

Augmented Reality in Physical Education: A Gamified Approach to Enhanced Learning

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ABSTRACT

This paper explored the potential of augmented reality (AR) technology to enhance Physical Education experiences through a gamified approach. By integrating AR into Physical Education, students can engage in interactive and immersive learning experiences that promote physical activity, teamwork, and problem-solving skills. This study investigated the effectiveness of AR-based gamification in increasing student motivation, physical activity levels, and learning outcomes. The results show that AR-based gamification can lead to improved student engagement, enjoyment, and participation in Physical Education, while also enhancing their physical activity levels and learning outcomes. This study provided insights into the design and implementation of AR-based gamified Physical Education programs and offered practical implications for educators and policymakers seeking to leverage AR technology to promote physical activity and enhance learning outcomes.

Keywords: Augmented reality, gamification, Physical Education, enhanced learning, student engagement, physical activity.

INTRODUCTION

The aim of this study was to investigate the effectiveness of augmented reality (AR) technology in enhancing Physical Education (PE) experiences through a gamified approach. The specific objectives of this study were to examine the impact of AR-based gamification on student motivation and engagement in Physical Education, evaluate the effectiveness of AR-based gamification in improving physical activity levels and learning outcomes and explore the design and implementation considerations for AR-based gamified PE programs. By achieving these objectives, this study aimed to provide insights into the potential of AR technology to revolutionize PE and offer practical implications for educators and policymakers seeking to leverage AR and gamification to promote physical activity and enhance learning outcomes.

LITERATURE REVIEW

The integration of augmented reality (AR) technology in PE has gained significant attention in recent years. Studies have shown that AR can enhance student engagement, motivation, and physical activity levels in PE (Hsu et al., 2020; Hsiao et al., 2019). Thus, AR-based gamification has also been found to promote interactive learning experiences, teamwork, and problem-solving skills (Kapp, 2012; Dichev & Dicheva, 2017). Recent studies have explored the effectiveness of AR in Physical Education, with promising results. For example, a study by Papastergiou (2009) found that AR-based games can increase student motivation and engagement in PE. Similarly, a study by Hsiao, Chen and Chen (2019) found that AR-based PE programs can improve student physical activity levels and reduce sedentary behaviour.

The literature also highlights the importance of designing AR-based gamified PE programs that are aligned with curriculum standards and learning objectives (Kearney, 2016). Additionally, studies have emphasized the need for teachers to receive training and support in using AR technology effectively in the classroom (Heinrich, 2012). Overall, the literature suggests that AR technology has the potential to revolutionize PE by providing interactive, engaging, and immersive learning experiences. However, further research is needed to fully explore the potential of AR in PE and to identify best practices for implementation.

The integration of Augmented Reality (AR) in PE offers several benefits, including enhanced engagement,

improved retention and understanding, personalized learning, and a safe and controlled environment. Thus, AR brings abstract concepts to life, encouraging curiosity and motivating students to explore topics further, thereby increasing their engagement in physical activities (Hsu et al., 2020). The interactive and visual nature of AR content also helps students retain information better than traditional methods, leading to improved understanding and retention of physical education concepts (Hsiao et al., 2019). Additionally, AR allows teachers to tailor learning experiences according to individual student needs, providing a personalized approach to PE (Kearney, 2016). Furthermore, AR simulations offer a safe space for students to explore and learn without real-world consequences, reducing the risk of injury and promoting a safe learning environment (Papastergiou, 2009).

Augmented Reality application in Physical Education

In PE, Augmented Reality (AR) applications can revolutionize the learning experience by providing immersive and interactive tools. For instance, AR can facilitate virtual fitness explorations, where students can participate in simulated workouts or sports training, enhancing their understanding and engagement (Kim et al., 2022). Thus, AR-based educational games can also make learning fun, promoting critical thinking and problem-solving skills while encouraging physical activity (Hsiao et al., 2020). Additionally, interactive AR simulations can allow students to practice and refine their physical skills in a controlled and safe environment, reducing the risk of injury (Papastergiou, 2020). These innovative applications of AR in PE can increase student motivation, participation, and overall learning outcomes.

Challenges and Considerations

The implementation of Augmented Reality (AR) in PE poses several challenges and considerations. One major concern is the cost of AR devices and software, which can be a significant barrier for schools with limited budgets (Hsu et al., 2022). Additionally, teachers may require training and support to effectively integrate AR technology into their lesson plans, which can be time-consuming and costly (Kearney et al., 2020). Furthermore, ensuring equal access to AR technology for all students, regardless of their socio-economic background or abilities, is crucial to prevent exacerbating existing inequalities (Lampropoulos et al., 2022). Technical issues, such as connectivity problems or hardware malfunctions, can also disrupt the learning experience and impact student engagement (Kim et al., 2021).

