant
Post. Control	32.87	4,951	0.605	Significant
Pre.AR	28.93	7,016	0.857	Significant
Post.AR	34.63	4.134	0.505	Significant

Table 6. Paired Sample Correlation

	N	Correlation	Sig.	information
Control Pretest & Posttest Scores	67	0.772	0.000	significant
AR Pretest & Posttest Scores	67	0.784	0.000	significant

In **Table 4** of the results of the homogeneity test , based on the Levene's Test output, the pretest data shows mark significance throughout method calculations (mean, median, adjusted df , and trimmed mean) are in the range p = 0.908–0.925, all of which more big from α = 0.05 . These results indicate that the variance of pretest scores in both groups is homogeneous or there is no significant difference in variance. In the posttest data, the significance value of the Levene test is in the range of p = 0.064–0.072, which is also greater than α = 0.05. Thus, the variance of the posttest scores of both groups remains in a homogeneous condition obtained with a Sig. value > 0.05 so that H0 is accepted, so it can be concluded that the data comes from the same variance (homogeneous).

Based on **Table 5** Paired Samples Statistics , it is known that in the control group the average pretest score was 27.00 with a standard deviation of 7.009, while the average posttest increased to 32.87 with a standard deviation of 4.951. This indicates an increase in ability after treatment in the control group. In the experimental group, the average pretest score was 28.93 with a standard deviation of 7.016, and increased to 34.63 in the posttest with a standard deviation of 4.134. The average increase in the experimental group was higher than the control group. In general, this table shows that both the control and experimental groups experienced an increase in learning scores after being given learning, with the experimental group showing a greater increase.

The Paired Samples Correlations results show that there is a very strong relationship between the pretest and posttest scores in both groups. In the control group, the correlation value is 0.772 with a significance of 0.000, while in the experimental group the correlation value is 0.784 with a significance of 0.000. A significance value smaller than 0.05 indicates that the correlation between the pretest and posttest scores in both groups is significant. This means that changes in pretest and posttest scores have a consistent relationship, and the increase that occurs is not random but shows a directional learning trend.c

Table 7. Paired Sample T-Test

	mean	t	df	Sig. (2-tailed)	informa-tion
Control Pretest & Posttest Scores	-5.866	-10.721	66	0.000*	significant
AR Pretest & Post-test Scores	-5.701	-10.228	66	0.000*	significant

The Paired Samples T-Test results show a significant difference between the pretest and posttest scores in both groups. In the control group, the mean difference was –5.866 with a t-value of –10.721 and a significance value of 0.000. This indicates that there was a significant increase in scores after the learning was given to the control group. In the experimental group, the mean difference was –5.701 with a t-value of –10.228 and a significance value of 0.000, which also indicates a significant increase. Since the p-value <0.05, it can be concluded that both the control and experimental groups experienced significant improvements in their abilities after the treatment was given. In addition, although both groups improved, the experimental group had a more consistent and stable improvement, as seen from the smaller standard deviation.

Table 8. ANOVA

	Sum of Squares	df	Mean Square	F	Sig.	informa-tion
Pre. Between Groups	124,187	1	7.009	0.856		significant
Pre. Within Groups	6490.627	132	7.009	0.856	0.114	significant
Pre. Total	6614.813	133	7.009	0.856		significant
Post. Between Groups	103.910	1	7.009	0.856		significant
Post. Within Groups	2745.463	132	7.009	0.856	0.027*	significant
Post. Total	2849.373	132	7.009	0.856		significant

ANOVA analysis was conducted to compare the differences in scores between the experimental group and the control group at the pretest and posttest stages. Based on Table 8, the results of the analysis show that in the pretest, there was no significant difference between the two groups. This can be seen from the value of F (1,132) = 2.526 with a significance value of p = 0.114, which is greater than α = 0.05. This means that before the treatment was given, the initial abilities of the two groups were in equal conditions. Conversely, in the posttest, the results of the ANOVA showed a significant difference between the experimental group and the control group. The value of F (1,132) = 4.996 with a significance value of p = 0.027, which is smaller than α = 0.05. This finding indicates that the treatment given (for example the use of Augmented Reality in learning) has a significant effect on improving student learning outcomes compared to conventional learning.

The findings revealed that both the groups involved in the experiment and those in the control showed notable advancements in their ability to learn motor skills from the initial assessment to the final evaluation. Nonetheless, students who engaged in augmented reality learning achieved significantly superior scores in the post-assessment when contrasted with their peers who underwent traditional learning methods, as evidenced by the ANOVA analysis after adjusting for pre-assessment results (F(1,132) = 4. 996, p = 0. 027). This outcome indicates that augmented reality learning offers additional benefits beyond standard teaching techniques in improving students' capacity for motor learning.

