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Augmented Reality in Breaststroke Swimming: Improving Techniques and Skills

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Abstract

This study aims to assess the impact of Augment Reality (AR) media on breaststroke swimming skills in students of the Faculty of Sports, Sebelas Maret University Surakarta. The research method used in this study is a pseudo-experimental method. The research design implemented was a nonequivalent control group design. The study involved 30 students as subjects. Data collection in this study using breaststroke swimming skills test. The data analysis used was an independent t-test, which distinguishes breaststroke swimming skills between the experimental group and the control group. The experimental group received breaststroke swimming lessons using AR media, while the control group was taught breaststroke swimming with conventional methods. The results of this study indicated a significant difference in breaststroke swimming skills between the experimental group and the control group. Data were analysed using paired sample t-test and N-Gain Score. The results of this research showed the average results of the N-Gain Score calculation in the experimental group (60.6%) and the control group (30.6%). This shows that breaststroke swimming learning media using AR media is more effective than learning media with conventional media. The conclusion in this study is that learning breaststroke swimming using AR media has a significant effect on improving breaststroke swimming skills in students of the Faculty of Sports, Sebelas Maret University, Surakarta.

Keywords: Augmented reality; breaststroke style; learning media; swimming skills

1. Introduction

The rapid advancement of technology has significantly impacted various fields, including sports science and education. One of the most notable technological innovations in recent years is Augmented Reality (AR), which overlays digital information onto the natural world through devices such as smartphones, tablets, or AR glasses (Arena, Collotta, Pau, & Termine, 2022; Billinghurst, 2020). Good learning media is learning media that can convey messages or learning materials clearly so that the material can be received and understood by students. There are several factors that must be considered in choosing learning media. These factors include; learning objectives to be achieved, characteristics of students who take part in learning, learning materials to be delivered, and ease of use of the selected media. Choosing the right learning media can assist students in comprehending the material presented by instructors. Learning media can provide concrete experiences and also as intermediaries that help learning (Wulandari, Salsabila, Cahyani, Nurazizah, & Ulfiah, 2023). The selection of the right media needs to be done by the teacher to make it easier for students to achieve

their learning goals. Learning media is needed by teachers to facilitate the delivery of material both theoretical and practical material. In learning materials that involve a lot of the psychomotor domain, a suitable learning media is needed to explain the movements to be learned.

Swimming is a fundamental physical activity that plays a crucial role in developing motor skills and overall physical fitness. It is also used to teach movements and is considered to have a high level of difficulty (Overbury, Conroy, & Marks, 2023; Rodríguez González, Melguizo-Ibáñez, Martín-Moya, & González-Valero, 2023). This is due to the complexity of the movements that must be learnt in swimming. To be able to master swimming skills requires a good understanding of the theory of swimming movements studied. Students be required to understand swimming movements and then be required to demonstrate the movements. Among the various swimming styles, breaststroke is particularly notable for its technical complexity, which requires swimmers to execute precise, synchronized movements involving both the upper and lower body. The arm and leg actions in breaststroke are distinct from other strokes, necessitating a simultaneous pull-push motion with the arms while performing a whip-like kick with the legs. This unique movement pattern, combined with the need for proper timing in breathing and maintaining streamlined body alignment, makes breaststroke one of the most challenging swimming techniques to master (Mashud et al., 2023; Strzała et al., 2012). At the stage of learning motion, understanding the movement will be obtained in the cognitive phase, where in that phase students try to recognise and understand the movements being studied. After being able to understand the movement well, students are expected to demonstrate the movement by understanding the movement that has been owned. Starting to try to do the movement is included in the associative phase, which is the phase when students start trying to do the movement (Fernandes et al., 2022; Filho, De, & Manoel, 2002). The feedback is needed in this associative phase to get the correct movement. To get a good understanding and practice in swimming learning, the right learning media is needed.

The integration of AR into swimming training, specifically in breaststroke, presents a promising approach to enhance technique and skill acquisition. AR can provide swimmers with immediate visual cues and corrections in real-time, allowing them to adjust their movements as they swim (Nohantiya & Putra, 2020; Richards & Clemente, 2012). For example, an AR system could highlight the correct body position or the optimal trajectory of the swimmer's hands and legs, making it easier for learners to internalize these movements. Additionally, AR can simulate different swimming conditions or challenges, helping students develop adaptability and problem-solving skills in a controlled environment. This integration not only makes the learning process more engaging but also more personalized, catering to the unique learning pace and style of each student (Powell, Polsley, Casey, & Hammond, 2023; Syahrastani, Hidayat, Komaini, Gemaini, & Zulbahri, 2022). AR in swimming lessons aims to create a more interactive and engaging learning environment. Through AR, instructors can present additional information on swimming techniques, correct body movements, and breathing strategies directly in the middle of the exercise. This allows students to get a more in-depth and visual view of key aspects of swimming. Instruction using AR has been shown to improve academic performance (Yi-Ming Kao & Ruan, 2022a). One AR-based technology, FORM Smart Swim Goggles (FORM Goggles), can improve overall backstroke, breaststroke and freestyle swimming skills (Eisenhardt, Kits, Madeleine, & Samani, 2023). One way to conduct creative and innovative learning is to use the latest technology (Batez, 2021). This is due to the view of experts who state that the use of the latest technology can provide opportunities for people to participate and interact with a positive mood (Cojocaru et al., 2022).

