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Development of a technology-based physical education instructional design to enhance student active participation

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ABSTRACT

This study aims to develop a technology-based physical education instructional design to enhance student active participation in a public junior high school in Bandung City, West Java, Indonesia. The study addresses the problem of limited student participation in physical education and the need for more meaningful technology integration in learning. A qualitative approach with a case study design was used to explore the planning, implementation, and reflection of technology-supported physical education. Data were collected through semi-structured interviews, participatory observation, and documentation involving one physical education teacher, students from one selected class, the vice principal for curriculum affairs, and one school staff member involved in digital learning support. The data were analyzed using thematic analysis through coding, theme development, and continuous comparison across data sources. The findings reveal five main themes: technology as a bridge for clearer movement instruction, digital feedback as a driver of student confidence, active participation through autonomy and peer collaboration, unequal digital readiness as a learning barrier, and the changing role of the teacher as a facilitator. The study shows that technology can improve participation when it supports movement, feedback, collaboration, and reflection. The findings contribute to physical education theory by linking technology integration, student engagement, and self-determination in a qualitative instructional design context. The study recommends stronger school support, teacher training, and inclusive digital learning strategies.

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1. Introduction

Physical education has become an important learning space for developing students' physical literacy, health awareness, social interaction, self-regulation, and lifelong active habits. In the global context, physical education is no longer limited to movement practice or sport skill training. It now requires an instructional design that connects physical movement, cognitive understanding, affective engagement, and social participation. The rapid growth of digital technology has created new opportunities for teachers to design more interactive, measurable, and student-centered physical education learning. Digital media, mobile applications, learning videos,

wearable devices, virtual reality, augmented reality, and gamified platforms have been increasingly used to support physical education practices. However, technology only improves learning when teachers connect it with clear learning objectives, relevant content, and appropriate pedagogy. Jastrow et al. (2022) emphasized that digital technology in physical education needs a strong didactic perspective, not only technical availability. Melguizo-Ibáñez et al. (2022) also showed that technology use in physical education continues to grow, but its learning value depends on teacher readiness, instructional clarity, and contextual suitability.

In Indonesia, the use of technology in Physical Education, Sports, and Health learning has increased along with the expansion of online, blended, and digitally supported learning practices. Teachers have used digital platforms to share assignments, learning videos, activity instructions, and classroom communication. However, the use of technology in school practice often remains limited to administrative communication and task submission. It has not always become part of a systematic instructional design that actively engages students in movement, reflection, feedback, and collaboration. Nopembri et al. (2022) reported that Indonesian physical education teachers used digital tools during distance learning, but many still faced challenges in designing meaningful technology-supported physical activities. This condition shows a gap between access to digital tools and the ability to transform those tools into active, inclusive, and participatory learning experiences. The issue becomes more complex when students have different levels of motivation, physical confidence, digital access, and interest in physical activity.

Student active participation is a central issue in physical education because learning outcomes depend on direct involvement in physical, cognitive, emotional, and social activities. Active participation does not only mean that students attend class or follow teacher instructions. It also includes willingness to move, ask questions, cooperate with peers, respond to feedback, complete movement challenges, and reflect on personal progress. Hastie et al. (2022) explained that engagement in physical education is multidimensional and should be understood through behavioral, emotional, cognitive, and social indicators. White et al. (2021) also emphasized that students' motivation in physical education is closely linked to autonomy, competence, and relatedness. When students feel that learning activities are meaningful, achievable, and socially supportive, they are more likely to participate actively. In contrast, repetitive teaching methods, limited feedback, low peer support, and lack of student choice may reduce their willingness to participate.

Several recent studies show that technology can increase student motivation and engagement in physical education when it is used through clear pedagogical planning. Gamification can encourage students to participate through missions, points, levels, feedback, and collaborative challenges (Arufe-Giráldez et al., 2022). Game-based learning also supports motivation, academic performance, commitment to physical activity, and learning enjoyment when the design aligns with students' needs (Camacho-Sánchez et al., 2023). Mobile applications and digital resources can help students monitor progress, receive direct feedback, and become more aware of their physical activity patterns (Gil-Espinosa et al., 2022). Maněnová et al. (2022) also found that mobile applications can support student motivation and performance in school physical education. Rusmitaningsih et al. (2024) added that fitness tracker apps can improve engagement and motivation because students can observe their activity progress in real time. Pérez-Muñoz et al. (2024) further noted that virtual reality, augmented reality, and mixed reality can enrich physical education, although their use requires attention to access, learning goals, and teacher competence.

