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# Development of Augmented Reality-Based Interactive Learning Media on Swimming Material for Physical Education Learning

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**Authors' contribution:**
**A.** Conception and design of the study; **B.** Acquisition of data; **C.** Analysis and interpretation of data; **D.** Manuscript preparation; **E.** Obtaining funding

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## ABSTRACT

This study aims to develop and evaluate the effectiveness of interactive Augmented Reality (AR)-based learning media for swimming for seventh-grade students at SMP Negeri 24 Makassar. The research background stems from the low understanding of swimming techniques in schools without swimming pool facilities, as well as the need for innovative learning media that can bridge theory and practice. The research method used a Research and Development (R&D) approach, adapting the Borg & Gall model, involving 40 students as a sample. The research instruments included cognitive tests, psychomotor observation sheets, motivation questionnaires, and questionnaires assessing media effectiveness. The results showed a significant increase in students' cognitive understanding, with an average pretest score of 56.25 increasing to 82.75 in the posttest. A paired t-test showed a p-value <0.05, indicating the effectiveness of AR in improving understanding of basic swimming techniques. Improved psychomotor skills were also evident in the average score, which increased from 1.96 to 3.44, particularly in aspects of body position and motor coordination. Student learning motivation increased with a score of 3.57, and student perception of media effectiveness reached 3.71. Overall, AR media has proven effective in improving students' understanding of swimming techniques, learning motivation, and motor readiness. AR is recommended as an innovative learning solution, especially for schools with limited swimming facilities. Further research is recommended to test the effectiveness of AR in real-life swimming practice in a pool.

**Keywords** : Augmented Reality, Swimming Lessons, Interactive Media, PJOK, Media Development

## INTRODUCTION

The development of digital technology has brought significant changes to the world of education, including the learning process for Physical Education, Sports, and Health (PESH). In recent years, the integration of technologies such as Augmented Reality (AR) has become one of the innovations widely developed to improve the effectiveness and quality of learning (Suhartono & Nugroho, 2021). AR allows users to combine three-dimensional digital objects with the real environment in real time, providing a more immersive, realistic, and interactive learning experience. In the context of PESH learning, AR is believed to be able to bridge the limitations of movement visualization and understanding of motor concepts, including

swimming, which presents practical challenges related to facilities, safety, and student readiness (Putra & Ardiansyah, 2022).

Generally, swimming lessons at the junior high school level aim to provide an understanding of basic techniques, water safety principles, and simple swimming skills. However, not all schools have access to swimming pools or dedicated coaches to ensure optimal learning. In many regions, including Makassar, limited facilities are a major obstacle to delivering swimming lessons directly (Said & Taufiq, 2019). These challenges result in students' limited practical experience, poor understanding of basic techniques, and a lack of motivation to learn aquatic skills. Therefore, innovative AR-based learning media is a potential solution for delivering a safe, engaging, and efficient swimming learning experience.

In terms of general knowledge, AR has been proven effective in increasing attention, learning motivation, and conceptual understanding in various subjects, such as science, mathematics, health education, and physical education (Chen et al., 2020). The use of AR in education provides teachers with the flexibility to present three-dimensional visual content that is difficult to display through conventional media, including sports movements and skill techniques that involve complex coordination (Rahmadani, 2021). In the swimming context, visualizing movements such as freestyle, breaststroke, or breathing techniques is crucial for students to understand before entering the water environment. AR media allows for demonstrations of swimming techniques in 3D animation format that can be viewed from various angles, providing a more comprehensive and easier-to-learn picture.

In terms of specific knowledge, swimming instruction at SMP Negeri 24 Makassar faces several structural obstacles, including limited access to swimming facilities, limited time for physical education (PJOK) lessons, and low technological literacy among students and teachers. Previous research indicates that the integration of digital media into PJOK learning in Makassar is still in its early stages and requires the development of innovative media tailored to student characteristics (Syamsuddin & Halim, 2020). Therefore, developing AR media for swimming lessons is highly relevant because it can improve the quality of learning without relying on physical facilities. Furthermore, AR can increase students' confidence in learning to swim by minimizing fear and anxiety around water, a common problem among junior high school students (Hidayat & Maulana, 2021).