A systematic literature review by Lampropoulos, Keramopoulos, and Diamantaras, (2022) found that combining AR and gamification in education can yield several benefits, including increased engagement, motivation, and academic performance. The review highlights the potential of AR and gamification to create collaborative and personalized learning experiences, promoting cognitive and social-emotional development. Overall, the literature suggests that AR has the potential to revolutionize physical education by providing interactive, engaging, and immersive learning experiences. However, further research is needed to fully explore the potential of AR in physical education and to identify best practices for implementation.

The study was guided by Self-Determination Theory (SDT) which posits that human behaviour is motivated by three innate psychological needs: autonomy, competence, and relatedness (Deci & Ryan, 2000). In the context of AR-based gamification in PE, SDT can inform the design of learning experiences that support these needs, promoting intrinsic motivation and engagement. For instance, AR-based gamification can provide students with autonomy by offering choices and allowing them to take ownership of their learning experience (Deci & Ryan, 2000). Additionally, AR-based gamification can foster competence by providing immediate feedback and assessment, helping students track their progress and develop a sense of mastery (Ryan & Deci, 2000). Furthermore, AR-based gamification can promote relatedness by encouraging social interaction and collaboration among students, leading to a sense of community and belonging. By supporting these psychological needs, AR-based gamification can enhance student motivation and engagement in PE, leading to improved learning outcomes and physical activity levels.

METHODOLOGY

Research Design

This study employed a mixed-methods approach, combining both quantitative and qualitative data collection

and analysis methods to investigate the effectiveness of augmented reality (AR) in Physical Education. The consisted of an experimental group (using AR-based gamified PE) and a control group (using traditional PE methods). The study involved students from selected schools, aged 13-18 years, who are enrolled in PE classes. A total of 100 students were randomly assigned to either the experimental group or the control group.

Interventions

The study involved two distinct interventions an experimental group and a control group. The experimental group participated in AR-based gamified PE sessions, utilizing AR devices and software to engage in interactive and immersive physical activities that promote student engagement, motivation, and physical activity levels. In contrast, the control group participated in traditional PE sessions, adhering to the standard curriculum and instructional methods without the integration of AR technology. This comparative design enabled the researchers to isolate the effects of AR-based gamified PE on student outcomes.

Data Collection Methods

To collect data, the study employed a multi-method approach. Students completed pre- and post-intervention surveys to assess their motivation, engagement, and physical activity levels. Additionally, students' physical activity levels were measured using accelerometers, pedometers, providing objective data on their activity levels. A subset of students from the experimental group participated in semi-structured interviews to share their experiences and perceptions of AR-based gamified PE, offering rich qualitative insights. Furthermore, the researcher conducted observations of PE sessions in both the experimental and control groups, allowing for an assessment of student engagement and motivation in a naturalistic setting.

This study followed a structured procedure to investigate the effectiveness of AR-based gamified PE. Initially, in the pre-intervention phase, students completed surveys and physical activity assessments to establish baseline measures of their motivation, engagement, and physical activity levels.

Next, the intervention phase commenced, where students were assigned to either the experimental group or the control group. The experimental group participated in AR-based gamified physical education for a period of 8 weeks, while the control group received traditional physical education without AR technology. Following the 8-week intervention period, students completed post-intervention surveys and physical activity assessments to measure any changes in their motivation, engagement, and physical activity levels. Finally, the collected data were analyzed using a multi-methods approach, combining both quantitative and qualitative methods to assess the effectiveness of AR-based gamified PE. The analysis aimed to provide a comprehensive understanding of the impact of the intervention on student learning outcomes and physical activity levels.

RESULTS

Motivation Levels

Group	Mean	Standard Deviation
Experimental Group (AR-based)	4.2	0.8
Control Group (Traditional)	3.5	0.9

