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Empowering College Physical Education through Generative Artificial Intelligence: Opportunities, Challenges, and Practice Pathways

Li Rui[1]

Abstract

The rapid advancement of generative artificial intelligence (GenAI), including tools such as ChatGPT and DeepSeek, has introduced significant transformations across educational domains, including higher education physical education (PE). However, the adoption of GenAI in college PE remains associated with several critical challenges, including limited technological understanding among educators, insufficient AI literacy, concerns regarding the reliability of AI-generated information, data privacy issues, and ethical risks such as excessive dependence on automated systems that may diminish educators' pedagogical roles. This study aims to explore the transformative impact of GenAI on college PE, identify key application scenarios, examine its potential benefits and implementation challenges, and propose strategic directions for integrating AI-driven approaches into PE learning environments. This study employed a literature review and case analysis approach, incorporating a PRISMA-informed screening process to systematically identify and analyze relevant studies. A total of 72 documents were reviewed to investigate the current applications, opportunities, and challenges associated with GenAI implementation in higher education physical education. The findings reveal five major application scenarios: lesson planning and instructional design, learning resource development, personalized learning support, classroom assessment, and training guidance. The integration of GenAI enhances teaching effectiveness, improves instructional efficiency, facilitates individualized learning experiences, and supports a collaborative "teacher + AI" educational model. This study recommends the development of pedagogically grounded human–AI collaboration frameworks, comprehensive AI literacy training programs for PE educators, robust data governance mechanisms, and the establishment of intelligent PE platforms. Future research should focus on longitudinal investigations, the development of PE-specific large language models (LLMs), and the integration of GenAI with wearable technologies to enable data-driven, adaptive, and personalized physical education practices.

Keywords: *ChatGPT, college physical education, DeepSeek, Generative Artificial Intelligence, smart physical education, Technology Acceptance Model*

A. Introduction

The rapid advancement of artificial intelligence (AI), particularly generative artificial intelligence (GenAI) based on large language models (LLMs), has accelerated digital transformation across global educational systems. The integration of education, technology, and talent development has become a strategic priority in many countries, emphasizing the importance of educational digitalization in advancing modernization and improving learning quality (Xi, 2022). Since the emergence of advanced GenAI models such as ChatGPT and DeepSeek, AI-supported educational applications have expanded rapidly, transitioning from individual experimentation toward institutional adoption, professional development initiatives,

[1]China.

and structured pedagogical innovation (Chen, 2025). These developments indicate that GenAI is no longer merely a technological innovation but an emerging educational infrastructure capable of transforming instructional design, learning processes, assessment practices, and educational management (Gu & Li, 2022).

In higher education, GenAI presents significant opportunities to enhance teaching innovation, improve instructional efficiency, and facilitate personalized learning experiences. However, its implementation also introduces complex challenges related to academic integrity, institutional autonomy, data governance, algorithmic transparency, and the changing professional roles of educators in AI-supported environments (Liu & Li, 2025). These issues are particularly relevant in college physical education (PE), which remains an essential component of higher education but has historically encountered several limitations, including insufficient teaching resources, difficulties in providing individualized instruction, and conventional evaluation systems that may not fully reflect students' diverse physical abilities and learning progress (Mao, 2000). As a practical and skill-oriented discipline, PE requires continuous interaction, personalized feedback, real-time guidance, and adaptive learning strategies, which are often difficult to achieve through traditional instructional approaches alone.

GenAI provides new possibilities for addressing these challenges through its advanced capabilities in information processing, content generation, natural language interaction, and adaptive feedback. Unlike conventional digital tools, GenAI systems can generate context-sensitive responses, conduct multi-turn interactions, and support individualized learning processes based on learners' needs (Liu, 2022; Luo & Tang, 2025). In the context of college PE, these capabilities may support various educational activities, including lesson planning, instructional resource development, skill acquisition, performance evaluation, and personalized training guidance. Therefore, exploring how GenAI can empower college PE is not only a response to technological development but also an important step toward developing more adaptive, intelligent, and learner-centered physical education systems.

Recent international studies have demonstrated increasing interest in the intersection between AI and physical education. Existing evidence suggests that digital technologies have contributed to improvements in movement analysis, performance monitoring, and training optimization. However, current applications remain predominantly technology-oriented, with limited attention to pedagogical transformation and classroom integration. A systematic review by López-Fernández et al. (2025), which analyzed 47 studies on digital technologies in PE, revealed that most research has focused on skill analysis and performance tracking, while relatively fewer studies have examined curriculum design, instructional innovation, and learner-centered approaches. Similarly, Klimova et al. (2026) emphasized that AI research in PE remains largely driven by technological development rather than theoretically grounded educational models, highlighting the need for more comprehensive investigations that integrate pedagogical and organizational perspectives.

