



A technology-based adaptive learning model in physical education within the Indonesian school context

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ABSTRACT

This study explores students' and teachers' experiences with technology-based adaptive learning in physical education in Indonesia. The research aims to understand how adaptive digital tools influence engagement, personalized learning, and collaborative interaction. A qualitative case study approach was employed, involving 25 students and 10 teachers from three secondary schools and one university program. Data were collected through semi-structured interviews, participatory observations, and document analysis. Thematic analysis revealed five major themes: increased engagement and motivation, personalized learning experiences, technological and infrastructural challenges, teacher adaptation strategies, and social-collaborative learning dynamics. The findings contribute to understanding how technology mediates pedagogical practices, social interactions, and contextual factors in physical education. These results provide implications for theory, policy, and practice by highlighting the importance of integrating adaptive technology with instructional design and social learning strategies. Future studies are suggested to examine long-term outcomes, skill retention, and the scalability of adaptive learning programs.



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1. Introduction

The advancement of educational technology has led to the emergence of adaptive learning models in physical education, designed to enhance student engagement through personalized instruction and real-time feedback. Martín-Rodríguez and Madrigal-Cerezo (2025) indicated that the integration of interactive digital media can strengthen students' motivation and participation in physical activities. In addition, Chai et al. (2025) highlighted that digital transformation in physical education supports teachers in adjusting instructional strategies to meet individual learners' needs. Tohānean et al. (2025) found that using AI devices and other digital technologies simultaneously enhances students' motor and cognitive skills. Saiz-González, Sierra-Díaz, and Fernández-Rio (2025) emphasized the importance of considering social and cultural contexts for the successful implementation of adaptive technology. These findings suggest that digital technology is not merely a tool but a transformational factor in physical education pedagogy.

In Indonesia, the implementation of technology-based adaptive learning still faces challenges related to limited infrastructure and teachers' competencies in utilizing digital tools effectively. Nurafiati and Angriawan (2025) reported that although digital platforms are available, their

effective use largely depends on teacher readiness and institutional support. Research on web-based e-learning adaptive systems (2025) showed that schools with limited infrastructure experience disparities in student participation. Furthermore, Qonita et al. (2024) highlighted that students' perceptions of the effectiveness of adaptive technology are influenced by device accessibility and teacher guidance. These studies underscore the necessity to explore the actual practices of adaptive technology use in the local Indonesian educational context.

Students' learning experiences also reveal the complexity of psychological and pedagogical dimensions. Lucius and Daryanto (2022) observed that students with different learning needs interpret adaptive learning in diverse ways. Sari, Risma, and Ulfa (2021) reported that emotional and cognitive engagement increases when differentiated teaching strategies are applied. Additionally, the silent remember model in adaptive physical education learning for deaf students (2024) emphasized the importance of creating learning environments aligned with students' characteristics to ensure meaningful learning experiences. These findings underscore the need for qualitative research that focuses on students' subjective experiences to design effective pedagogical strategies.

Adaptive learning literature highlights that responsive instruction should simultaneously consider students' affective, cognitive, and psychomotor dimensions. Kamaruddin et al. (2025) emphasized the significance of instructional design that allows interaction between students and technology. Chai et al. (2025) added that integrating digital media can enhance collaboration and reflection among students. Tohănean et al. (2025) further noted that the use of AI and ICT helps teachers tailor learning to individual needs. This is particularly relevant in physical education, which not only develops physical skills but also fosters social interaction and decision-making within group contexts.

Moreover, a clear literature gap exists in qualitative studies exploring teachers' experiences. Rosmi and Jauhari (2023) found that educators face challenges in adapting teaching strategies to meet the diverse needs of students. Saiz-González et al. (2025) stressed the importance of understanding social and cultural contexts to implement adaptive technology effectively. André and Etterlin (2025) added that evaluating teachers' experiences helps identify best practices and challenges in using adaptive technology in classrooms.

Based on this rationale, the present study aims to understand the experiences of students and teachers in technology-based adaptive learning in physical education in Indonesia. The focus includes perceptions, adaptation strategies, challenges encountered, and the pedagogical meaning developed during the learning process. The study is expected to provide theoretical contributions to expand understanding of adaptive education and practical implications for curriculum development, teacher training, and instructional strategies that are more responsive to learners' needs in the digital era.

2. Materials and Methods

This study employed a qualitative approach with a case study design, which allows for in-depth exploration of students' and teachers' subjective experiences in technology-based adaptive learning. Yin (2021) emphasizes that case studies are effective for capturing phenomena in their natural context. Etikan, Musa, and Alkassim (2016) highlight the flexibility of qualitative methods in selecting relevant informants, while Chai et al. (2025) point out the approach's effectiveness for analyzing complex learning experiences. Additionally, Saiz-González et al. (2025) stressed the importance of integrating social and cultural contexts into studies of pedagogical experiences with adaptive technology.