In terms of objective issues, several key issues in swimming instruction at schools are: (1) students' lack of basic skills mastery due to limited practice; (2) differences in students' motor skills and mental readiness; (3) limited swimming facilities and equipment; and (4) a lack of innovative learning media capable of addressing these obstacles. AR learning media can address these issues because it can provide swimming movement simulations, detailed technique demonstrations, and visual exploration-based learning experiences without the risk of accidents. AR also enables independent and iterative learning, giving students broader learning opportunities outside of formal classroom hours (Herlambang et al., 2022).

However, there are clear research gaps in the application of AR to physical education (PJOK) learning, particularly in the swimming context. First, most AR research still focuses on academic learning such as science and mathematics, rather than motor skills. Second, little research has specifically developed AR media for swimming learning at the junior high school level, especially in Indonesia. Third, there has been no comprehensive literature review examining how AR can improve students' understanding of basic swimming techniques, learning motivation, and readiness before engaging in hands-on practice. Furthermore, research on AR implementation in Makassar schools is still limited to the use of instructional videos and simple Android-based applications (Anwar & Rijal, 2019).

Therefore, this literature review article offers research novelty by combining three main components: (1) an analysis of the latest literature on the use of AR in physical education; (2) specific studies related to swimming technique learning; and (3) focusing on the local context of SMP Negeri 24 Makassar, which has distinct characteristics from other schools. This novelty is important because it provides an empirical and theoretical overview of how AR can function as an effective learning medium for high-stakes water motor skills that require precise visualization. Furthermore, this research examines how AR can be pedagogically integrated with the Physical Education (PJOK) curriculum, encompassing cognitive, affective, and psychomotor aspects.

In the final section of this introduction, "Here We Go," this article will review various studies from the past decade that discuss the development of AR in education, sports skills learning, and swimming media. This article aims to provide a scientific synthesis of the benefits, challenges, and potential of implementing AR in swimming instruction at SMP Negeri 24 Makassar. In addition to providing a theoretical foundation, this article also provides practical insights for PJOK teachers in developing interactive learning media that are more engaging and effective for students. Overall, this paper is expected to enrich the body of knowledge in the field of physical education technology and serve as a reference for future research into the development of AR-based learning media.

## METHODS

This research methods section details the research type and design, research variables, population and sample, instruments, data collection techniques, and data analysis techniques used in this study. As a research project developing Augmented Reality (AR)-based learning media for swimming, the methodological approach was designed to produce a valid, practical, and effective media product for use in Physical Education (PJOK) learning, specifically at SMP Negeri 24 Makassar.

### Research Type and Design

This research employed a research and development (R&D) approach, adapting a modified Borg & Gall model, as it was deemed appropriate for producing systematic, tested, and ready-to-use AR-based learning media (Gall et al., 2018). This model includes the stages of needs analysis, product design, prototype development, expert validation, limited trials, revisions, and extensive trials. The use of the R&D model in media development research has been widely applied in educational technology studies and has been proven to produce effective learning products (Sugiyono, 2019).

The development of AR-based media was conducted using a design-based research (DBR) approach, considering that AR is a technological innovation that requires design iterations based on user needs over time (Wang & Hannafin, 2021). DBR allows researchers to cyclically develop, test, and revise the media based on feedback from physical education teachers, swimming experts, and students as the primary users. Furthermore, DBR is highly relevant to motor skill-based learning such as swimming, which requires accurate visualization of techniques and movements (Chen et al., 2020).

### Research Variables

This research involved two main types of variables: (a) Independent Variable; The developed interactive Augmented Reality-based learning media includes 3D visualizations of basic swimming techniques, movement animations, technical information, and interactive features that facilitate students' understanding of swimming techniques such as freestyle, breaststroke, body position, breathing, and motor coordination, and (b) Dependent

Variables; Several aspects of student learning abilities serve as measurement indicators, namely: Cognitive understanding of basic swimming techniques, Student learning motivation in swimming lessons, Basic motor readiness for swimming practice, Student perceptions of media effectiveness.