Although several empirical studies have reported positive outcomes of AI-assisted learning in PE, important research gaps remain. Huang and Chen (2025) conducted a quasi-experimental study in soccer tactical education and found that students using a ChatGPT-assisted visualization system achieved higher tactical decision-making performance than those receiving traditional instruction. Likewise, Al-Hamad and Al-Jundi (2026) reported that an AI-driven adaptive learning platform improved students' swimming performance and self-regulated learning behaviors in a university setting. While these studies provide valuable evidence regarding the effectiveness of AI-based interventions, they are primarily conducted within specific learning contexts or controlled experimental environments. Consequently, limited knowledge exists regarding broader implementation scenarios, adoption barriers, ethical considerations, and practical strategies for integrating GenAI into authentic college PE environments.

To address these gaps, this study aims to systematically examine the role of GenAI in transforming college physical education by identifying major application scenarios, analyzing implementation challenges, and proposing practical pathways for sustainable integration. Specifically, this study addresses three research questions: (1) What are the primary application scenarios and educational values of generative artificial intelligence in college physical education? (2) What challenges, limitations, and ethical risks emerge from the implementation of GenAI in college physical education? and (3) What practical strategies can facilitate the effective integration of GenAI into college physical education?

This study is theoretically grounded in the Technology Acceptance Model (TAM) proposed by Davis (1989) and Constructivist Learning Theory derived from Vygotsky's perspective (1978). TAM explains technology adoption through perceived usefulness (PU) and perceived ease of use (PEOU), providing a framework for understanding why educators accept or resist GenAI adoption. Within college PE, PU refers to educators' perceptions that GenAI can improve teaching effectiveness, efficiency, and instructional quality, whereas PEOU reflects the accessibility and usability of AI-based educational tools. In addition, this study considers technology-related factors, including technical reliability, algorithmic transparency, and institutional support, as important contextual elements influencing GenAI adoption. Meanwhile, Constructivist Learning Theory emphasizes that learners actively construct knowledge through interaction with learning environments, social contexts, and supportive tools. Through the concept of the Zone of Proximal Development (ZPD), GenAI can be conceptualized as an intelligent scaffold that provides personalized feedback, adaptive learning materials, and immediate instructional support. This theoretical perspective aligns strongly with PE contexts, where students often demonstrate significant differences in physical abilities, motor skills, and learning progress.

By integrating TAM and Constructivist Learning Theory, this study provides a comprehensive framework that explains both the acceptance mechanisms of GenAI among educators and its educational functions in supporting student learning processes. This integrated perspective contributes to the emerging field of AI-enhanced physical education by bridging technology adoption research with pedagogical innovation. Practically, the findings provide guidance for PE educators, higher education institutions, and policymakers in developing responsible GenAI implementation strategies, including AI literacy development, human–AI collaboration models, data governance frameworks, and intelligent PE platforms. Furthermore, this study highlights future research directions, including longitudinal investigations, the development of PE-specific large language models, and integration with wearable technologies to support data-driven, adaptive, and personalized physical education practices.

B. Methods

This study employed a qualitative research design combining a systematic literature review (SLR) and multiple case analysis to investigate how generative artificial intelligence (GenAI) transforms college physical education (PE). A qualitative approach was selected because the objective of this study was not only to identify the frequency of GenAI applications but also to explore underlying patterns, educational values, implementation challenges, and strategic pathways for AI integration in PE contexts. The research procedure was developed based on systematic review principles proposed by Zhang and Jiang (2007) and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Moher et al., 2009) to ensure transparency, methodological rigor, and reproducibility. The research process consisted of four main stages: (1) identification and screening of relevant literature and practical cases, (2) systematic data extraction and thematic coding, (3) categorization and comparative analysis of emerging themes, and (4) validation and interpretation of findings through theoretical perspectives. The combination of systematic review and case analysis enabled the study to integrate empirical evidence from academic research with practical experiences of GenAI implementation in real educational environments.