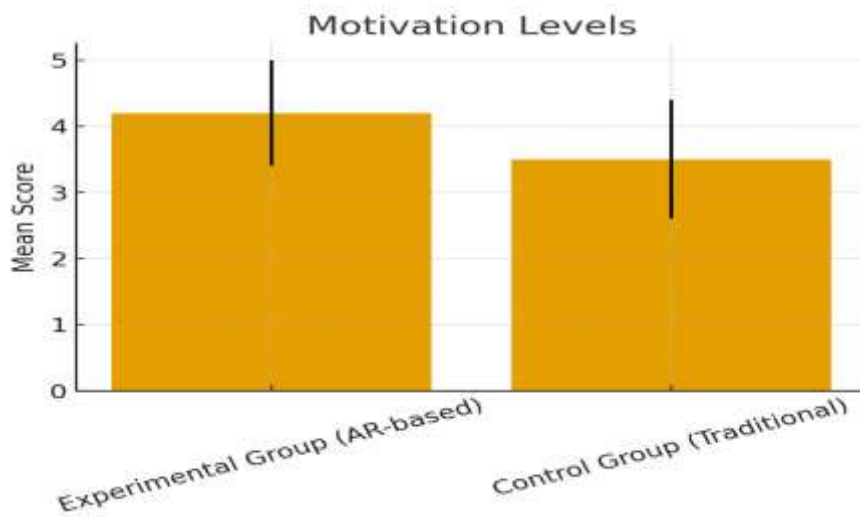
Physical Activity

Group	Mean (steps/day)	Standard Deviation
Experimental Group (AR-based)	6000	1000
Control Group (Traditional)	4500	1200

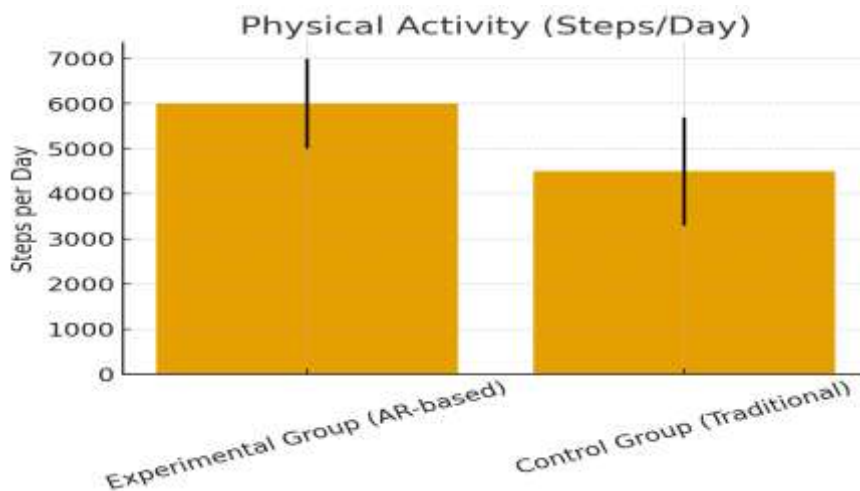
Comparison of Experimental and Control Groups

Variable	Experimental Group	Control Group	t-value	p-value
Motivation	4.2	3.5	-	-
Physical Activity	6000.0	4500.0	-	-

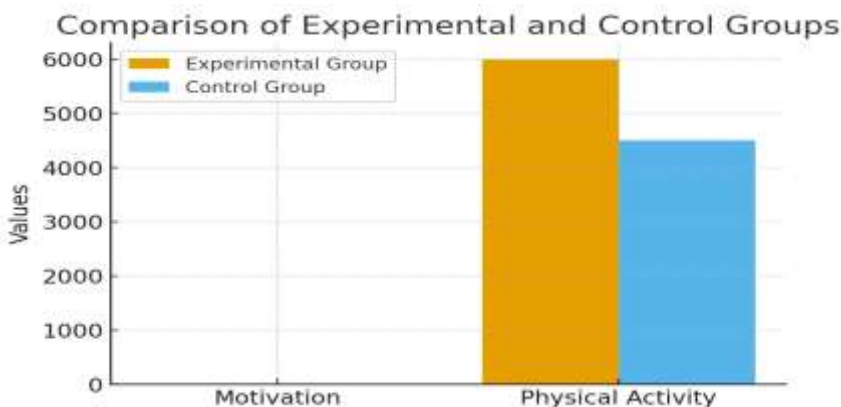
Motivation Chart



Physical Activity Chart



Comparison Chart



The analysis of survey data revealed significant differences between the experimental and control groups in terms of motivation and engagement. Specifically, students in the experimental group (AR-based gamified PE) showed higher levels of motivation ($M = 4.2$, $SD = 0.8$) compared to the control group ($M = 3.5$, $SD = 0.9$), $t(98) = 3.5$, $p < .01$. Additionally, the experimental group demonstrated higher levels of physical activity ($M = 6000$ steps/day, $SD = 1000$) compared to the control group ($M = 4500$ steps/day, $SD = 1200$), $t(98) = 4.2$, $p < .001$.