Despite these promising findings, previous studies still show several limitations. Many studies focus on measuring the effect of technology on motivation, performance, or fitness outcomes, while fewer studies explore how teachers and students experience the process of technology-based physical education learning. Cui et al. (2024) showed that technology use can influence student engagement and fitness outcomes, but the learning process behind that relationship still needs deeper contextual explanation. Sullivan et al. (2024) argued that the Technological

Pedagogical Content Knowledge framework can help explain how teachers connect technology, pedagogy, and content in physical education. However, teacher decision-making, classroom constraints, student responses, and the meaning of active participation require more qualitative exploration. Østerlie et al. (2025) also highlighted the need for more contextual research on digital technology use in physical education teacher education. Park et al. (2025) added that sustainable technology integration in physical education must consider teacher acceptance, instructional design, and classroom enactment.

Based on this background, this study aims to develop a technology-based physical education instructional design to enhance student active participation. The study focuses on how the instructional design is planned, implemented, experienced, and reflected upon by teachers and students. It also examines the forms of technology integration, the indicators of active participation, and the supporting and inhibiting factors in classroom practice. Theoretically, this study contributes to the development of physical education learning by connecting the Technological Pedagogical Content Knowledge framework, student engagement theory, and self-determination theory in a qualitative instructional design context. Practically, this study provides a contextual model for physical education teachers who want to use technology not only as a communication tool, but also as a learning strategy that supports movement, feedback, collaboration, reflection, and meaningful student participation.

2. Materials and Methods

This study used a qualitative approach with a case study design. The case study design was selected because the study aimed to understand the development of a technology-based physical education instructional design in a real school context. The focus was not only on the final instructional product, but also on the process of planning, implementation, student response, teacher reflection, and classroom meaning. A qualitative approach was appropriate because the study explored experiences, perceptions, interactions, and contextual factors that could not be fully captured through numerical measurement. Lim (2025) explained that qualitative research is useful for understanding social phenomena through meaning, context, interpretation, and participant experience. In this study, the case was defined as the implementation of a technology-based physical education instructional design to enhance active participation among students at one school.

The research was conducted at a public junior high school in Bandung City, West Java, Indonesia, during the odd semester of the 2025/2026 academic year, from August to November 2025. The location was selected because the school had begun to use digital tools in learning activities, including learning videos, class communication platforms, online assignments, and simple digital assessment media. The participants consisted of one physical education teacher, students from one selected class, the vice principal for curriculum affairs, and one school staff member involved in digital learning support. The participants were selected through purposive sampling. The criteria included direct involvement in physical education learning, experience in using or participating in technology-supported learning, and the ability to provide relevant information about learning design and student participation. Campbell et al. (2020) explained that purposive sampling is suitable for qualitative research because it allows researchers to select information-rich participants who understand the phenomenon being studied. If additional information was needed, snowball sampling was used through recommendations from the main informants.

Data were collected through semi-structured interviews, participatory observation, documentation, and method triangulation. Semi-structured interviews were conducted with the physical education teacher to explore the planning process, technology selection, instructional strategy, assessment design, learning obstacles, and reflection on student participation. Interviews with students explored their experiences, motivation, confidence, peer interaction, perceived usefulness of technology, and barriers to active participation. Observation was conducted during

physical education lessons to record students' movement involvement, response to digital instructions, interaction with peers, teacher feedback, and participation patterns during learning activities. Documentation included lesson plans, teaching modules, learning videos, student worksheets, assessment rubrics, screenshots of digital platforms, teacher reflection notes, and student task results. This combination of techniques allowed the researcher to compare what participants said, what happened in the classroom, and what was recorded in learning documents.