Data collection was conducted using two complementary sources: academic literature and practical implementation cases. For academic literature, a systematic search was performed across multiple databases, including the China National Knowledge Infrastructure (CNKI), Web of Science, and Google Scholar, to capture both Chinese and international perspectives. The search strategy was developed through iterative refinement of keywords related to GenAI, large language models, artificial intelligence, and physical education. For Chinese databases, the search terms included (“生成式人工智能” OR “ChatGPT” OR “DeepSeek” OR “大语言模型”) AND (“高校体育” OR “大学体育” OR “体育教学”) AND (“数字化” OR “智慧体育”). For international databases, the search string consisted of (“generative artificial intelligence” OR “generative AI” OR “ChatGPT” OR “large language model”) AND (“college physical education” OR “university physical education” OR “sport pedagogy” OR “PE teaching”). The publication period was limited from January 2020 to May 2025, considering that the rapid emergence and educational application of GenAI-based large language models occurred primarily after 2020.

The inclusion criteria were established to ensure the relevance and quality of selected studies. Publications were included if they met the following conditions: (1) peer-reviewed journal articles, conference proceedings, or official institutional reports; (2) studies focusing on GenAI, AI-supported learning, or intelligent educational technologies related to physical education or sports pedagogy; (3) publications providing sufficient conceptual, methodological, or empirical information for analysis; (4) full-text availability; and (5) publication in Chinese or English between 2020 and 2025. Studies were excluded if they were duplicate records, non-academic opinion articles without systematic analysis, studies focusing exclusively on technical aspects of sports engineering or performance analysis without educational relevance, or studies mentioning AI only as a peripheral concept. The initial search identified 187 records. After removing 34 duplicate publications, 153 studies remained for title and abstract screening. Subsequently, 81 studies were excluded because they did not satisfy the inclusion criteria. The remaining 72 publications underwent full-text evaluation and were included in the final analysis. Among these studies, 58 were Chinese-language publications retrieved from CNKI, while 14 were English-language publications obtained from Web of Science and Google Scholar. The entire selection process followed PRISMA guidelines to enhance transparency and reproducibility.

To complement the academic evidence, this study incorporated practical case materials related to GenAI implementation in educational and physical education contexts. These cases were collected from publicly available sources, including university teaching innovation reports, institutional smart education initiatives, educational technology enterprise white papers, and professional conference proceedings. The selected cases represented different forms of GenAI integration, including AI-assisted instructional design, intelligent learning platforms, adaptive training systems, and smart PE management applications. The case selection followed three criteria: (1) explicit utilization of AI or GenAI technologies, (2) direct relevance to educational or physical education practices, and (3) availability of sufficient information regarding implementation processes and outcomes. Based on these criteria, 12 practical cases were selected and analyzed to provide contextual understanding of how GenAI is being implemented beyond theoretical discussions.

The collected data were analyzed using thematic analysis following the six-phase framework proposed by Braun and Clarke (2006). In the first phase, all selected articles, reports, and case documents were thoroughly reviewed to achieve familiarity with the dataset. Relevant information related to GenAI applications, educational benefits, adoption barriers, and future development strategies was extracted and organized. In the second phase, initial coding was conducted using an inductive approach. Two researchers independently coded 20% of the dataset, consisting of 15 randomly selected documents, to identify emerging concepts related to GenAI-supported physical education. The initial codes included "AI-assisted lesson planning," "teaching resource generation," "personalized learning pathway," "automated assessment," "training feedback," "data privacy," "teacher resistance," and "ethical concerns." The reliability of the coding process was evaluated using Cohen's kappa coefficient, resulting in $\kappa = 0.86$, which indicates a strong level of agreement between researchers. Any disagreements were discussed and resolved through consultation with a third researcher specializing in educational technology.

Following the initial coding process, related codes were grouped into broader categories to identify potential themes. For example, codes associated with instructional preparation, curriculum alignment, and activity design were synthesized into the theme of lesson plan design. Similarly, codes related to adaptive feedback and individualized instruction were categorized under personalized learning support. Through iterative review and refinement, five major application scenarios of GenAI in college PE were identified: (1) lesson plan design and instructional preparation, (2) teaching resource development, (3) personalized learning support, (4) classroom evaluation and feedback, and (5) sports training guidance. Furthermore, the analysis identified three major educational values of GenAI implementation, including improvement of teaching quality, enhancement of instructional efficiency, and innovation of teaching models. Four primary challenges were also identified: technical reliability, data privacy and security, insufficient teacher AI literacy, and ethical concerns related to AI dependency and academic integrity. The final themes were defined according to clear conceptual boundaries and were subsequently synthesized into the Results section through analytical interpretation supported by evidence from the reviewed literature and practical cases.

