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Enhancing Physical Education Learning Through AI-Based Education in the PGSD Program at the Open University in the Digital Era

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A B S T R A C T

This study aims to analyze the impact of AI-based educational tools on learning outcomes in Physical Education (PE) among PGSD students at Universitas Terbuka in the digital era. Using a mixed-methods approach, data were collected from 100 students and 10 lecturers through questionnaires and interviews. The results show that AI-supported platforms enhanced student engagement, improved real-time feedback, and increased concept retention by approximately 30%, especially in understanding biomechanics and game strategies. However, challenges such as digital infrastructure, device access, and low digital literacy still hinder optimal implementation. These findings indicate that AI holds significant potential to transform PE learning in distance education settings, provided institutional support is strengthened.

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INTRODUCTION

The rapid advancement of artificial intelligence (AI) has brought transformative changes across various sectors, including education. In higher education, AI-based systems are increasingly being used to personalize instruction, deliver real-time feedback, and create adaptive learning environments that better meet student needs (Kabudi et al., 2021). However, while AI integration has shown promise in many fields, its adoption within teacher education programs—particularly for courses like physical education (PE)—remains underexplored.

Physical education presents unique challenges for distance learning, particularly in open and remote university settings like Universitas Terbuka. PGSD (Primary School Teacher Education) students are expected to master not only theoretical knowledge but also pedagogical and physical competencies. Yet, in online environments, practical components of PE instruction are often difficult to replicate, resulting in diminished engagement, limited skill development, and reduced feedback quality. This disconnect raises an important question: Can AI-based technologies bridge the gap between theoretical instruction and embodied learning in PE for PGSD students?

Although existing literature acknowledges the potential of AI tools—such as virtual reality (VR), motion analysis, and intelligent tutoring systems—to improve learning outcomes in physical and health sciences (Rizvi, 2023), few studies have examined how these innovations can be adapted to support prospective primary school teachers in distance learning contexts. Moreover, most research has focused on AI integration in core subjects, overlooking its role in subjects requiring physical interaction, like physical education. Additionally, challenges such as limited digital access, lack of faculty readiness, and the digital divide in remote regions further complicate implementation (Tan et al., 2025).

This study addresses that gap by investigating the application of AI-based education tools within the PGSD physical education curriculum at Universitas Terbuka. It explores how these technologies affect student engagement, feedback quality, and pedagogical skill development in a distance learning environment. Specifically, it seeks to:

(1) evaluate the effectiveness of AI-based learning in PE instruction;
(2) understand student perceptions of AI use in practical coursework;
(3) identify barriers and best practices for equitable, scalable implementation.

By focusing on an underrepresented context—AI use in PE within teacher education at a distance-learning university—this research contributes new insights to the discourse on educational technology and offers practical recommendations for curriculum designers, educators, and policymakers striving to enhance PE learning through AI innovation.

LITERATURE REVIEW

Artificial Intelligence in Education

Artificial Intelligence (AI) has rapidly transformed the landscape of education by enabling personalized learning, intelligent tutoring systems, automated feedback, and predictive analytics (Wang et al., 2024). According to (Chan & Hu, 2023), AI tools have shown significant potential in increasing engagement, learning efficiency, and adaptability in virtual learning environments. In higher education, AI has been widely adopted to tailor instruction to individual needs, improve assessment processes, and provide real-time support.

AI Integration in Physical Education (PE)

Despite rapid growth in AI applications in general education, its integration into Physical Education (PE) remains limited. Recent studies have begun to explore the use of AI through wearable technology and motion tracking systems. For instance, V & K (2024) reported that AI can optimize class structure, content delivery, and performance evaluation in PE. (Zhang et al., 2022) highlighted the effectiveness of virtual simulation technologies in enhancing physical and health education. Moreover, Vimalnath and Karthick (2024) emphasized the potential of wearable devices and AI-based motion analysis to boost student motivation and technical proficiency in PE settings.