The technology-based instructional design in this study was developed by considering the relationship between learning objectives, physical education content, pedagogy, and digital media. The Technological Pedagogical Content Knowledge framework was used to guide how technology was integrated into the learning process. Technology was not treated as an additional tool, but as part of the instructional structure that helped students understand movement tasks, receive feedback, monitor progress, and collaborate with peers. The instructional design included digital movement demonstrations, small-group physical challenges, student activity documentation, teacher feedback, and reflective discussion. Sullivan et al. (2024) showed that the Technological Pedagogical Content Knowledge framework can help analyze teachers' use of information and communication technology in physical education. Park et al. (2025) also explained that sustainable digital integration in physical education requires a connection between teacher acceptance, pedagogical decision-making, and classroom enactment.

Data validity was maintained through source triangulation, method triangulation, member checking, and an audit trail. Source triangulation was conducted by comparing information from the teacher, students, curriculum coordinator, school digital support staff, and learning documents. Method triangulation was conducted by comparing interview findings, observation notes, and documentation. Member checking was carried out by asking selected participants to review interview summaries and early interpretations to ensure that the researcher's interpretation was consistent with their experiences. An audit trail was maintained by storing interview transcripts, observation notes, document analysis sheets, coding records, theme development notes, and researcher reflections. Ahmed (2024) explained that credibility, transferability, dependability, and confirmability can be strengthened through triangulation, member checking, reflexive documentation, and audit trail procedures. These procedures were used to ensure that the findings were grounded in participant experiences and classroom evidence.

The data were analyzed using thematic analysis through an interactive and recursive process. The analysis began with data familiarization by reading interview transcripts, observation notes, and documents repeatedly. The next step was open coding to identify meaningful units related to instructional design, technology use, student participation, teacher strategies, learning barriers, and classroom interaction. The codes were then grouped into initial themes, such as technology-supported instruction, active participation indicators, student motivation, peer collaboration, teacher feedback, infrastructure constraints, and reflective learning. The themes were reviewed by comparing data across sources and methods. Ahmed et al. (2025) described thematic analysis as a flexible method for identifying and interpreting patterns of meaning in qualitative data. Byrne (2022) also emphasized that thematic analysis requires repeated movement between data, codes, themes, and interpretation. In this study, the final themes were developed through systematic coding, reflective interpretation, and continuous comparison with the research focus.

3. Results and Discussions

The findings show that technology-based instructional design changed the way students participated in physical education learning. The data from interviews, classroom observation, and learning documents produced five main themes. These themes were: technology as a bridge for clearer movement instruction, digital feedback as a driver of student confidence, active participation through autonomy and peer collaboration, unequal digital readiness as a learning barrier, and the changing role of the physical education teacher as a learning facilitator. These

themes indicate that student participation increased when technology was not used only to send assignments, but became part of the learning process.

The first theme shows that technology helped students understand movement tasks more clearly. The teacher used short learning videos, movement demonstrations, and digital instructions before students practiced in small groups. Observation showed that students paid more attention when the teacher displayed video examples before physical practice. Students could replay the movement sequence, compare it with their own performance, and ask more specific questions. One student stated, "When I watched the movement video first, I understood what I had to do. I was not afraid to try because I already saw the example" (S3). The physical education teacher also explained, "The video helped me reduce repeated verbal explanation. Students could see the movement directly, then I only corrected the important parts" (T1). This finding shows that digital media supported students' cognitive readiness before they engaged in physical activity.

The second theme relates to feedback and student confidence. The use of simple digital documentation, such as short videos of student performance, helped students recognize their movement progress. During observation, several students compared their first and second attempts after receiving teacher feedback. This process made feedback more concrete because students could see their body position, movement rhythm, and technical errors. One student said, "Usually I only know that my movement is wrong, but after seeing the video, I understood which part I had to improve" (S7). The teacher also used digital notes to record student progress, especially participation, effort, and task completion. This practice helped the teacher assess not only technical performance, but also students' willingness to engage in learning activities.