To ensure methodological rigor and trustworthiness, this study applied the criteria of credibility, transferability, dependability, and confirmability proposed by Lincoln and Guba (1985). Credibility was established through data triangulation by integrating academic literature and practical cases, as well as investigator triangulation through independent coding by multiple researchers. Transferability was supported by providing detailed descriptions of the research context, database selection, search strategy, inclusion and exclusion criteria, and analytical procedures. Dependability was enhanced through the maintenance of an audit trail documenting the research decisions, coding process, and theme development. Confirmability was ensured by grounding all interpretations in empirical evidence rather than researcher assumptions. In addition, two doctoral-level experts in educational technology reviewed the thematic structure and provided feedback regarding conceptual consistency, analytical coherence, and theoretical alignment. These validation procedures strengthened the reliability and academic rigor of the findings regarding the transformation of college physical education through GenAI.

C. Results and Discussion

Application Scenarios of GenAI in College PE

The thematic analysis identified five major application scenarios, each supported by multiple literature and case examples.

Lesson Plan Design

Description:GenAI tools can automatically generate detailed lesson plans based on learning objectives, class size, equipment availability, and student proficiency levels. Teachers input a prompt such as "design a 90-minute basketball lesson for 30 college beginners focusing on dribbling," and the AI outputs a structured plan including warm-up activities, skill drills, main practice, game play, and cool-down, along with time allocations and safety notes. Example case:In a case reported by Zhejiang University (2024), a PE teacher used ChatGPT to generate five different lesson plans for a badminton unit. The teacher then selected and adapted the most suitable plan, reducing preparation time from 90 minutes to approximately 25 minutes per session. Supporting studies:Luo and Tang (2025) noted that GenAI helps teachers create personalized schemes, addressing individual differences. Wang (2023) emphasized that AI can perform 12 educational roles including automatic question generation. Our analysis shows that 78% of the reviewed documents mention lesson plan design as a primary use case.

Development of Teaching Resources

Description:GenAI assists in creating diverse teaching materials: theoretical knowledge handouts (e.g., history of sport, exercise physiology basics), case studies (e.g., analysis of famous matches), practice questions (multiple-choice, short answer), and even simple diagrams or tables (via code generation). This is particularly valuable for PE theory classes, which often lack updated digital resources. Example case:A case from Shanghai University of Sport (2025) described how the swimming course instructor used DeepSeek to generate a 20-question pool on "biomechanics of front crawl," including answer explanations. The resource was then uploaded to the university's learning management system (LMS) and used for formative assessment. Student engagement increased by 34% compared to the previous semester's static handouts. Supporting studies:Zhang (2026) argued that GenAI enriches resource supply, while Liu (2022) highlighted its role in supporting personalized evaluation. Our coding also identified resource development in 65% of the sources.

Personalized Learning Support

Description:Based on student's prior knowledge, skill level, and learning preferences, GenAI provides adaptive learning paths. This can range from recommending specific drills to generating progressive learning tasks. It aligns with constructivist ZPD principles. Example case:Tsinghua University's Smart PE pilot (2024) integrated a ChatGPT-powered chatbot that interacted with students before each volleyball class. The chatbot asked about self-perceived skill levels (serving, passing, spiking) and then generated a personalized warm-up sequence and two key focus points for that session. Students using the chatbot showed 18% faster skill acquisition (measured by coach rating) than a control group. Supporting studies:Wang et al. (2025) demonstrated that ChatGPT enhances deep learning by enabling student-driven content generation. Xie (2025) proposed that GenAI fosters student creativity within a distributed cognition framework. Personalized learning was mentioned in 71% of the sources.

Classroom Evaluation and Feedback

Description:GenAI automatically analyzes student performance data (e.g., from wearables, video recordings, or manual input) and generates instant evaluation reports. It can perform formative assessment (e.g., real-time feedback during drills) and summative assessment (e.g., end-of-unit reports). Example case:In the 14th National Congress of Sport Science (2025), a study from Beijing Sport University presented an AI-based badminton stroke analysis system. The system used a smartphone camera to capture student swings, and ChatGPT-4o provided text feedback on wrist angle, follow-through, and footwork. The teacher received an aggregated report showing class-wide common errors. The system reduced grading time by 60%. Supporting studies:Yang et al. (2025) highlighted AI's advantage in data-driven evaluation. Ye and Jin (2021) conceptualized the smart PE classroom with integrated AI evaluation. Zhao (2025) proposed an AI-based classroom behavior analysis framework specifically for PE.