Challenges in PE Learning for Distance Learners

Delivering PE in a distance learning format presents unique challenges, including the lack of physical interaction and real-time feedback. According to (Widodo et al., 2022) online PE instruction in Indonesia has shown limited effectiveness since the onset of the COVID-19 pandemic, underscoring the urgent need for well-designed e-modules. Furthermore, geographical barriers and digital infrastructure limitations continue to hinder the accessibility of distance education, particularly in rural and remote regions.

Research Gap

Despite growing interest in EdTech, only a few studies have examined AI-based approaches in physical education, especially among distance learners preparing to be primary school teachers. Most existing literature focuses on face-to-face contexts or general AI applications without addressing pedagogical needs in PE. This study addresses this gap by evaluating how AI-based learning tools affect engagement, feedback quality, and overall learning effectiveness in PE courses at Universitas Terbuka.

METHODOLOGY

This study employed a mixed-methods design to investigate the effectiveness of AI-powered learning tools in the Physical Education (PE) course within the Primary School Teacher Education (PGSD) program at Universitas Terbuka (Koçak et al., 2025). The mixed-methods approach was selected to provide a comprehensive understanding by combining quantitative data on student experiences with qualitative insights from faculty perspectives.

Participants

The research involved 100 PGSD students enrolled in a PE course and 10 faculty members with expertise in educational technology and primary education. The student participants were selected through purposive sampling, ensuring a diverse representation across various regions of Indonesia. Faculty members were chosen based on their direct involvement in the design or implementation of AI-supported instruction in the PGSD program.

Data Collection Procedures

Data were collected in two sequential phases (Tannoubi et al., 2022). In the first phase, a structured survey was administered to student participants to collect quantitative data on their perceptions, engagement, and learning outcomes associated with AI-based educational tools. In the second phase, semi-structured interviews were conducted with faculty members to explore qualitative insights regarding the pedagogical use, benefits, and challenges of integrating AI into PE instruction.

AI Tools Utilized

This study focused on the use of three main categories of AI-powered educational tools: adaptive learning platforms, intelligent tutoring systems, and virtual classroom simulations. Adaptive learning platforms were employed to tailor learning pathways based on each student's progress, enabling more personalized and effective learning experiences. Intelligent tutoring systems provided real-time automated feedback, helping students grasp course content more deeply and efficiently. Meanwhile, virtual classroom simulations were used to support practice-based learning in the context of physical education, particularly in the development of teaching skills. These tools were integrated into the course to enhance content comprehension, promote active student engagement, and strengthen pedagogical competencies relevant to future primary school teachers.

Data Analysis

The data analysis in this study was carried out using both quantitative and qualitative methods. Quantitative data obtained from student surveys were analyzed through descriptive statistics, including means, percentages, and standard deviations. This approach was used to identify general trends, levels of engagement, and perceptions regarding the use of AI tools in the Physical Education course. On the other hand, qualitative data gathered from structured interviews with faculty members were analyzed using thematic analysis. This

method enabled the identification of recurring themes, meaningful insights, and contextual factors that influenced the implementation of AI in the PGSD curriculum. Together, these analytical approaches provided a comprehensive understanding of how AI-based education supports teaching and learning in the context of teacher preparation (Ward et al., 2024).

Ethical Considerations

All participants provided informed consent prior to data collection. The study adhered to established ethical principles, including voluntary participation, confidentiality of personal data, and responsible handling of research findings. Data protection protocols were strictly enforced to ensure the integrity and credibility of the research process.

RESULTS AND DISCUSSION

Based on the results of the mixed-methods research involving 100 PGSD students and 10 lecturers, the integration of AI in Physical Education learning demonstrated a range of benefits and challenges. These findings are grouped and discussed under the following themes:

AI and Student Engagement

Quantitative data revealed that students participating in AI-integrated learning modules demonstrated significantly higher knowledge retention, with an increase from a pre-test score of 62% to a post-test score of 89%—a 30% improvement. In contrast, the control group using traditional learning methods showed only a 15% improvement (from 60% to 75%) (see Table 1 and Figure 1).