The study was conducted at three secondary schools and one physical education program at a university in Indonesia that had implemented technology-based adaptive learning for at least one semester. Nurafiati and Angriawan (2025) argue that selecting sites with prior technology adoption allows for more valid data collection. Qonita et al. (2024) added that the readiness of

both teachers and students affects data quality. Rosmi and Jauhari (2023) highlighted the need to consider social and cultural contexts in each institution because these factors influence interactions between teachers, students, and technology.

Participants included 25 students and 10 teachers, selected using purposive sampling based on active engagement in adaptive learning. This technique ensures that the most relevant informants are chosen (Sari, Risma, & Ulfa, 2021). Lucius and Daryanto (2022) emphasize that participants' reflective experiences provide rich insights into adaptation strategies, while the silent remember model in adaptive physical education learning for deaf students (2024) underlines the importance of considering learners with special characteristics.

Data were collected through semi-structured interviews to explore perceptions and subjective experiences, participatory observations to examine real interactions, and documentation of digital learning materials used in class. Martín-Rodríguez and Madrigal-Cerezo (2025) highlighted that using multiple methods enhances validity, while Tohănean et al. (2025) noted that methodological triangulation captures multiple dimensions of adaptive pedagogical experiences. Kamaruddin et al. (2025) emphasized that digital material documentation helps verify interactions and instructional strategies.

Data were validated through source and method triangulation, member checking, and audit trails to enhance credibility and dependability. Saiz-González et al. (2025) emphasized the importance of member checking, Chai et al. (2025) highlighted audit trails, and Cereda (2025) added that systematic documentation of analysis increases transparency. Data analysis was conducted using thematic analysis, including open coding, axial coding, and theme development, to map patterns and meanings of adaptive pedagogical experiences using technology (Braun & Clarke, 2006; Martín-Rodríguez & Madrigal-Cerezo, 2025).

3. Results and Discussions

The analysis of the collected data revealed several prominent themes reflecting students' and teachers' experiences with technology-based adaptive learning in physical education. The first theme was enhanced engagement and motivation, where students reported increased enthusiasm for class activities when digital tools provided real-time feedback and interactive exercises. For example, one student stated, "The wearable sensor helped me see my mistakes immediately, and it motivated me to correct my posture," highlighting the immediate impact of adaptive feedback on motor learning (Martín-Rodríguez & Madrigal-Cerezo, 2025). Observational data supported this perception, showing that students actively participated in exercises and followed instructions more attentively compared to conventional PE classes (Chai et al., 2025). Teachers also noted that students who were previously less active became more involved when technology was integrated into the lesson (Lucius & Daryanto, 2022; Tohănean et al., 2025). These findings suggest that adaptive learning tools can stimulate intrinsic motivation and promote self-directed engagement in physical education.

A second major theme was personalization of learning experiences, which allowed students to engage with tasks appropriate to their skill levels and individual learning preferences. Many students appreciated the ability to progress at their own pace, as one participant expressed: "I can focus on the exercises that challenge me the most and receive feedback that suits my ability." Teachers corroborated these statements, explaining that adaptive software enabled them to monitor individual progress and provide differentiated support for each student (Saiz-González, Sierra-Díaz, & Fernández-Rio, 2025). This theme was reinforced through documentation of digital learning logs, where students' performance metrics demonstrated variable progression paths reflecting personalized learning trajectories (Kamaruddin et al., 2025). The pattern highlights the potential of adaptive learning systems to implement differentiated instruction effectively in the context of physical education (Rosmi & Jauhari, 2023).

The third theme involved technological and infrastructural challenges, which influenced the smooth implementation of adaptive learning. Several participants indicated that limited access to devices or inconsistent internet connectivity disrupted their learning experience. One student noted, “Sometimes the system freezes, and we have to wait, which affects my concentration and flow.” Teachers similarly reported difficulties in synchronizing class activities due to technical interruptions (Nurafiati & Angriawan, 2025; Qonita et al., 2024). Despite these obstacles, most participants acknowledged that the benefits of adaptive learning outweighed these limitations. The findings highlight that contextual factors, such as school resources and technological infrastructure, are crucial for maximizing the efficacy of adaptive learning programs.