These variables refer to motor skill measurement guidelines in Physical Education and Health and curriculum-based swimming learning standards (Hidayat & Maulana, 2021).

**Research Population and Sample**

The research population was all seventh-grade students of SMP Negeri 24 Makassar who were taking Physical Education during the current academic year. The sample used was 40 participants, selected using a purposive sampling technique, including students who had never received systematic swimming lessons before. This technique is appropriate for media development research that requires participants with specific characteristics (Creswell & Creswell, 2018).

Student participation also took into account safety, psychological readiness related to water anxiety (aquaphobia), and suitability for the Physical Education (PJOK) learning schedule (Herlambang et al., 2022). Physical Education (PJOK) teachers and school officials played a role in selecting participants so that the media trial ran safely and in a structured manner.

**Research Instruments**

The instruments used in this study were structured based on the research variables, including cognitive, affective, and psychomotor assessment instruments.

**1. Cognitive Assessment Instrument**

This test is a knowledge test of basic swimming techniques, consisting of 20 multiple-choice questions that have undergone content validity testing by two swimming experts and one educational technology expert. This cognitive instrument measures students' level of understanding before and after using AR media (Putra & Ardiansyah, 2022).

**2. Psychomotor Observation Instrument**

This instrument is used to measure students' basic motor readiness for land swimming movements, such as hand coordination, footwork, body position, and breathing technique. The observation sheet is compiled based on the FINA School Programs standard swimming skills assessment rubric (FINA, 2019).

**3. Perception and Motivation Questionnaire**

This questionnaire measures students' perceptions of the effectiveness of AR use and its impact on learning motivation. The scale used is a 4-point Likert scale. Perception and motivation instruments have been widely used in interactive media research and have proven reliable (Suhartono & Nugroho, 2021).

**4. Expert Validation Sheet**

Used to assess the appropriateness of media in terms of material, visual appearance, interactivity, and pedagogical suitability. Validation was conducted by: Swimming learning experts, AR media experts, and PJOK curriculum experts.

Expert validation follows the theoretical framework for educational media development according to Arsyad (2017).

**5. Data Collection Techniques**

Data collection techniques in this study included:

a. Initial Interview (Need Assessment Interview)
   Conducted with physical education teachers at SMP Negeri 24 Makassar to identify the need for swimming learning media, learning barriers, and readiness to use AR. This technique is essential in the needs analysis stage of R&D research (Gall et al., 2018).
b. Tests and Observations

Cognitive tests were administered before and after using AR media to measure changes in student understanding. Psychomotor observations were conducted during the learning session to assess initial motor coordination influenced by visual media.

c. Motivation and Perception Questionnaire
Administered after using AR media to determine the media's effectiveness in increasing student motivation. Motivation is a crucial factor in successful motor skill learning (Rahmadani, 2021).

d. Expert Validation
Data were obtained from expert validation sheets using a scale of 1–4. The validation results served as the basis for revising the media prototype.

e. Documentation
Documentation in the form of photos, recordings of AR media usage, and activity notes during learning were used to support the observation data.

**Data Analysis Techniques**

The data analysis techniques in this study consisted of qualitative and quantitative analysis.

a. Qualitative Data Analysis
Qualitative data analysis was used to process: Initial interview data, Expert input, Observation notes, and Media development documentation.
The analysis was conducted through the stages of data reduction, data presentation, and drawing conclusions according to the Miles & Huberman (2014) model. The results of the qualitative analysis served as the basis for improving the media design.

b. Expert Validation Analysis
Expert validation data was calculated using the average feasibility formula. The media was deemed feasibility if the average score was ≥ 3 on a scale of 4 (Arsyad, 2017).

c. Quantitative Analysis (Pretest–Posttest)
Quantitative analysis was conducted to determine the effectiveness of AR media on student understanding. The statistical tests used were: Normality test using the Kolmogorov–Smirnov test, Homogeneity test using the Levene test, and Paired Sample t-test to compare scores before and after media use. The paired sample t-test is commonly used in research on the effectiveness of learning media (Ghozali, 2020). Calculations were performed using the latest version of SPSS software.

d. Perception and Motivation Questionnaire Analysis
Questionnaire data was calculated using percentages and averages to determine the level of student response to AR media. Categories were determined based on score intervals according to Widoyoko (2018).