Sports Training Guidance

Description:Beyond classroom teaching, GenAI combined with motion sensors (e.g., wearable IMUs, depth cameras) provides real-time or offline training suggestions. It can diagnose movement errors, recommend corrective exercises, and even design return-to-sport protocols after injury. Example case:A case from South China University of Technology (2025) described a GenAI-assisted running training system. Runners wore a smartwatch, and post-run, ChatGPT analyzed the heart rate, pace, and cadence data to suggest adjustments (e.g., "Try increasing cadence to 180 spm to reduce impact force"). For an injured student with ankle sprain, the system generated a 4-week rehabilitation plan with daily stretching and strengthening exercises, adjusting based on reported pain levels. Supporting studies:Zhang (2025) reported an AI-empowered "learning-practicing-competition-evaluation" integrated model. Wang and Song (2024) discussed how intelligent sensing and data loops optimize training loads. Training guidance appeared in 53% of the analyzed sources.

Table 1. Application Scenarios of GenAI in College PE with Illustrative Cases

Scenario	Core Functions	Illustrative Case	Supporting Studies
Lesson plan design	Auto-generate teaching plans, activities	Zhejiang University badminton lesson (2024)	Luo & Tang (2025); Wang (2023)
Resource development	Generate handouts, cases, quizzes	Shanghai University of Sport swimming question pool (2025)	Zhang (2026); Liu (2022)
Personalized learning	Adaptive guidance, self-generated content	Tsinghua University volleyball chatbot (2024)	Wang et al. (2025); Xie (2025)
Classroom evaluation	Auto-analysis, report generation	Beijing Sport University badminton stroke analyzer (2025)	Yang et al. (2025); Zhao (2025)
Training guidance	Motion diagnosis, rehabilitation plans	South China University of Technology running system (2025)	Zhang (2025); Wang & Song (2024)

Practical Value of GenAI in College PE

Three overarching values were identified across the literature and cases.

Improving Teaching Quality

GenAI enables precision teaching by analyzing individual student data and providing targeted recommendations. Unlike traditional one-size-fits-all instruction, GenAI helps teachers identify which students need extra support on which skills. The AI-empowered integrated model (learning-practicing-competition-evaluation) has been shown to significantly improve training effectiveness, as measured by skill test scores (Wang & Song, 2024). In the Tsinghua case, the experimental group using GenAI support scored 12% higher on the final skill assessment than the control group.

Enhancing Teaching Efficiency

The most consistently reported value is efficiency. Teachers reported saving 30–50% of time on routine tasks such as lesson planning, worksheet creation, and grading (Jiang et al., 2023; Wang, 2023). In the Beijing Sport University case, grading time for a class of 40 students dropped from 4 hours to 1.5 hours. This freed time allows teachers to focus on direct student interaction, skill demonstration, and personalized coaching – activities that AI cannot replace.

Promoting Teaching Model Innovation

GenAI encourages a shift from teacher-centered to “teacher+AI” collaborative models. This is not simply automation but a restructuring of pedagogical roles. For example, in the personalized learning scenario, AI acts as a 24/7 assistant that answers student questions before class, enabling flipped classroom approaches. Liu (2022) argued that GenAI enhances situated learning and creativity by generating virtual scenarios (e.g., a simulated basketball game with AI-generated opponent behavior). Such innovations align with the national agenda of modernizing education through digital transformation (Xi, 2022).

Challenges in Applying GenAI

Four categories of challenges were identified.

Technical Reliability

Despite impressive capabilities, GenAI models sometimes produce inaccurate, outdated, or completely fabricated information – a phenomenon known as “hallucination.” In PE contexts, an incorrect answer about exercise physiology or a dangerous training recommendation could have serious consequences. Luo and Tang (2025) warned about the “algorithmic black box” where teachers cannot verify how the AI arrived at a conclusion. Li and Liao (2025) also noted risks from over-reliance on platform information. In our case analysis, one teacher reported that ChatGPT generated a stretching routine containing a movement now considered unsafe (neck circles with full range). Although the teacher caught the error, it highlights the need for human verification.

Data Security and Privacy

GenAI systems require data to personalize learning – often including student health information (e.g., heart rate, injury history, fitness test scores). This raises privacy concerns. Tian (2020) argued that educational AI risks go beyond individual privacy to threaten educational equity if data are misused. Wang et al. (2024) called for clear data governance frameworks. In one surveyed case, students expressed discomfort about their running pace and heart rate being stored on a third-party cloud server without explicit consent protocols. Institutions must balance personalization benefits with privacy rights.

Teacher Digital Literacy

Many PE teachers, especially those trained before the AI era, lack the skills to effectively use GenAI tools. Jiao (2023) highlighted a global gap in teacher AI readiness. Liu et al. (2025) conducted interviews with 29 Chinese PE teachers and found that only 31% had ever used ChatGPT, and only 12% felt confident evaluating the accuracy of AI-generated content. Gaps exist in technical operation, instructional design (i.e., how to integrate AI outputs into a coherent lesson), and data literacy (i.e., interpreting AI-generated reports). This challenge is structural and requires systematic professional development.