A possible reason for the better performance seen in the augmented reality group could be the superior visual information offered by AR technology. Augmented reality enables learners to view movement demonstrations in an interactive and three-dimensional style, which helps clarify complicated movement patterns and diminishes confusion in executing motor tasks. According to Cognitive Load Theory, clear visual aids can lessen unnecessary cognitive load, allowing learners to focus more of their cognitive resources on crucial movement details (Sweller et al., 2019). In this research, the use of AR for visualization likely helped students grasp movement sequences, spatial awareness, and timing all essential facets of motor skill development.

Moreover, motor educability highlights a person's ability to efficiently acquire new movements rather than simply executing a specific skill accurately. The results of this research bolster the idea that augmented reality influences the learning journey on a deeper level by enhancing the connection between sensory input and movement perception. This aligns with earlier studies that point out the close relationship between motor educability and the speed at which learners adjust to new motor tasks and transfer knowledge across varying movement scenarios (Arlioni et al., 2021; Panji et al., 2020). The elevated post-assessment scores in the AR group imply that students not only enhanced their immediate abilities but also improved their foundational capacity to learn and adapt to new movements.

Another factor that contributes to these results is the level of student interest and motivation during the learning experience. Learning with augmented reality through the Active Arcade application integrates gamification elements like points, challenges, and interactive tasks, which can boost students' intrinsic motivation and active involvement. This heightened engagement encourages learners to practice movements more carefully and regularly, which leads to improved motor learning results. Prior studies have indicated that augmented reality instruction elevates both motivation and engagement within physical education environments, which subsequently has a positive impact on learning achievements (Chen et al., 2017; Liang et al., 2023). While motivation was not evaluated directly in this study, the noted enhancements in motor educability may, in part, result from increased student participation during augmented reality sessions.

The results of this research align with studies related to learning in football, demonstrating that football-related activities enhance essential motor skills such as balance, coordination, agility, and eye-foot coordination (Biino et al., 2023). The incorporation of augmented reality (AR) into football education strengthens these skills by providing clear visual instructions and instant feedback. Consequently, learners can better enhance their control over movements, leading to greater motor learning capabilities. In contrast to earlier research that mainly concentrated on outcome metrics like accuracy in passing or shooting effectiveness (Pérez-Muñoz et al., 2024; Pratama et al., 2022), this study emphasizes the necessity of focusing on process-related results that indicate students' readiness and ability to acquire movement skills.

In spite of these encouraging results, there are a few points to consider. The length of the intervention was quite short, consisting of just five learning sessions. Although notable advancements were detected, it is uncertain whether the advantages of AR-driven education on motor learning would persist over an extended timeframe. Additionally, the study was conducted in a single school setting, which may limit the generalizability of the findings. Variations in school facilities, teacher competence in using technology, and student characteristics could influence the effectiveness of AR implementation in different contexts.

Overall, the results of this study provide empirical support for the integration of AR in physical education, particularly for learning materials that require complex movement understanding. By focusing on motor educability as the main outcome, this study contributes to the existing literature by demonstrating that AR not only enhances motor performance but also strengthens students' fundamental capacity to learn new movements. This finding reinforces the role of AR as an innovative instructional tool that supports deeper and more sustainable motor learning in school-based physical education.

CONCLUSION

Thus, the use of AR can be recommended as an effective learning approach to improve students' motor skills and learning outcomes in schools, especially when learning objectives require precise, interactive, and easily visualized understanding of motion.

Several recommendations can be made to physical education teachers, schools, and curriculum developers. First, Augmented Reality (AR)-based learning is suitable for implementation as an alternative method in learning motor skills because it can increase student motivation, focus, and the ability to understand complex movement techniques through interactive visualization. Teachers can utilize AR-based educational applications such as Active Arcade or similar applications to help students practice basic soccer techniques in a more structured and engaging manner. Second, school facilities need to support the use of technological devices (smartphones/tablets, internet, and visual projection) so that AR implementation can run optimally in learning activities. Third, the integration of teacher training related to the use of AR is also important so that the learning process is effective and can be adapted to class needs.

This study has several limitations that should be considered when interpreting the results. First, the study was conducted in a single school with a limited sample size, so generalizing the results to a broader population requires caution. Student characteristics, school culture, and the quality of learning facilities can influence the effectiveness of AR implementation, so results may differ in other educational contexts. Second, the intervention duration was relatively short, making it impossible to accurately describe the long-term impact of AR use on students' motor skill development. The sustainability of skills and learning retention cannot be determined through this study.