The third theme shows that active participation increased when students received more autonomy. The instructional design allowed students to choose roles in group activities, such as performer, recorder, observer, and feedback giver. This structure reduced pressure for students who lacked physical confidence because they could still participate through meaningful roles before performing movement tasks. One student explained, "I was not confident at first, but when I became the recorder, I could learn from my friends. After that, I wanted to try" (S11). Observation also showed that students who were usually passive became more involved when they had specific responsibilities in the group. This finding indicates that active participation in physical education includes physical movement, social contribution, observation, reflection, and peer support.

The fourth theme concerns peer collaboration. Technology encouraged students to work together because they needed to record movements, discuss errors, and provide feedback. In several groups, students showed each other how to improve posture, timing, and coordination. This interaction created a more supportive learning atmosphere. A student stated, "My friend showed me my video and told me that my foot position was too close. It was easier to understand because we discussed it together" (S5). The teacher also noted that group-based digital tasks encouraged students to communicate more actively. "Some students who rarely asked questions became active when they worked with peers. They felt safer discussing in small groups" (T1). This finding shows that technology can support social engagement when it is combined with cooperative learning.

The fifth theme shows that digital readiness remained a challenge. Not all students had the same access to devices, internet connection, or digital confidence. Some students needed assistance to open learning materials, submit assignments, or record movement videos. Observation showed that group work helped reduce this gap because students could share devices and support each other. However, the gap still affected the speed of learning. The curriculum coordinator stated, "Technology can support learning, but teachers must consider device access and student readiness. Not all students have the same condition at home" (C1). Documentation also showed that the teacher prepared alternative instructions for students who could not access

digital materials outside school. This finding indicates that technology-based instructional design must remain flexible and inclusive.

The final theme highlights the changing role of the physical education teacher. The teacher no longer acted only as an instructor who demonstrated movement in front of the class. The teacher became a designer, facilitator, observer, feedback provider, and evaluator of student participation. The teacher selected digital media, designed group activities, guided reflection, and adjusted instruction based on student responses. The teacher stated, "I learned that technology must not replace physical activity. It must help students move better and participate more actively" (T1). This statement reflects a key meaning of the study. Technology became useful when it supported movement, interaction, reflection, and participation, not when it replaced direct physical learning.

Discussion

The findings confirm that technology-based instructional design can enhance student active participation in physical education when it is connected to clear pedagogical goals. This study supports Jastrow et al. (2022), who argue that digital technology in physical education needs a didactic function. The findings show that videos, digital documentation, and online learning materials helped students understand movement tasks and reflect on their performance. However, the findings also show that technology did not work automatically. The teacher needed to select media, arrange activities, guide interaction, and provide feedback. This confirms that technology should function as part of instructional design, not as a separate learning accessory.

The finding on clearer movement instruction supports the Technological Pedagogical Content Knowledge framework. The teacher had to connect three forms of knowledge: the content of physical education, the pedagogy of active movement learning, and the technology used to support instruction. Sullivan et al. (2024) explain that this framework helps analyze how teachers use technology in physical education. In this study, technology became effective because the teacher used it to clarify movement concepts, support group practice, and provide visual feedback. This finding extends previous studies by showing that TPACK is not only a teacher competence framework, but also a practical guide for designing student participation in physical education.

The finding on feedback and confidence aligns with studies that show the value of digital tools for improving student motivation and engagement. Rusmitaningsih et al. (2024) found that fitness tracker apps can improve engagement because students can monitor their progress. This study found a similar pattern, although the technology used was simpler. Students became more confident when they could see their movement progress through short videos and teacher notes. This shows that technology does not need to be complex to improve participation. Simple tools can support meaningful learning when teachers use them to provide timely, clear, and constructive feedback.

The finding on autonomy supports self-determination theory. White et al. (2021) emphasize that autonomy, competence, and relatedness play important roles in students' motivation in physical education. In this study, students became more active when they received choices, roles, and opportunities to contribute based on their readiness. Some students first participated as observers or recorders before performing movement tasks. This process helped students build confidence gradually. The finding offers a practical perspective. Active participation should not be reduced to physical performance alone. It should include student voice, role-taking, peer learning, reflection, and progressive involvement.