Despite the potential benefits of augmented reality (AR) in swimming training, some challenges and gaps need to be addressed. Current research on AR applications in sports is still in its early stages, particularly in the context of swimming. There is a lack of empirical studies exploring the effectiveness of AR in improving swimming techniques, and the practical implementation of AR in aquatic environments poses technical and logistical challenges (Hinojo Lucena, López Belmonte, Fuentes

Cabrera, Trujillo Torres, & Pozo Sánchez, 2019). These challenges are even more pronounced for students who are still learning it in a real class situation. The absence of targeted training programs incorporating AR for breaststroke swimming creates a gap in the available educational tools to enhance student performance. Thus, the learning that is carried out can adapt to the times and in accordance with the needs of today's students (Hinojo Lucena et al., 2019). In addition, the use of technology can make the world of physical education more developed (Lee & Lee, 2021) because higher education institutions must continue to develop and strategise to improve the quality of learning to meet the needs of students in a competitive environment (H'mida et al., 2020). AR as a media in learning breaststroke swimming is very relevant to use because it can clearly explain step by step the movements that must be learned and performed in breaststroke swimming. Swimming learning using AR media, students not only master swimming skills but also can think at a high level and have high motivation in learning both individually and in groups.

2. Method

This research employed an experimental method using a Nonequivalent Control Group Design to investigate the effects of media enhancement on students' performance in swimming. The research subjects comprised 30 students from the Faculty of Sports Science at Sebelas Maret University, randomly selected to include a balanced representation of both male and female participants. All selected students were enrolled in swimming courses, ensuring that they had a foundational level of skill relevant to the study.

The randomization process was carefully implemented to guarantee an equitable distribution of participants across the experimental and control groups. This sampling strategy was designed to minimize bias and provide all students with an equal opportunity to participate in the research. By employing this method, we aimed to enhance the validity of our findings and ensure that any observed effects could be attributed to the intervention rather than pre-existing differences between groups.

This study divided students into two groups: an experimental group that used Augmented Reality (AR) media enhancement for breaststroke swimming learning and a control group that used conventional learning methods. It is important to note that the AR used in this study was proprietary and was the result of the previous research development. Data was collected through a breaststroke swimming skill test with a distance of 50 metres. The test results from both groups (experimental and control) were then analysed to assess the effect of the intervention. The experimental design table chosen for the product effectiveness test stage is as follows:

Table 1. Experiment design

E	O_1	X_1	O_2
K	O_3	X_2	O_4

Data were analysed using SPSS software with a significance level (p-value) of 0.05 as the criteria for hypothesis testing. The test was conducted first with an independent t-test to compare the results of breaststroke swimming skills between the experimental group using AR and the control group using conventional methods. Furthermore, learning effectiveness analysis was conducted by calculating N-Gain (Normalised Gain) to measure skill improvement in each group in more detail.

3. Result

The data in this study consisted of two groups, namely the experimental group and the control group. The experimental group received breaststroke swimming lessons using Augmented Reality (AR) media, while the control group was given learning with conventional methods. The normality test was conducted to assess whether the data had a normal distribution as a prerequisite for parametric

analysis, namely paired sample t-test and independent sample t-test. The normality tests used were the Kolmogorov-Smirnov test and the Shapiro-Wilk test, which resulted in a value (sig.) > 0.05. These results indicate that the data on breaststroke swimming skills of students of the Faculty of Sports Science, Sebelas Maret University Surakarta are normally distributed.

Furthermore, the paired sample t-test produces a Sig. (2-tailed) of 0.05, which indicates that the data in this study are homogeneous. The independent sample t-test test showed a Sig. (2-tailed) of 0.001 <0.05, so it can be concluded that there is a significant difference in breaststroke swimming skills between the group using AR media and the group using conventional methods. Furthermore, the N-Gain (Normalised Gain) test will be conducted to measure the effectiveness of using a method in research. The results of the N-Gain test are listed in the table.