Taking these limitations into account, further research is expected to broaden the scope of the research, extend the duration of treatment, and integrate additional variable measurements to obtain a more comprehensive understanding of the effectiveness of Augmented Reality-based learning.

Suggestions for further research include expanding the sample size to different levels or regions, and considering additional variables such as self-efficacy or specific motor coordination to gain a more comprehensive understanding of AR's effectiveness. Long-term experimental designs can also be used to assess the sustainability of AR's impact on students' motor skill development. Furthermore, future research could evaluate the effectiveness of AR compared to other learning technologies such as Virtual Reality

(VR) or gamification learning to determine the most optimal approach in the context of modern physical education.

REFERENCES

Akçayır, M., & Akçayır, G. (2016). SC. Educational Research Review. https://doi.org/10.1016/j.edurev.2016.11.002

Arlioni, Aminuddin, Awaluddin, & Suhardianto. (2021). Hubungan Antara Motor Educability Terhadap Kemampuan Servis Bawah Bola Voli Siswa Kelas Viii Smp the Relationship Between Motor Educability Towards Under Service Ability in Volleyball At Greade Viii Students of Smp Negeri 4. Jurnal Pendidikan, Sosial Dan Humaniora, 1(1), 57–65.

Bacca, J., Baldiris, S., Fabregat, R., & Graf, S. (2014). Augmented Reality Trends in Education : A Systematic Review of Research and Applications. 17, 133–149.

Biino, V., Giustino, V., Gallotta, M. C., Bella, M., Battaglia, G., Lanza, M., Baldari, C., Giuriato, M., Figlioli, F., Guidetti, L., & Schena, F. (2023). children ' s gross motor coordination level. December. https://doi.org/10.3389/fspor.2023.1310074

Chen, P., Liu, X., Cheng, W., & Huang, R. (2017). A review of using augmented reality in education from 2011 to 2016. Lecture Notes in Educational Technology, 9789811024184, 13–18. https://doi.org/10.1007/978-981-10-2419-1_2

Kementerian Pendidikan dan Kebudayaan Republik Indonesia. (2016). Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 22 Tahun 2016 tentang Standar Proses Pendidikan Dasar dan Menengah. https://jdih.kemdikbud.go.id/arsip/Permendikbud_Tahun2016_Nomor22.pdf

Liang, L., Zhang, Z., & Guo, J. (2023). The Effectiveness of Augmented Reality in Physical Sustainable Education on Learning Behaviour and Motivation. Sustainability (Switzerland) , 15(6). https://doi.org/10.3390/su15065062

Neldi, H., Aziz, I., & Erita, Y. (2025). Augmented Reality in Basketball Education : A Systematic Review on Teaching and Skill Development. 13(2), 255–262. https://doi.org/10.13189/saj.2025.130201

Panji, N. W., Pendidikan, P., Ilmu, F., Pendidikan, U., Pemuda, M., Gomong, N. A., Email, C., & Connor, O. (2020). Available online at : http://journal.unj.ac.id/unj/index.php/gjik Permalink / DOI : https://doi.org/10.21009/GJIK.111.04 Pengaruh Metode Mengajar Dan Motor Educability Terhadap Keterampilan Renang Gaya Kupu-Kupu mempelajari koordinasi gerakan penulis tertarik untuk melakukan. 11(01), 46–59.

Pérez-Muñoz, S., Castaño Calle, R., Morales Campo, P. T., & Rodríguez-Cayetano, A. (2024). A Systematic Review of the Use and Effect of Virtual Reality, Augmented Reality and Mixed Reality in Physical Education. Information (Switzerland), 15(9). https://doi.org/10.3390/info15090582

Pratama, B. A., Sucipto, S., & Nanda Hanief, Y. (2022). Improving learning in physical education: Augmented reality mobile app-based for fundamental motor skill. Jurnal SPORTIF : Jurnal Penelitian Pembelajaran, 8(2), 314–326. https://doi.org/10.29407/js_unpgri.v8i2.18508

Rafiandi, W., Sumpena, A., Hambali, B., & History, A. (2025). Journal of Physical Education , Sport , Health and Recreations. 14(2), 753–758.

Sırakaya, M., & Sırakaya, D. A. (2020). Augmented reality in STEM education : a systematic review. Interactive Learning Environments, 0(0), 1–14. https://doi.org/10.1080/10494820.2020.1722713

Sweller, J., Merriënboer, J. J. G., & Paas, F. (2019). Cognitive Architecture and Instructional Design : 20 Years Later. Educational Psychology Review, 261–292. https://doi.org/10.1007/s10648-019-09465-5

Zubaida, I., & Lestari, A. T. (2021). Journal Sport Area Teaching methods and educability motors : Effectiveness in improving long-jump skills. 6(1), 59–66.