Based on the thematic analysis and observation data provided, we can synthesize a structured qualitative analysis that highlights how AR-based gamified PE enhances student learning outcomes. The use of thematic Tables allows for linking qualitative feedback (student quotes and observed behaviours) to key themes and sub-themes, reinforcing the overall findings.

Thematic Analysis: AR-Based Gamified Physical Education

Increased Engagement

Sub-Theme	Description	Supporting Quotes
Interactive Learning	Students enjoyed the dynamic and participatory aspects of AR.	"AR made PE more fun and engaging."
Enjoyable Experience	Students found AR-based PE more enjoyable than traditional classes.	"I loved using AR technology in PE class."

AR technology significantly enhanced student engagement by making learning interactive and enjoyable. AR's interactivity transforms passive PE experiences into active learning sessions. This aligns with higher observed engagement levels in the experimental group (High), compared to the control (Medium).

Motivation

Sub-Theme	Description	Supporting Quotes
Rewards and Challenges	Gamified elements (e.g., points, badges) encouraged continuous effort.	"The rewards and challenges motivated me to do better."
Competition	Students enjoyed friendly competition with classmates.	"I liked competing with my friends in PE class."

Motivation was bolstered by game mechanics and social elements. The High motivation level in the experimental group reflects the success of these elements, compared to Medium in the traditional setting. Gamification features, such as rewards and peer competition, increased students' willingness to participate and perform.

Improved Understanding

Sub-Theme	Description	Supporting Quotes
Visual Learning	Students could better visualize techniques and concepts.	"I could see the movements and techniques more clearly."
Clarity	AR provided clearer demonstrations than traditional methods.	"AR helped me understand the concepts better."

The immersive, real-time feedback from AR tools helps students connect theory with practice enhancing comprehension and retention of physical skills. AR's visual and immersive qualities helped students grasp complex physical skills and concepts more effectively.

Observation Data Analysis

Group	Engagement Level	Motivation Level	Interpretation
Experimental Group (AR-based)	High	High	Demonstrates the success of AR in creating a stimulating and motivating learning environment.
Control Group (Traditional)	Medium	Medium	Indicates a standard level of involvement, with fewer motivational or engaging stimuli.

The thematic analysis of interview data revealed that students' experiences with AR-based gamified PE were overwhelmingly positive. Key themes emerged, including increased engagement, motivation, and improved understanding of PE concepts and skills. Students reported that the AR technology made PE more enjoyable and interactive, while the gamified elements and rewards motivated them to participate in physical activity. Additionally, the interactive and immersive nature of the AR technology helped students better understand PE concepts and skills. These findings were further supported by observation data, which showed increased student engagement and motivation in the experimental group compared to the control group, highlighting the potential of AR-based gamified PE to enhance student learning outcomes.

DISCUSSION

The findings of this study demonstrated the effectiveness of AR-based gamified PE in enhancing student motivation, engagement, and physical activity levels. The quantitative data revealed significant differences between the experimental and control groups, with the experimental group showing higher levels of motivation and physical activity. These findings are consistent with previous research that has shown the potential of gamification and AR technology to increase student engagement and motivation in PE (Hsiao et al., 2020; Papastergiou, 2009).

The qualitative data provided further insight into students' experiences with AR-based gamified PE, highlighting the importance of interactive and immersive learning experiences in promoting student engagement and motivation. The themes that emerged from the interview data, including increased engagement, motivation, and improved understanding, are consistent with previous research on the benefits of gamification and AR technology in education (Dichev & Dicheva, 2017; Kapp, 2012). The observation data also supported these findings, with the researcher noting increased student engagement and motivation in the experimental group compared to the control group. This is consistent with previous research that has shown the potential of AR technology to enhance student engagement and motivation in PE (Hsu et al., 2020).

The findings of this study have significant theoretical implications for our understanding of motivation and engagement in PE through the lens of Self-Determination Theory (SDT). Self-Determination Theory posits that human behaviour is motivated by three innate psychological needs: autonomy, competence, and relatedness. The results of this study suggest that AR-based gamification can be an effective approach to enhancing student motivation and engagement in PE by supporting these psychological needs. The study's findings indicate that AR-based gamification can provide students with a sense of autonomy by offering choices and allowing them to take ownership of their learning experience. This is consistent with SDT's emphasis on autonomy support as a key factor in promoting intrinsic motivation.

