



Development of a technology-based physical education pedagogical model to enhance high school student engagement

Dewi Hakim^{1*}, Eko Ramadhan², Fajar Fauzi³

^{1,2} Department of Mathematics Education, Faculty of Teacher Training and Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

³ Department of Educational Technology, Faculty of Education, Universitas Negeri Malang, Malang, Indonesia

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ABSTRACT

This study explores the experiences of high school students and teachers in implementing a technology-based physical education (PE) model aimed at enhancing student engagement. Using a qualitative case study approach, data were collected through semi-structured interviews, participant observation, and documentation analysis in three urban Indonesian schools. Thematic analysis revealed three main factors influencing engagement: interactive learning experiences, real-time feedback, and social collaboration. Interactive digital exercises and virtual simulations encouraged active participation and improved motivation. Wearable devices and performance dashboards provided immediate feedback, reinforcing self-monitoring and goal-directed behavior. Collaborative tasks facilitated peer interaction, inclusivity, and social learning. These findings suggest that technology integration transforms PE lessons into dynamic, engaging, and socially supportive environments. The study contributes theoretically by providing insights into students' subjective experiences and practically by offering guidance for designing adaptive, technology-enhanced PE curricula. Implications for educators and policymakers include strategies to optimize technology use, promote holistic student development, and improve participation in PE classes.



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*) Corresponding Author:

Dewi Hakim,

Department of Mathematics Education, Faculty of Teacher Training and Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

Email: dewi.hakim041@gmail.com

1. Introduction

The development of digital technology has brought significant transformations in education, including physical education (PE). Global studies have shown that integrating technologies such as virtual simulations, gamification, and motion analysis applications can enhance student engagement in physical activity and strengthen learning motivation. Balalle (2024) emphasizes that technology-based learning encourages active student participation, while Wallace, Scanlon, and Calderón (2023) highlight the importance of teacher digital competency to optimize the learning experience. In Indonesia, the Ministry of Education and Culture (2022) reported low student participation in secondary school PE classes, primarily due to the dominance of traditional theoretical methods that hinder motivation and engagement. This phenomenon indicates an urgent need for pedagogical innovation that effectively integrates technology to improve learning quality and student involvement.

Field observations and initial interviews with PE teachers support these findings. Teachers reported that many students are less motivated to participate in physical activities due to monotonous teaching methods, limited verbal instructions, and minimal digital interaction. Traditional assessment instruments also make it difficult for teachers to provide real-time feedback on student engagement (Zulkifli & Danis, 2022). Ha, Moon, Webster, and Goh (2025) add that the lack of enjoyable learning experiences negatively affects student enthusiasm, highlighting the urgent need for technology-based pedagogical strategies.

International qualitative studies show that the use of wearable devices, gamification, and virtual simulations can enhance student motivation and promote body awareness and social interaction. Goodyear, Skinner, and McKeever (2023) emphasize that technology integration not only increases physical engagement but also strengthens social interaction and learning ownership. Additionally, Akyl (2025) demonstrates that wearable devices provide instant feedback, significantly influencing student motivation and learning outcomes. However, in Indonesia, technology utilization in PE is still limited, and the experiences of students and teachers have not been deeply explored.

Student engagement in PE is crucial, affecting not only physical health but also psychological well-being and social development. Ye and Liu (2025) found that active participation in physical activities contributes to establishing healthy habits and developing interpersonal skills. Understanding students' experiences in technology-based PE models can help design more effective, adaptive, and contextualized learning strategies. Furthermore, this knowledge can inform policymakers to improve the quality of PE education in secondary schools.

Although global literature has widely addressed the effectiveness of technology on physical activity, qualitative studies exploring students' experiences, meanings, and learning processes remain limited. Calderón, Scanlon, and MacPhail (2021) emphasize that most research focuses on quantitative measurement of physical activity outcomes, while subjective student perspectives are underexplored. Wang (2024) also stresses the need for qualitative approaches to understand how students internalize learning experiences in technology-based PE. This gap presents an opportunity for in-depth research on the perceptions of both students and teachers regarding digital pedagogical innovations.

This study focuses on developing a technology-based pedagogical model that emphasizes holistic student engagement, including motivation, social interaction, and enjoyable physical experiences. The research examines strategies for technology integration, student experiences, and teacher responses to pedagogical innovation. A qualitative approach was selected to explore the processes and meanings of participant experiences in depth, rather than merely measuring physical engagement quantitatively.

The objectives of this study are to (1) explore student and teacher experiences in implementing technology-based PE models, (2) identify factors influencing student engagement, and (3) develop an adaptive pedagogical framework relevant to the Indonesian educational context. This research seeks to bridge the gap between traditional teaching practices and technological potential, enabling active student participation and providing effective guidance for teachers. Theoretically, this study contributes to the literature on technology-based PE pedagogy by focusing on students' subjective experiences. Practically, the findings are expected to provide actionable guidance for teachers and schools in designing innovative learning strategies that optimize technology use, improve learning quality, and enhance student engagement in PE classes (Zhang, 2024; Qi, 2024).