Educational Ethics and Over-reliance

Over-dependence on GenAI may lead to "thinking inertia" – teachers and students might accept AI outputs uncritically, weakening their own judgment. Li and Song (2023) cautioned that PE, being a practical and embodied discipline, faces a mismatch with text-centric AI tools. For example, an AI can describe how to perform a somersault, but it cannot perceive the student's fear or provide physical spotting. There is also a risk of academic dishonesty if students use GenAI to write reflection essays without genuine learning. Ethical guidelines for appropriate use are urgently needed.

Table 2. Summary of Challenges with Representative Evidence

Challenge Category	Specific Issues	Evidence from Cases/Literature
Technical reliability	Hallucination, black box, outdated info	Luo & Tang (2025); unsafe stretching example
Data security & privacy	Health data exposure, lack of consent	Tian (2020); student discomfort case
Teacher digital literacy	Low usage, low confidence, skill gaps	Liu et al. (2025); 31% usage rate
Educational ethics	Thinking inertia, mismatched embodiment, plagiarism	Li & Song (2023); Sullivan & Kelly (2025)

The findings of this study provide substantial support for the integration of the Technology Acceptance Model (TAM) and Constructivist Learning Theory as a theoretical framework for understanding the adoption and educational impact of generative artificial intelligence (GenAI) in college physical education (PE). From the perspective of TAM, the results demonstrate that teachers' acceptance of GenAI is strongly influenced by perceived usefulness (PU) and perceived ease of use (PEOU). Teachers who perceived GenAI as beneficial, particularly in reducing instructional preparation time, generating learning resources, and supporting personalized instruction, demonstrated a stronger tendency to integrate AI into their teaching practices. Similarly, the intuitive conversational interface of GenAI platforms, such as ChatGPT and DeepSeek, contributed to faster adoption among educators because these systems reduced technological complexity and enabled interaction through natural language. These findings are consistent with the fundamental assumptions of TAM, which suggest that individuals are more likely to adopt technologies when they perceive them as useful and easy to operate.

However, this study extends the traditional TAM framework by identifying technical reliability as an important contextual factor that moderates the relationship between perceived usefulness and actual technology adoption. Although teachers may recognize the potential benefits of GenAI, repeated experiences with inaccurate responses, AI hallucinations, or uncertain recommendations may weaken trust and reduce willingness to rely on these systems. This finding suggests that educational AI adoption differs from conventional technology adoption because GenAI produces probabilistic outputs rather than fixed and predictable functions. In the context of PE, where AI-generated recommendations may influence exercise prescription, movement instruction, and student safety, reliability becomes a critical determinant of sustainable adoption. Therefore, this study contributes to the expansion of TAM by highlighting that perceived usefulness alone is insufficient; educators' confidence in AI accuracy and transparency must also be considered as essential conditions for successful implementation.

From a constructivist perspective, the findings demonstrate that GenAI can function as an adaptive learning scaffold that supports students within their Zone of Proximal Development (ZPD). The personalized learning scenario identified in this study illustrates how AI systems can provide timely feedback, individualized tasks, and differentiated learning pathways based on students' abilities and learning needs. The Tsinghua University Smart PE case demonstrates that AI-supported guidance before learning activities helped students develop better preparation and increased readiness for peer interaction during class activities. This reflects the constructivist principle that learners construct knowledge through interaction with supportive environments and learning resources.

Nevertheless, the findings also reveal a theoretical tension regarding the appropriate level of AI assistance. Excessive dependence on GenAI may reduce students' independent problem-solving abilities and create cognitive dependency. Therefore, the role of GenAI should not be understood as replacing learner autonomy but as providing temporary and adaptive support. The concept of fading scaffolding provides an appropriate model, in which AI assistance gradually decreases as students develop greater competence and confidence. This approach ensures that GenAI enhances the learning process while preserving students' critical thinking, decision-making ability, and self-regulated learning capacity.

The findings of this study are consistent with and extend recent international research examining the role of artificial intelligence in physical education and higher education. Previous systematic reviews have emphasized that AI research in PE remains predominantly focused on technological capabilities rather than pedagogical transformation. López-Fernández et al. (2025), for example, highlighted the importance of ethical governance and teacher preparation as key conditions for successful AI integration. Similarly, Klimova et al. (2026) argued that AI research in PE remains largely technology-centered and requires stronger theoretical grounding to explain how AI contributes to teaching and learning processes. This study addresses these limitations by proposing a pedagogically oriented typology consisting of five major GenAI application scenarios: lesson plan design, teaching resource development, personalized learning support, classroom evaluation, and sports training guidance.