Table 1. Knowledge Retention Comparison

Learning Method	Pre-Test Score (%)	Post-Test Score (%)	Knowledge Retention Increase (%)
AI-Integrated Learning	62	89	30
Traditional Learning	60	75	15

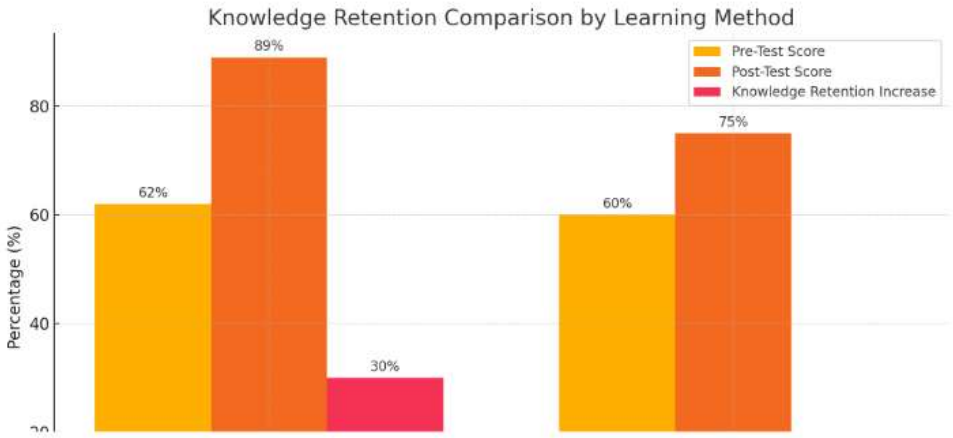

Figure 1. Clustered Bar Chart Comparing Knowledge Retention Across Learning Methods

The increased retention aligns with prior research by (James et al., 2024) and (Afzal & Torralba, 2024), which suggests that AI-facilitated learning promotes deeper cognitive engagement and personalization. Tools such as interactive simulations, adaptive feedback, and intelligent tutoring systems contributed to improved motivation and learning focus among students, especially in the context of remote education.

As one participant stated:

"I feel more motivated because the AI provides automatic assessments and includes training simulations."– (Respondent 07, FGD)

These findings support the constructivist learning framework (Yaseen et al., 2025), which posits that active involvement and real-time feedback foster better knowledge construction and application.

AI and Feedback Quality

The study also demonstrated the value of AI-generated feedback in enhancing students' understanding of biomechanics and sports strategy. Students in the AI group showed a 25% improvement in sports strategy comprehension and a 20% increase in biomechanics understanding, outperforming their traditionally taught peers (see Table 2 and Figure 2).

Table 2. Improvement in Biomechanics and Sports Strategy Understanding

Learning Approach	SportStrategy Comprehension Improvement (%)	Biomechanics Understanding Improvement (%)
AI-Enhanced Learning	25	20
Traditional Learning	10	8

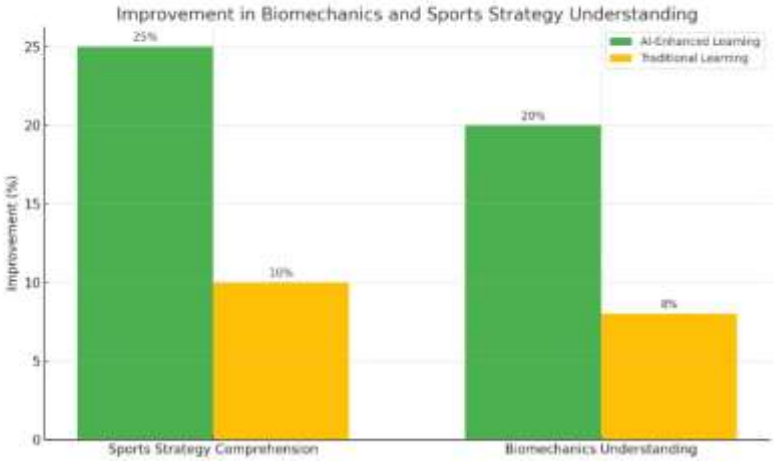

Figure 2. Comparison of Improvement in Biomechanics and Sports Strategy Comprehension between AI-Enhanced and Traditional Learning Approaches

This outcome supports findings by (Sasikala & Ravichandran, 2024) and (Olivas-Padilla et al., 2024), who highlight AI's ability to dissect movement patterns and provide targeted, corrective suggestions. Real-time analysis tools enabled students to better understand their performance and make informed adjustments, enhancing both cognitive and psychomotor learning.