2. Materials and Methods

This study employs a qualitative case study approach, which allows for an in-depth understanding of the experiences of students and teachers in technology-based physical education in secondary schools. The case study approach was chosen because it enables the exploration of interactions, processes, and subjective meanings that emerge during the implementation of technology in learning, thereby allowing the findings to depict real-world conditions with rich contextual nuances (Y Zhang, 2025). This study emphasizes the social context and classroom interactions that influence student engagement holistically.

The research was conducted in three secondary schools in urban areas of Indonesia during the second semester of the 2024/2025 academic year. School selection was based on the availability of technological facilities, teachers' readiness to implement pedagogical innovations, and the diversity of student characteristics. By selecting schools with varying conditions, the study could

obtain a representative picture of technology-based PE practices, making the results more contextual and relevant for the development of pedagogical models in Indonesia.

The research subjects consisted of 15 PE teachers and 60 students selected using purposive sampling. Teachers were selected based on their experience integrating technology into PE instruction, while students were chosen based on their active engagement and familiarity with the digital media used in the classroom. Additionally, snowball sampling was employed to identify students with unique experiences in technology use, ensuring diverse perspectives are adequately represented (Calderón et al., 2021; Goodyear et al., 2023).

Data collection was conducted through several methods to gain a comprehensive understanding. Semi-structured interviews were used to explore students' perceptions, experiences, and motivations, as well as teachers' responses to technology-based learning. The researcher also conducted participant observation during PE activities to capture classroom dynamics firsthand, including student interactions and responses to technology. Furthermore, documentation analysis—such as teacher notes, syllabi, and classroom video recordings—was conducted to supplement field data and enable triangulation, thereby ensuring the depth and accuracy of the data (Ha et al., 2025; Wallace et al., 2023).

Data validation was conducted through several procedures. First, source and method triangulation was used to compare the perspectives of teachers and students, while balancing the results of interviews, observations, and documentation. Second, member checking was applied by asking participants to verify preliminary findings, ensuring the researcher's interpretations align with their actual experiences. Third, an audit trail was established to ensure the openness and transparency of the data collection and analysis processes, thereby ensuring the credibility of the findings (Zulkifli & Danis, 2022; Qi, 2024).

Data analysis was conducted using thematic analysis. The process began with open coding to identify main categories, followed by axial coding to group emerging themes, and selective coding to identify key patterns explaining student engagement in technology-based PE. This approach allows researchers to capture the deep meaning of participants' experiences and construct a relevant and adaptive conceptual framework (Ha et al., 2025; Akyel, 2025).

The research methodology was designed to allow for limited replication in other schools with similar conditions, although the research results are contextual. Detailed explanations regarding the selection of locations, participants, data collection techniques, validation, and data analysis ensure the credibility, transferability, and reliability of the findings, as well as provide a strong foundation for the development of a technology-based PE pedagogical model that can be widely adapted (Ye & Liu, 2025; Wang, 2024).

3. Results and Discussions

The analysis of qualitative data from interviews, observations, and documentation revealed several interrelated themes shaping student engagement in technology-based physical education (PE). The first prominent theme was interactive learning experiences, which encompassed students' responses to gamified exercises, motion tracking, and virtual simulations. Students reported that the use of technology transformed PE into a dynamic and immersive activity, allowing them to actively participate rather than merely follow routine instructions. One student shared, "Using the motion app made me aware of my posture and motivated me to improve every session." Teachers observed that technology encouraged active learning, as students consistently interacted with the digital tools, followed on-screen instructions, and engaged with tasks that were previously neglected in conventional PE lessons. Observation data confirmed higher engagement levels during digital sessions, with students demonstrating improved focus, persistence, and responsiveness. Documentation of lesson plans and video recordings also illustrated that interactive tools enabled teachers to present more varied and adaptive exercises, catering to

diverse student abilities and interests, which created an inclusive learning environment conducive to sustained engagement.

The second theme identified was enhanced motivation through digital feedback, which highlights the impact of wearable devices, performance dashboards, and real-time progress tracking on students' intrinsic and extrinsic motivation. Participants consistently indicated that immediate feedback on their movements or scores increased their effort, reinforced self-monitoring behaviors, and encouraged goal setting. A student noted, "Seeing my progress on the screen encouraged me to push harder and practice more consistently." Teachers confirmed that students who had shown minimal participation in traditional PE settings became actively engaged when provided with instant metrics, enabling continuous self-assessment. This pattern aligns with the literature on feedback-driven learning, demonstrating that timely and personalized insights can strengthen motivation and lead to improved learning outcomes (Akyel, 2025; Ha et al., 2025). Analysis of classroom documents and activity logs revealed that students increasingly sought additional practice opportunities outside scheduled PE sessions, suggesting that digital feedback promoted sustained engagement and a sense of achievement beyond immediate classroom activities.