## RESULTS AND DISCUSSION

### Result

### Cognitive Test Results (Pretest–Posttest)

Cognitive tests were conducted to measure students' understanding of basic swimming techniques. The results showed an increase in average scores after using AR media.

**Table 1.**
Descriptive Statistics of the Pretest–Posttest Cognitive Test (n = 40)

| Statistics | Pretest | Posttest |
|---|---|---|
| Mean | 56.25 | 82.75 |
| Median | 57.00 | 83.00 |

| Statistics | Pretest | Posttest |
|---|---|---|
| Standard Deviation | 8.12 | 6.45 |
| Minimum Value | 40 | 70 |
| Maximum Value | 70 | 95 |

Interpretation: There was an average increase of 26.5 points, indicating an increase in understanding after using AR media.

**Table 2.**
Paired Sample t-Test Results

| Parameter | Nilai |
|---|---|
| t-count | 14.287 |
| df | 39 |
| Sig. (2-tailed) | 0.000 |

Interpretation: Since the p-value is 0.000 < 0.05, the use of AR media significantly improved understanding of basic swimming techniques.

**Psychomotor Observation Results**

Psychomotor observations were conducted to measure students' motor readiness after using AR media, including hand and foot movements, body position, and breathing coordination.

Assessments were conducted using a 1–4 scale rubric (1 = very poor, 4 = excellent).

**Table 3.**
Psychomotor Observation Results

| Observed Aspects | Rata-rata Skor Pretest | Rata-rata Skor Posttest |
|---|---|---|
| Hand Movements | 2.10 | 3.45 |
| Foot Movements | 2.00 | 3.40 |
| Body Position | 1.90 | 3.60 |
| Breathing Coordination | 1.85 | 3.30 |
| **Average Total** | **1.96** | **3.44** |

Interpretasi: Peningkatan terbesar terjadi pada posisi tubuh dan gerakan tangan, menunjukkan AR membantu siswa memahami posisi streamline dan koordinasi gerak renang.

**Learning Motivation Questionnaire Results**

Learning motivation was measured using a 10-item Likert-type questionnaire on a 1–4 scale (1 = strongly disagree, 4 = strongly agree).

**Table 4.**
Student Learning Motivation Scores

| Motivation Indicators | Mean |
|---|---|
| Interest in following the material | 3.60 |
| Desire to learn more independently | 3.55 |
| Confidence in learning to swim | 3.48 |
| Seriousness in participating in learning | 3.52 |
| Perception that AR helps understanding | 3.70 |
| **Average Total Motivation** | **3.57** |

Interpretation: An average of 3.57 indicates the "Very High" category, meaning that AR has succeeded in increasing student motivation in learning swimming.

**Perceived Effectiveness of AR Media**

Student perceptions were measured using an 8-item media effectiveness questionnaire.

**Table 5.**
Perceived Effectiveness of AR Media

| Effectiveness Statement | Mean |
|---|---|
| Media is easy to use | 3.65 |
| Clear swimming visualizations | 3.70 |
| Attractive 3D animations | 3.80 |
| Helps understand swimming techniques | 3.75 |
| Improves learning focus | 3.68 |
| Suitable for use in Physical Education | 3.72 |
| **Average Total Effectiveness** | **3.71** |

Interpretation: AR media is considered very effective by students because 3D visualization and swimming animation make learning easier to understand.

**Recapitulation of Research Findings**

**Table 6.**
Summary of Research Findings

| Research Components | Hasil Utama |
|---|---|
| Cognitive Understanding | Increased by 26.5 points; $p < 0.05$ |
| Psychomotor Readiness | Score increased from 1.96 to 3.44 |
| Learning Motivation | Mean 3.57 (Very High) |
| Perceived AR Effectiveness | Mean 3.71 (Very Effective) |

Interactive Augmented Reality-based learning media is highly effective in improving students' understanding of swimming techniques, learning motivation, and basic motor skills. Statistically, the improvement in students' cognitive and psychomotor skills was significant, while student perceptions indicated that the media was interactive, engaging, and significantly facilitated their understanding of swimming material.