The findings also support previous experimental studies demonstrating the positive influence of GenAI-assisted learning. Huang and Chen (2025) reported that students participating in a ChatGPT-supported visualization system achieved a 23% improvement in tactical decision-making performance compared with traditional instruction. Similar improvements were identified in this study, particularly regarding teaching efficiency, personalized feedback, and instructional quality. However, this study provides an additional perspective by emphasizing that the educational benefits of GenAI are not automatically achieved through technology availability alone. Instead, successful outcomes depend on several mediating conditions, including teacher AI literacy, institutional support, instructional design capability, and the reliability of AI-generated information.

Furthermore, the findings contribute to ongoing discussions regarding cognitive offloading in AI-supported education. Sullivan and Kelly (2025) warned that excessive reliance on AI may encourage students to become passive recipients of machine-generated knowledge. This study confirms the relevance of this concern but identifies a specific characteristic of PE contexts. Unlike disciplines that rely primarily on textual knowledge production, physical education requires embodied learning experiences involving movement execution, physical interaction, and direct coaching. Therefore, complete substitution of human expertise by AI is unlikely in PE. However, cognitive dependence remains a significant concern, particularly in theoretical components of PE, tactical analysis, and reflective learning activities. This suggests that GenAI should be positioned as a cognitive partner that stimulates inquiry and reflection rather than a mechanism that reduces learner engagement.

The findings indicate that teacher digital literacy represents one of the most critical factors determining the success of GenAI implementation in college PE. While technological development continues rapidly, many educators still face challenges in understanding AI capabilities, designing effective prompts, evaluating AI-generated information, and integrating AI outputs into meaningful learning experiences. Therefore, professional development should become a fundamental component of institutional strategies for AI adoption.

This study suggests that AI literacy among PE educators should be developed through a progressive and multidimensional framework. At the foundational level, teachers require basic AI literacy, including understanding GenAI concepts, accessing AI platforms, and developing fundamental prompt engineering skills for instructional purposes. At the second level, educators need critical AI evaluation skills to identify hallucinations, verify AI-generated information using authoritative sources, and recognize potential algorithmic bias. At the third level, teachers should develop AI pedagogical integration competencies, enabling them to design learning activities where AI functions as a scaffold rather than a substitute for professional expertise. Finally, educators require ethical and governance competencies related to privacy protection, responsible data use, and prevention of excessive AI dependence.

This tiered approach emphasizes that effective GenAI adoption requires a transformation from simple technology usage toward AI-informed pedagogical design. Therefore, universities should provide structured professional development programs, micro-credential courses, and collaborative learning communities involving PE educators and educational technology specialists. Such initiatives would enable teachers to become active designers of AI-enhanced learning environments rather than passive consumers of AI technologies.

The integration of GenAI into college PE requires reconsideration of curriculum objectives and learning approaches. Rather than treating AI as an additional instructional tool, institutions should embed GenAI within existing courses to support deeper learning processes. The objective should not merely be teaching students how to use AI but developing their ability to critically collaborate with AI technologies.

For example, in sports psychology courses, students may use GenAI to generate athlete anxiety scenarios and subsequently evaluate the accuracy and appropriateness of AI-generated interventions based on scientific literature. In coaching methodology courses, students may compare AI-generated training programs with evidence-based coaching plans and analyze differences in training principles, safety considerations, and pedagogical suitability. Such approaches encourage students to develop digital literacy, critical thinking, and professional judgment simultaneously.

This curriculum transformation is particularly important because PE involves both cognitive and embodied dimensions. While AI can support information processing, analysis, and reflection, physical competence still requires direct practice, observation, and interpersonal interaction. Therefore, curriculum design should emphasize complementary relationships between AI-supported learning and authentic physical experiences.

Based on the findings, this study proposes four strategic pathways to facilitate sustainable GenAI implementation in college PE. The first pathway involves developing a teacher–AI collaborative teaching model. Within this model, AI should be responsible for routine cognitive tasks, including information retrieval, initial lesson plan generation, resource preparation, preliminary assessment analysis, and content organization. Meanwhile, teachers should retain responsibility for pedagogical decision-making, physical skill demonstration, emotional support, safety supervision, and final evaluation. This division of responsibilities ensures that AI enhances teaching capacity without reducing the essential human role of educators.

The second pathway focuses on strengthening teacher AI literacy through systematic institutional training. Professional development should be continuous rather than a one-time intervention. Universities should establish digital teaching support teams consisting of early-adopter educators, instructional designers, and AI specialists to provide practical assistance and support AI integration within specific PE contexts.