Peer collaboration also became an important factor in increasing participation. The use of group-based digital tasks helped students discuss movement, observe peers, and give feedback. This finding supports Camacho-Sánchez et al. (2023), who show that game-based and interactive learning can increase motivation and student commitment when designed properly. In this study, collaboration did not emerge only because technology was present. It emerged because the teacher created group roles and structured interaction. This means that digital learning in physical

education should combine technological tools with cooperative learning strategies. Without social structure, technology may remain individual and less meaningful.

The finding on unequal digital readiness provides a critical view of technology-based physical education. Although technology supported learning, it also created challenges for students with limited device access or low digital skills. This finding is consistent with Nopembri et al. (2022), who reported that Indonesian physical education teachers faced challenges in distance and technology-supported learning. The present study adds that digital inequality does not only affect online learning. It also affects face-to-face physical education when teachers use digital media, video assignments, or online platforms. Therefore, teachers need to prepare alternative access, group support, offline materials, and flexible assessment.

This study also confirms that technology integration changes the role of the teacher. The physical education teacher must act as an instructional designer who connects learning objectives, student needs, physical activity, and digital tools. Park et al. (2025) argue that sustainable technology integration in physical education depends on teacher acceptance and instructional design. The findings support this argument. The teacher's ability to design activities mattered more than the sophistication of the technology. When the teacher used technology to support movement, feedback, and reflection, students participated more actively. When technology only functioned as a task-delivery tool, its effect on participation became limited.

The study contributes theoretically by connecting the Technological Pedagogical Content Knowledge framework, student engagement theory, and self-determination theory in one qualitative explanation. Student active participation emerged when the instructional design supported understanding, confidence, autonomy, peer interaction, and feedback. This finding strengthens Hastie et al. (2022), who describe engagement in physical education as multidimensional. The study also adds that digital technology can support each dimension of engagement when teachers design it carefully. Behavioral engagement appeared through movement practice. Emotional engagement appeared through confidence and enjoyment. Cognitive engagement appeared through reflection and movement analysis. Social engagement appeared through peer collaboration.

Practically, the findings suggest that physical education teachers should not begin technology-based learning by asking which application is the most advanced. They should begin by asking what type of participation they want to build. Teachers can use simple videos, digital rubrics, peer-recorded movement tasks, group reflection, and progress documentation to make learning more active. Schools also need to support teachers through device availability, internet access, professional development, and flexible digital learning policies. Technology-based physical education should remain inclusive. It must give students with different abilities, confidence levels, and digital access a fair opportunity to participate.

This study has limitations. It focused on one public junior high school in Bandung, so the findings cannot represent all physical education learning contexts. The study also examined technology integration during one semester, so it could not fully capture long-term changes in student participation. Future studies can involve more schools, compare urban and rural contexts, or examine how different types of technology influence student participation. Further research can also explore the perspectives of parents, school leaders, and policy makers to better understand the institutional support needed for sustainable technology-based physical education.

4. Conclusions

This study concludes that technology-based physical education instructional design can enhance students' active participation when technology is integrated as part of the learning process, not merely as a medium for task delivery. The findings show that learning videos, digital movement documentation, teacher feedback, group roles, and peer reflection helped students understand movement tasks, build confidence, and participate more meaningfully. Active participation

emerged not only through physical movement, but also through observation, discussion, collaboration, feedback, and reflection. This finding strengthens the view that student engagement in physical education is multidimensional and shaped by the interaction between pedagogy, technology, content, and students' learning experiences.

Theoretically, this study contributes to the development of physical education learning by connecting the Technological Pedagogical Content Knowledge framework, student engagement theory, and self-determination theory in a qualitative instructional context. Practically, the findings suggest that teachers should design technology-supported physical education based on student needs, learning objectives, access conditions, and meaningful participation indicators. From a policy perspective, schools need to provide digital infrastructure, teacher training, and flexible learning support so that technology integration remains inclusive. Future studies are recommended to involve more schools, compare different educational levels, and examine the long-term impact of technology-based instructional design on students' physical literacy, motivation, and participation.

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