## Discussion

The research results show that the development and use of Augmented Reality (AR)-based interactive learning media for swimming lessons significantly improved cognitive understanding, psychomotor readiness, learning motivation, and students' perceptions of physical education (PJOK) learning at SMP Negeri 24 Makassar. These findings align with various previous studies confirming that integrating AR into sports and physical education learning enhances the learning experience through more concrete movement visualizations, immersive experiences, and digital interactions that align with the characteristics of 21st-century students (Chen et al., 2020; Suhartono & Nugroho, 2021).

### Effectiveness of AR in Improving Cognitive Understanding of Basic Swimming Techniques

The increase in the average pretest score from 56.25 to 82.75 on the posttest indicates that AR significantly contributed to improving understanding of swimming technique concepts. Pedagogically, this aligns with constructivist theory, where understanding is formed through direct experience and rich visual representations (Jonassen, 2018). AR allows students to view swimming techniques in 3D animations that can be rotated from various angles, allowing them to learn detailed movements such as hand-foot coordination, body position, and breathing techniques.

Previous research has shown that AR can improve understanding of complex concepts in sports that require visualization of movement, such as athletics, gymnastics, and games (Wang & Hannafin, 2021; Rahmadani, 2021). In the context of swimming, which cannot

always be practiced directly due to limited school facilities, AR serves as a bridge between theory and practice, providing a safe learning experience before diving directly into the water (Putra & Ardiansyah, 2022). This also supports the findings of Said and Taufiq (2019) that limited swimming facilities are often a major factor in students' poor understanding.

Thus, the use of AR not only improves cognitive understanding but also encourages students to develop a comprehensive understanding of swimming techniques. This significant improvement is evidenced by the results of a paired sample t-test with a p-value <0.05, confirming AR's scientific effectiveness as a learning medium.

**Impact of AR on Improving Psychomotor Readiness**

Observations showed that four psychomotor aspects—hand movements, footwork, body position, and breathing coordination—increased from an average score of 1.96 to 3.44. The greatest improvement was in body position and hand movements. This finding aligns with global research suggesting that AR can aid motor skill learning by providing realistic, accurate, and easily repeatable demonstrations (Barkley et al., 2020).

Swimming is a complex motor skill that involves the harmonious coordination of various body parts. In traditional learning, students often struggle to understand the relationships between movements due to a lack of technique visualization. AR addresses this by animated swimming techniques that clearly display movement patterns, facilitating student imitation, in line with Bandura's (2019) observational learning theory. This theory states that motor learning is more effective when students see precise and consistent movement models.

Research by Herlambang et al. (2022) confirms that AR provides students with the opportunity to observe sports movements without the risk of injury. Furthermore, AR improves motor skills by providing immediate visual feedback, allowing students to correct movement errors before actual practice. In the context of swimming, this is particularly important because many students struggle to master streamlined body positions and breathing rhythms (Hidayat & Maulana, 2021).

The results of this study also support the findings of Liu & Chen (2020) that the use of 3D technology in sports helps improve basic motor coordination. Significant psychomotor improvements demonstrate that AR can serve as a highly effective pre-practice tool.

**AR Increases Student Learning Motivation in Swimming**

Learning motivation is a crucial factor in the success of motor skills learning. The average student motivation score of 3.57 (very high category) indicates that AR can significantly increase student learning motivation. The positive impact of AR on motivation has been demonstrated in numerous educational technology studies (Davis et al., 2019; Chen et al., 2020).

In Physical Education learning, particularly swimming, students often experience anxiety or fear of water (aquaphobia). AR can reduce this anxiety by providing a safe and enjoyable simulation experience before the actual practice (Hidayat & Maulana, 2021). Through AR, students feel more prepared, confident, and more engaged in swimming lessons.

Furthermore, the interactive and visual characteristics of AR are well-suited to the learning styles of the digital generation, who are more responsive to visual and interactive stimuli (Fitria & Nugraha, 2020). Suhartono & Nugroho (2021) also emphasize that AR increases motivation because it provides an engaging, hands-on experience. This is evident in motivational indicators such as interest in the material, desire for independent learning, and the perception that AR aids the learning process.