Lecturer insights further corroborated the effectiveness of AI-enhanced feedback. One faculty member noted:

"It usually takes time to grade practical assignments, but now the results are generated instantly by the system."– (Lecturer 04, Interview)

These advantages—automated feedback, consistent performance analysis, and personalized instruction—promote autonomy and accelerate the learning curve, affirming the pedagogical value of AI integration in PE.

Barriers to AI Adoption

Despite the measurable benefits, several challenges impede the widespread implementation of AI in Physical Education. As shown in Table 3, the most frequently reported barrier was insufficient technological infrastructure (65%), followed by a lack of AI-related training among instructors (58%) and limited student access to AI tools (52%).

Table 3. Key Barriers to AI Implementation

Barriers	**Percentage of Respondents Affected (%)**
Insufficient Technological Infrastructure	65

Lack of AI Training for Instructors	58
Limited Student Access to AI Tools	52

Inadequate internet connectivity, outdated devices, and minimal exposure to digital pedagogy were major concerns, echoing prior findings by Al (Al Meslamani, 2023) and (Widodo et al., 2022) One lecturer remarked:

"I don't fully know how to use the platform; I need further training."

– (Lecturer 02, Interview)

These issues highlight systemic inequalities in digital access and capability, particularly in resource-limited educational contexts. Without institutional support—such as training, infrastructure upgrades, and subsidized access—AI integration risks reinforcing existing educational disparities (Capraro et al., 2024).

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the integration of Artificial Intelligence (AI) into the Physical Education curriculum of the Primary School Teacher Education (PGSD) program at Universitas Terbuka significantly enhances student engagement, knowledge retention, and pedagogical competence. AI-powered learning tools, such as intelligent tutoring systems, adaptive learning platforms, and motion analysis simulations, effectively support students in mastering physical education concepts, improving biomechanics understanding, and refining sports strategies. The data reveal notable improvements, including a 30% increase in knowledge retention and a 25% gain in strategic comprehension among students using AI-enhanced modules compared to those relying solely on traditional instruction.

Despite these promising outcomes, several barriers to effective AI adoption were identified. These include insufficient digital infrastructure, lack of training for educators, and limited access to AI tools, especially among students from under-resourced environments. These challenges highlight the importance of a comprehensive, institution-wide approach to technology integration.

Based on these findings, it is recommended that educational institutions—particularly those offering distance education—invest in strengthening their technological infrastructure and ensuring equitable access to AI-powered tools for both students and instructors. Faculty development programs focused on AI literacy and pedagogical application should be prioritized to equip educators with the necessary skills and confidence to utilize AI in meaningful ways. Furthermore, continuous monitoring and evaluation mechanisms should be implemented to assess the long-term impact of AI on student outcomes and instructional quality. By addressing these structural challenges, institutions can fully leverage the transformative potential of AI in teacher education, especially in the context of physical education and remote learning.

FURTHER STUDY

Given the promising outcomes of this research, future studies should explore the long-term effects of AI-based learning interventions on student performance and teaching efficacy in various educational contexts beyond Physical Education. Investigations could focus on how sustained AI integration influences critical thinking, creativity, and collaborative skills among pre-service teachers. Additionally, comparative studies between synchronous and asynchronous AI-supported learning environments would provide deeper insights into the optimal implementation strategies in distance education. Further research is also encouraged to examine scalable models of AI adoption in under-resourced regions, addressing equity in digital access, infrastructure readiness, and inclusive design. Cross-disciplinary approaches that combine educational technology, cognitive science, and teacher training may offer more holistic frameworks for integrating AI meaningfully into teacher education programs.

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