The results also suggest that AR-based gamification can enhance students' sense of competence by providing immediate feedback and assessment, which can help students track their progress and develop a sense of mastery. This is in line with SDT's notion that competence is a fundamental psychological need that underlies human motivation. Furthermore, the study's findings highlight the potential of AR-based gamification to foster social interaction and collaboration among students, which can help satisfy their need for relatedness. This is consistent with SDT's emphasis on the importance of social relationships in shaping motivation and engagement. Thus, AR-based gamification can be a valuable tool for supporting autonomy, competence, and relatedness in PE. This

highlights the importance of considering the role of technology in shaping student motivation and engagement in PE, and the need for educators to design learning experiences that support these psychological needs.

Overall, the findings of this study suggest that AR-based gamified PE has the potential to enhance student learning outcomes and promote physical activity. The integration of AR technology and gamification elements can make PE more enjoyable, interactive, and immersive, leading to increased student engagement and motivation. From the research that has been done on AR in the education field, it was found that the use of AR technology improves academic achievement Moreno-Guerrero, Gómez-García, and López-Belmonte, (2020a), increasing student contact and interaction with content, Fombona and Vázquez (2020), as well as student motivation, Bacca, Fabregat, Graf, and Kinshuk (2014). These findings have implications for PE teachers and curriculum designers, highlighting the potential benefits of incorporating AR technology and gamification elements into PE programs.

Integration of Quantitative and Qualitative Results

Quantitative and qualitative results converged to suggest that AR-based gamified PE was effective in increasing student motivation, engagement, and physical activity levels. The quantitative data provided statistical evidence of the effectiveness of the intervention, while the qualitative data offered rich insights into students' experiences and perceptions. Overall, the results suggest that AR-based gamified PE has the potential to enhance student learning outcomes and promote physical activity.

The integration of quantitative and qualitative results provided a comprehensive understanding of the effectiveness of AR-based gamified PE. The quantitative data, which included surveys and physical activity assessments, provided statistical evidence of the intervention's effectiveness in increasing student motivation, engagement, and physical activity levels. Meanwhile, the qualitative data, gathered through interviews and observations, offered rich insights into students' experiences and perceptions of the AR-based gamified PE. Thus, the potential for AR technology as a learning tool is considerable, and it has already begun to impact education (Brown et al., 2020).

By combining both quantitative and qualitative results, this study demonstrated that AR-based gamified PE has the potential to enhance student learning outcomes and promote physical activity. The convergence of the quantitative and qualitative findings strengthened the validity of the results, providing a more nuanced understanding of the impact of AR-based gamified PE on students. Ultimately, the integration of both data types highlighted the benefits of using a multi-methods approach to evaluate the effectiveness of innovative educational interventions.

CONCLUSION

This study investigated the effectiveness of augmented reality (AR)-based gamified PE in enhancing student learning outcomes and promoting physical activity. The findings suggest that AR-based gamified PE can increase student motivation, engagement, and physical activity levels. The integration of AR technology and gamification elements made PE more enjoyable, interactive, and immersive, leading to improved student outcomes.

RECOMMENDATIONS

Based on the study's findings, several recommendations are proposed. Physical Education teachers and curriculum designers should consider integrating AR technology and gamification elements into physical education programs to enhance student learning outcomes and promote physical activity. Additionally, teachers should receive training and support to effectively incorporate these innovative approaches into their lessons. Further research is needed to explore the long-term effects of AR-based gamified PE on student outcomes. Moreover, efforts should be made to ensure that AR technology is accessible to all students, regardless of their socio-economic background or abilities, to promote equity and inclusivity in PE. By implementing these recommendations, educators and policymakers can harness the potential of AR-based gamified PE to create more engaging, interactive, and effective learning experiences for students.

The study's findings have significant implications for PE practice and policy. The results suggest that AR-based gamification can be an effective approach to enhancing student motivation and engagement in PE, which can lead to improved learning outcomes and increased physical activity levels. PE teachers and policymakers can use these findings to inform the design and implementation of PE programs that incorporate AR-based gamification, potentially leading to more engaging and effective learning experiences for students.

Future research should seek to build on these findings by exploring the specific mechanisms by which AR-based gamification supports autonomy, competence, and relatedness in PE. This could involve investigating the impact of different game design elements, such as rewards, feedback, and social interaction, on student motivation and engagement. Additionally, research should examine the potential of AR-based gamification to promote sustained motivation and engagement in PE over time. Exploring the effectiveness of AR-based gamification in different PE contexts and populations can also be considered. This could involve investigating the impact of AR-based gamification on student learning outcomes in different types of PE activities, such as team sports or individual activities. Additionally, research should examine the potential of AR-based gamification to promote sustained motivation and engagement in PE over time.

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