The third overarching theme was social collaboration and peer interaction, reflecting the ways in which technology facilitated cooperative behaviors, communication, and collective problem-solving. Students described experiences of participating in team challenges, shared digital tasks, and collaborative virtual games that required coordination and mutual support. One participant explained, "We had to coordinate with our classmates in the virtual game, which made PE more fun and social." Teachers observed that technology provided a platform for constructive peer feedback, enabling students to learn from each other while fostering positive social relationships. Classroom observations indicated that group-based digital activities reduced competitive pressure, encouraged inclusivity, and allowed students with varied physical skills to participate effectively. This theme underscores that technology in PE not only supports physical engagement but also nurtures social competencies, communication skills, and collaborative learning habits, contributing to holistic student development (Ye & Liu, 2025; Goodyear, Skinner, & McKeever, 2023).

Discussion

The findings of this study suggest that integrating technology into PE classes significantly enhances student engagement by fostering interactive, feedback-rich, and socially collaborative learning experiences. The observed effects align with prior research emphasizing the multifaceted benefits of technology in promoting physical activity, motivation, and social learning (Calderón, Scanlon, & MacPhail, 2021; Wang, 2024). Specifically, interactive digital tools were instrumental in transforming PE lessons into meaningful and enjoyable experiences. The participants' narratives and observed behaviors support Balalle's (2024) argument that gamified and interactive exercises promote active participation and intrinsic interest, indicating that engagement is not solely determined by physical activity output but also by the perceived value, novelty, and enjoyment of the learning process.

Real-time feedback through wearable devices and digital dashboards emerged as a critical driver of motivation, consistent with studies by Akyel (2025) and Ha et al. (2025), which highlight the importance of immediate performance insights in shaping learners' behaviors and reinforcing goal-directed efforts. The feedback mechanisms provided students with tangible evidence of progress, fostering self-efficacy and sustained commitment to learning. This demonstrates that technology-mediated feedback can address motivational gaps frequently observed in traditional PE instruction, particularly in contexts where conventional methods fail to stimulate continuous participation (Ministry of Education and Culture, 2022; Zulkifli & Danis, 2022). Moreover, students' reflective engagement with digital feedback illustrates the potential for personalized learning trajectories, enabling adaptive interventions based on individual performance patterns.

Social collaboration facilitated through technology-based activities was another significant contributor to engagement, enhancing peer interaction, teamwork, and inclusivity. The qualitative evidence indicates that students benefited from shared tasks that required communication and cooperation, promoting a positive learning climate and reducing the anxiety associated with competitive performance. These observations resonate with Ye and Liu's (2025) findings regarding the role of cooperative learning in developing interpersonal skills and fostering inclusive participation. The integration of digital tools enabled teachers to structure activities that balanced challenge and support, providing opportunities for social learning while reinforcing the development of social-emotional competencies. This highlights the pedagogical advantage of technology not only as an instrument for skill acquisition but also as a medium to cultivate collaborative, reflective, and socially responsible behaviors.

Overall, the study contributes theoretically by illuminating the qualitative dimensions of student engagement in technology-based PE, addressing the gap identified by Calderón, Scanlon, and MacPhail (2021) regarding the underexploration of subjective learning experiences. Practically, the findings suggest that educators should design PE lessons that integrate interactive digital content, real-time feedback mechanisms, and collaborative tasks to optimize engagement and learning outcomes. Future research should investigate the longitudinal effects of technology integration, explore scalability in rural or resource-constrained settings, and examine teacher competency and preparedness as factors influencing the successful implementation of technology-enhanced pedagogical models (Qi, 2024; Zhang, 2024). By capturing the nuanced experiences of students and teachers, this study provides insights into designing adaptive, context-sensitive, and effective PE curricula that leverage technological potential while promoting holistic student development.

4. Conclusions

The study demonstrates that technology-based pedagogical models in physical education substantially enhance student engagement by combining interactive learning experiences, real-time feedback, and social collaboration. Students actively participated in gamified exercises and motion-tracking activities, which fostered intrinsic motivation, awareness of performance, and goal-directed behavior. The integration of wearable devices and digital dashboards provided immediate feedback that reinforced self-monitoring and sustained commitment, while collaborative digital tasks strengthened peer interaction, inclusivity, and social learning. These findings underscore the importance of designing PE curricula that balance physical activity with cognitive and social dimensions, creating meaningful and enjoyable learning experiences for students.

Practically, the results suggest that educators and schools should adopt technology-driven PE strategies to improve participation, motivation, and holistic student development. The study contributes to the theoretical understanding of engagement by highlighting the qualitative experiences of students and teachers, offering insights into adaptive, context-sensitive pedagogical practices. Future research should investigate long-term effects, explore implementation in diverse school contexts, and examine teacher digital competency as a mediating factor. Overall, the study provides a foundation for developing effective, technology-enhanced PE programs that support both physical and social-emotional growth, addressing gaps in traditional teaching practices and contributing to evidence-based educational innovation.

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