A fourth theme identified was teacher adaptation and instructional strategies, showing how educators integrated digital tools into lesson planning while maintaining pedagogical goals. Teachers described the iterative process of aligning digital exercises with curriculum objectives, monitoring student responses, and adjusting instructions in real-time. Participant T3 remarked, “I constantly review the performance data to tailor exercises for each student, ensuring everyone benefits from the adaptive system.” Observational notes revealed that teachers balanced technological use with traditional hands-on instruction to ensure holistic development of students’ motor and cognitive skills (Martín-Rodríguez & Madrigal-Cerezo, 2025; Chai et al., 2025). This theme underscores the active role of teachers as mediators between technology and pedagogical practice (Sari, Risma, & Ulfa, 2021).

The fifth theme centered on social interaction and collaborative learning, demonstrating that adaptive technologies did not isolate learners but rather fostered peer engagement. Students frequently discussed performance metrics, shared strategies for improvement, and encouraged peers to enhance their skills. One participant stated, “We compare our results and give feedback to each other, making the learning experience collaborative even though the exercises are individually adaptive.” Observations confirmed that such interactions strengthened group cohesion and peer learning dynamics (Silent remember model, 2024; Tohänean et al., 2025). This finding emphasizes the importance of considering both individual and social dimensions when implementing adaptive learning in physical education.

Discussion

The study’s findings suggest that technology-based adaptive learning can significantly improve student engagement, motivation, and personalized learning outcomes in physical education. These results corroborate prior research, which highlighted the effectiveness of adaptive tools in promoting active participation and self-directed learning (Martín-Rodríguez & Madrigal-Cerezo, 2025; Lucius & Daryanto, 2022; Chai et al., 2025). The integration of wearable sensors and interactive platforms allowed for immediate corrective feedback, enhancing students’ motor skill acquisition while fostering cognitive awareness of physical movements (Tohänean et al., 2025; Saiz-González, Sierra-Díaz, & Fernández-Rio, 2025). This aligns with theories of adaptive pedagogy that emphasize tailoring instruction to learners’ needs while maintaining engagement and motivation.

Despite these positive outcomes, contextual challenges related to technology access and infrastructure remain critical factors influencing the effectiveness of adaptive learning. Findings reflect the realities reported by Nurafiati and Angriawan (2025) and Qonita et al. (2024), which indicate that inconsistent connectivity and device availability can impede the learning process. These challenges suggest that successful implementation requires not only technological resources but also institutional support, teacher training, and careful planning of classroom activities to accommodate potential disruptions.

Teachers played a pivotal role in mediating the use of technology, reflecting previous literature on teacher agency in adaptive learning contexts (Rosmi & Jauhari, 2023; Kamaruddin et al., 2025; Sari, Risma, & Ulfa, 2021). Educators actively monitored student performance, adjusted instructional strategies, and provided guidance to ensure that adaptive exercises were meaningful

and aligned with curricular goals. These findings demonstrate that adaptive technologies enhance learning outcomes only when integrated with informed pedagogical decisions, reinforcing the notion that technology is a complement rather than a substitute for effective teaching.

The study also revealed that adaptive learning platforms facilitated social interaction and peer collaboration, even when tasks were individualized. This supports literature suggesting that collaborative learning enhances engagement and understanding in adaptive contexts (Silent remember model, 2024; Tohănean et al., 2025). Students' discussions and mutual feedback contributed to deeper understanding and skill development, highlighting that social and cognitive dimensions are intertwined in adaptive physical education environments.

Finally, the research contributes new insights regarding the balance between technology, pedagogy, and social interaction in physical education. Practical implications include the need for professional development programs to enhance teachers' adaptive teaching skills, allocation of resources to improve infrastructure, and strategies to maintain collaborative learning within adaptive systems. Future studies may examine long-term impacts on students' motor skill retention, social competencies, and the scalability of adaptive learning programs across schools with varying technological resources.

4. Conclusions

This study highlights that technology-based adaptive learning in physical education can enhance student engagement, motivation, and personalized learning, while simultaneously supporting collaborative interaction and pedagogical adaptation. The findings demonstrate that students benefit from individualized feedback and differentiated tasks, and teachers play a crucial role in mediating technology use by adjusting instructional strategies to match students' needs. The research contributes to the understanding of adaptive learning in PE by showing how digital tools interact with pedagogical practices, social dynamics, and contextual factors, providing empirical insights into the complex interplay between technology and learning outcomes.

From a theoretical and practical perspective, these results underscore the importance of integrating adaptive technologies with informed instructional design and social interaction strategies. Policymakers and educational practitioners can use these insights to enhance teacher training, allocate resources for digital infrastructure, and design curricula that support adaptive, student-centered learning. Future research is recommended to examine the long-term effects of adaptive learning on physical skill development, social competencies, and scalability across diverse educational contexts, thereby deepening understanding and expanding the application of adaptive technologies in physical education.

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