Table 2. N-Gain score of breatstroke swimming skills in students of the Faculty of Sports, Sebelas Maret University, Surakarta

N-Gain Score Calculation Results			
No.	**Experiment Class**	**No.**	**Control Class**
	N-Gain Score (%)		**N-Gain Score (%)**
1	33.33	1	16.67
2	39.66	2	13.46
3	46.43	3	23.08
4	50.00	4	20.00
5	48.15	5	20.00
6	51.92	6	20.00
7	61.54	7	33.33
8	60.00	8	33.33
9	64.00	9	33.33
10	70.00	10	34.78
11	70.00	11	31.82
12	68.75	12	31.82
13	67.39	13	45.45
14	88.64	14	50.00
15	88.64	15	52.38
Mean	60.5627	Mean	30.6306
Minimum	33.33	Minimum	13.46
Maximum	88.64	Maximum	52.38

N-Gain Test (Normalised Gain) To measure the effectiveness of using AR media, the N-Gain (*Normalised Gain*) calculation was carried out, which aims to classify the improvement of skills into high, medium, or low categories according to criteria (Hake, 1998):

Table 3. N-Gain effectiveness interpretation category

Percentage	Interpretation
<40	Not Effective
40-55	Less Effective
56-75	Moderately Effective
>76	Effective

The results of the N-Gain score calculation show that the average N-Gain score for the experimental group (AR) is 60.5627 or 60.6%, which is included in the medium category and is considered quite effective. Meanwhile, the average N-Gain score for the control group was 30.6306 or 30.6%, which falls into the low category, indicating low effectiveness.

Based on this data, the use of AR media proved to be quite effective in improving breaststroke swimming skills in students. The effectiveness of AR media is supported by its ability to provide real-time visual feedback, which allows learners to instantly correct their movements. Previous research by (Powell et al., 2023) and (Yi-Ming Kao & Ruan, 2022) also showed that AR media can provide an interactive learning experience and accelerate the learning process. The N-Gain classification according to (Hake, 1998) provides a strong basis for assessing the effectiveness of this media in improving students' practical skills.

4. Discussion

The outcome indicated that there were differences in outcomes between the experimental group, which used AR media for breaststroke swimming lessons, and the control group, which employed conventional learning media. Breaststroke swimming learning using AR media can develop breaststroke swimming skills. The N-Gain scores, which measure the effectiveness of the teaching method, were substantially higher in the experimental group (Mean = 60.5627%) compared to the control group (Mean = 30.6306%). This indicates that the students who were taught breaststroke swimming using AR media improved their skill ore than those who received conventional instruction. Breaststroke swimming learning using AR media is one of the learning media that uses technological assistance to help students who have difficulty achieving breaststroke swimming course competencies (Nohantiya & Putra, 2020). The higher N-Gain score in the experimental group suggests that AR media provides students with a more engaging and effective learning environment. AR has the unique capability of delivering real-time, context-specific feedback, crucial in skill-based learning environments such as swimming. This real-time feedback allows students to immediately correct their movements, reducing the time spent on incorrect practices and accelerating the learning process. In contrast, conventional teaching methods often rely on delayed feedback, which can be less effective in facilitating immediate correction and learning.

The selection of breaststroke swimming learning media using AR technology assistance is one of the factors that influence student success in mastering breaststroke swimming skills. One of the factors that has an influence on learning activities is the selection of interesting and interactive learning media without reducing the essence of the learning being carried out (Feri Apriani, Rahma Devi, & Nurkadri, 2023). AR is an interactive learning media that can increase student activeness, motivation and active participation in learning. Interactive learning media is needed to increase students' interest, including augmented reality media (Haryanto, Lubis, Saleh, Fujiati, & Lubis, 2019). Learning media using the AR technology offers a combination of the virtual world with the real world, so that the real object or model displayed is very similar to the real object so that it will make it easier for students to learn, understand and demonstrate the motion material being studied (Putri, Sitoayu, & Ronitawati, 2021). AR media is the right choice in learning a movement. AR media can be used in physical education learning (Muhayat, Wahyudi, Wibawanto, & Hardyanto, 2017). Most of the material in physical education in the form of movements will be understood better and easier because AR media can describe movements clearly and realistically (Istiningsih, Mukti, & Santoso, 2020). The use of AR media in physical education learning is a more advanced learning media by utilising current technological developments.

In addition, AR learning media can attract the attention of students so that students are motivated to learn. The use of AR has a positive impact on students' self-evaluation of their academic abilities in college (Connor & Mahony, 2023). Since AR has the potential to provide students with additional learning materials, students may perceive that using technology in the future can help them successfully achieve certain academic goals (Chen & Liu, 2020). In particular, AR can boost student motivation because they perceive the technology as new, exciting, and fascinating (Tuli, Singh, Mantri, & Sharma, 2022). The more students' motivation increases, the more learning outcomes are obtained

(Hadi, 2023). This aligns with the findings of this study that AR media is effective enough to improve breaststroke swimming learning outcomes.

5. Conclusion and Recommendation

In conclusion, the higher N-Gain scores in the experimental group provide strong evidence that AR-enhanced instruction is significantly more effective in teaching breaststroke swimming skills than conventional methods. AR's ability to enhance the learning experience through real-time, immersive feedback and its potential for customization and multisensory engagement makes it an invaluable resource for teaching complex motor skills. Combining AR with these technologies could create even more immersive and data-driven training environments, where feedback is not only immediate but also highly precise and tailored to the specific biomechanical and physiological needs of the athlete. Such advancements could revolutionize how sports are taught and how athletes are trained, ultimately leading to higher levels of performance across various disciplines. Future research could explore how AR can be optimized for different learning environments and how it impacts long-term skill retention and performance in swimming and other sports disciplines.

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