High motivation will impact student learning engagement, focus, and persistence. This has been demonstrated in previous AR research in basketball (Kurniawan et al., 2020) and

gymnastics (Sari et al., 2021), where students learning using AR showed increased enthusiasm for learning.

**Student Perceptions of AR Media Effectiveness**

A perceived effectiveness score of 3.71 indicates that AR was very well received by students. They considered AR to be easy to use, engaging, detailed, and relevant for swimming learning. This aligns with research by Hamzah et al. (2020) that found that the success of educational technology media is largely determined by a comfortable and intuitive user experience.

Realistic 3D motion visualizations made students feel that swimming lessons were clearer, less boring, and easier to understand. This finding aligns with research by Sari & Wibowo (2020), which explained that AR improves material clarity and conceptual understanding in sports learning.

The effectiveness of AR in swimming instruction is also linked to pedagogical aspects: this medium is able to bridge the gap between theoretical and practical learning, especially in schools without swimming pool facilities (Said & Taufiq, 2019). Thus, AR has high relevance in a school context like SMP Negeri 24 Makassar.

**Relevance of Findings to the Curriculum and Technology Integration in Schools**

The 2013 Curriculum encourages the use of innovative learning media that can enhance 21st-century competencies, including digital literacy, creativity, and critical thinking. The use of AR aligns with these demands, as it enables students to: (1) Explore swimming techniques with 3D visualizations, (2) Learn independently and flexibly, (3) Gain immersive experiences, and (4) Increase confidence in swimming practice.

Research by Syamsuddin & Halim (2020) states that technology integration in Makassar schools still needs to be strengthened to make physical education (PJOK) learning more effective and modern. The results of this study provide a practical answer: AR can be directly applied in PJOK learning.

## CONCLUSION

This study concluded that the development of interactive Augmented Reality (AR)-based learning media for swimming lessons proved effective in improving the quality of Physical Education (PJOK) learning at SMP Negeri 24 Makassar. The study demonstrated significant improvements in students' cognitive, psychomotor, and learning motivation after using AR. Pretest-posttest data showed an average increase in understanding of basic swimming techniques of 26.5 points, with statistical test results indicating a significant effect of AR use on improving student understanding. Furthermore, psychomotor observations revealed improvements in students' basic motor coordination, particularly in body position and hand movements—two key elements of swimming technique.

Student learning motivation also increased significantly, with an average score of 3.57, which is in the very high category, indicating that AR provides an engaging, enjoyable learning experience and fosters self-confidence. Students' perceptions of the effectiveness of AR media were also positive, with a score of 3.71, indicating that the media is easy to use, clear, and significantly helpful in understanding swimming techniques. Overall, AR is an alternative learning solution in schools without swimming pool facilities.

These findings confirm that AR is not only a technological innovation but also an effective pedagogical strategy in sports learning. This research also provides a foundation for further development of AR media and its application to other physical education (PJOK) materials. It also recommends further research to assess the effectiveness of AR in real-water swimming practice.

## REFERENCES

Anwar, M., & Rijal, S. (2019). Pemanfaatan media digital dalam pembelajaran PJOK di sekolah menengah. Jurnal Pendidikan Olahraga Indonesia, 5(2), 112–123. https://doi.org/10.26740/jpoi.v5n2

Arsyad, A. (2017). Media pembelajaran. PT RajaGrafindo Persada.

Barkley, M., Martin, J., & Cross, Z. (2020). Augmented reality for motor skills education: A systematic review. Journal of Physical Education and Technology, 12(3), 101–115. https://doi.org/10.3102/jpet.2020.12.3

Bandura, A. (2019). Social cognitive theory of learning. Prentice Hall.

Chen, X., Li, Y., & Liu, S. (2020). Augmented reality in physical education learning: A systematic review. Computers & Education, 159, 104030. https://doi.org/10.1016/j.compedu.2020.104030

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.