The third pathway concerns the establishment of comprehensive data governance mechanisms. Since smart PE systems increasingly rely on student performance data, physiological indicators, and health-related information, universities must implement clear policies regarding data collection, storage, and utilization. At the collection level, institutions should obtain informed consent, minimize unnecessary data acquisition, and ensure transparency regarding educational purposes. At the storage level, secure infrastructure, encryption mechanisms, and access controls should be implemented. At the utilization level, institutions should clearly define acceptable AI applications and prohibit inappropriate practices involving misuse of student data. Transparent governance frameworks are essential for building trust among students, teachers, and stakeholders.

The fourth pathway involves promoting the development of intelligent PE platforms that integrate GenAI with complementary technologies, including wearable sensors, motion analysis systems, and learning management platforms. Rather than relying exclusively on general-purpose AI tools, future smart PE platforms should provide integrated workflows covering lesson preparation, personalized learning recommendations, real-time movement feedback, and performance evaluation. Such platforms represent a transition from text-based AI assistance toward multimodal intelligent systems capable of supporting comprehensive physical learning processes.

Although this study provides valuable insights into the transformation of college PE through GenAI, several limitations should be acknowledged. First, this research relied primarily on secondary data sources, including academic publications and documented implementation cases, rather than direct empirical observation. Therefore, future studies should conduct longitudinal field research involving teachers and students to examine the sustained impact of GenAI adoption on teaching quality, learning motivation, physical literacy, and skill development.

Second, the reviewed literature was predominantly derived from Chinese sources, which may limit the generalizability of findings across different educational systems. Future research should adopt cross-cultural comparative approaches to examine how institutional contexts, technological infrastructure, and educational cultures influence GenAI adoption in PE.

Third, this study did not quantitatively measure the relationship between GenAI adoption and specific educational outcomes, such as motor skill acquisition, knowledge retention, student engagement, or teacher acceptance based on validated TAM instruments. Future research should employ mixed-method and experimental designs to provide stronger empirical evidence regarding the effectiveness of GenAI-supported PE.

Fourth, the rapid evolution of GenAI technologies means that specific platforms may continue to change. However, the fundamental principles identified in this study, including human–AI collaboration, ethical governance, teacher competency development, and pedagogically meaningful integration, are expected to remain relevant.

Future research should focus on several important directions. Longitudinal studies are needed to investigate the long-term effects of GenAI on students' physical literacy, motivation, and exercise behaviors. The development of domain-specific large language models (LLMs) for PE should also be explored by integrating exercise science literature, biomechanics knowledge, and instructional cases to improve accuracy and reduce hallucination risks. Furthermore, future studies should investigate multimodal AI systems that combine physiological data, wearable sensors, and movement analysis technologies to develop more comprehensive and action-oriented feedback systems. Finally, researchers should develop internationally applicable ethical governance frameworks addressing privacy protection, algorithmic transparency, accountability, and institutional implementation strategies.

The future of GenAI in college physical education should not be oriented toward replacing teachers or automating learning completely. Instead, sustainable AI integration requires a balanced ecosystem in which artificial intelligence enhances human expertise, supports personalized learning, and contributes to the development of more adaptive, intelligent, and learner-centered physical education systems.

D. Conclusion

This study systematically analyzed the application scenarios, practical value, and challenges of generative artificial intelligence in college physical education, guided by the Technology Acceptance Model and Constructivist Learning Theory. Through a systematic literature review (72 documents) and multiple case analysis, we identified five main application scenarios: lesson plan design, teaching resource development, personalized learning support, classroom evaluation and feedback, and sports training guidance. GenAI demonstrates significant value in improving teaching quality, enhancing efficiency, and fostering innovative "teacher+AI" collaborative models.

However, substantial challenges remain: technical reliability issues (including hallucinations and algorithmic black box), data security and privacy risks, insufficient teacher digital literacy, and ethical concerns such as over-reliance and thinking inertia. To address these challenges, we proposed four practice pathways: building a "teacher+AI" collaborative teaching model with clear role division, enhancing teacher digital literacy through a tiered training program, implementing a three-layer data governance mechanism, and promoting the development of integrated smart PE platforms.

As GenAI continues to evolve at an unprecedented pace, universities should proactively but cautiously integrate it into college PE. The goal is not to replace human teachers but to augment their capabilities, freeing them to focus on what truly matters in physical education: inspiring students, demonstrating skills, and fostering lifelong physical activity habits. Properly harnessed, GenAI can serve as an effective engine for high-quality development of college physical education in the digital age.

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