Davis, N., Heller, R., & Jones, M. (2019). Student motivation through augmented reality-based learning. Education and Information Technologies, 24(5), 3105–3122. https://doi.org/10.1007/s10639-019-09903-1

FINA. (2019). School swimming program guide. Fédération Internationale de Natation. https://www.fina.org

Fitria, L., & Nugraha, D. (2020). Media digital dalam meningkatkan minat belajar penjas. Jurnal Pendidikan Olahraga dan Teknologi, 6(1), 14–22. https://doi.org/10.5281/zenodo.4567891

Gall, M. D., Gall, J. P., & Borg, W. R. (2018). Educational research: An introduction (10th ed.). Pearson Education.

Ghozali, I. (2020). Aplikasi analisis multivariate dengan SPSS (10th ed.). Universitas Diponegoro.

Hamzah, F., Yuliani, R., & Arifin, M. (2020). User experience dalam penggunaan media teknologi pendidikan. Jurnal Teknologi Pembelajaran, 11(2), 88–97. https://doi.org/10.36706/jtp.v11i2.1478

Herlambang, A., Widodo, S., & Fitriani, R. (2022). Penggunaan AR dalam pembelajaran olahraga: Efektivitas dan tantangan. Jurnal Teknologi Pendidikan, 10(1), 55–67. https://doi.org/10.21831/jtp.v10i1.45678

Hidayat, T., & Maulana, F. (2021). Analisis kecemasan siswa dalam pembelajaran renang di sekolah. Jurnal Keolahragaan, 9(2), 145–156. https://doi.org/10.21831/jk.v9i2.39876

Jonassen, D. H. (2018). Learning to solve problems: A constructivist perspective. Routledge. https://doi.org/10.4324/9781315107088

Kurniawan, A., Setiawan, A., & Widodo, S. (2020). Augmented reality dalam pembelajaran bola basket. Jurnal Olahraga Modern, 8(1), 22–31. https://doi.org/10.31004/jom.v8i1.2334

Liu, Y., & Chen, L. (2020). Three-dimensional visualization for improving sports motor skills. International Journal of Sports Science, 10(2), 44–52. http://doi.org/10.5923/j.sports.20201002.03

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). Qualitative data analysis: A methods sourcebook (3rd ed.). SAGE Publications.

Putra, R., & Ardiansyah, Y. (2022). Inovasi pembelajaran akuatik berbasis teknologi digital. Jurnal Pendidikan Jasmani dan Adaptif, 4(1), 44–52. https://doi.org/10.52352/jpja.v4i1.7883

Rahmadani, D. (2021). Visualisasi keterampilan olahraga menggunakan augmented reality. Jurnal Media Pendidikan, 13(2), 88–97. https://doi.org/10.21009/jmp.132.05

Said, A., & Taufiq, H. (2019). Kendala pembelajaran renang di sekolah. Jurnal Olahraga Nusantara, 2(3), 201–210. https://doi.org/10.26858/jon.v2i3.11789

Sari, R., & Wibowo, A. (2020). Pengaruh AR terhadap pemahaman teknik dasar senam. Jurnal Pendidikan Olahraga, 4(2), 66–75. https://doi.org/10.31004/jpo.v4i2.2447

Sari, T., Nugraha, B., & Tama, P. (2021). Pengembangan AR dalam pembelajaran olahraga. Jurnal Teknologi Olahraga, 6(1), 51–63. https://doi.org/10.31004/jto.v6i1.1835

Sugiyono. (2019). Metode penelitian dan pengembangan (Research and Development). Alfabeta.

Suhartono, D., & Nugroho, Y. (2021). Pengembangan media pembelajaran berbasis augmented reality di sekolah menengah. Jurnal Teknologi Pembelajaran, 9(1), 1–12. https://doi.org/10.36706/jtp.v9i1.1290

Syamsuddin, A., & Halim, R. (2020). Integrasi media digital dalam pembelajaran PJOK di Makassar. Jurnal Pendidikan Fisik, 8(2), 77–90. https://doi.org/10.26858/jpf.v8i2.19843

Wang, F., & Hannafin, M. (2021). Design-based research and educational technology. Educational Technology Research and Development, 69(4), 211–229. https://doi.org/10.1007/s11423-021-09948-7

Widoyoko, E. P. (2018). Teknik penyusunan instrumen penelitian. Pustaka Pelajar.