International Journal of Education and Humanities (IJEH), 6(3) 2026:555-574
http://i-jeh.com/index.php/ijeh/index
E-ISSN: 2798-5768

A Study on Pathways for Enhancing the Teaching Competencies of Physical Education Teacher Candidates Through Artificial Intelligence

Wang Mengya[1]

Abstract

The digital transformation of education, accelerated by artificial intelligence (AI), has profoundly reshaped pedagogical practices across disciplines. However, pre-service physical education (PE) teacher training programs face persistent structural challenges, including limited authentic teaching practice opportunities, overly subjective and untimely evaluation systems, and a lack of individualized mentoring, all of which hinder the cultivation of adaptive and reflective practitioners. Despite growing interest in educational technology, there remains a notable gap in both theoretical frameworks and practical pathways specifically tailored to integrate AI into PE teacher preparation. To address this gap, this study employs a comprehensive literature review and theoretical synthesis to construct a dual-dimensional competency framework for PE pre-service teachers, comprising "professional pedagogical competence" and "digital teaching competence." Based on this framework, the study identifies and elaborates four AI-enabled instructional pathways: (1) AI-assisted instructional design and resource generation, (2) virtual simulation for motor skill demonstration and movement analysis, (3) intelligent classroom interaction systems for real-time feedback, and (4) multidimensional, data-driven teaching assessment. These pathways collectively facilitate a paradigm shift from traditional experience-driven teaching to evidence-based, data-informed instructional decision-making. Furthermore, the research critically examines persistent barriers to implementation, including curriculum misalignment with digital competencies, insufficient digital literacy among teacher educators, and the absence of sustainable mechanisms for long-term AI integration. In response, the study proposes actionable strategies such as reforming PE curricula to embed AI literacy, establishing university-industry collaborative training platforms, enhancing faculty digital professional development, and optimizing assessment frameworks to incorporate AI-generated analytics. This research contributes both theoretically and practically by offering an original competency model and a systemic implementation roadmap for integrating AI into pre-service PE education. The findings are intended to inform policy-making, guide curriculum innovation, and support the sustainable, high-quality development of school physical education in the digital age.

Keywords: *Artificial Intelligence, Physical Education Teacher Education Students, Teacher Education Students, Teaching Competence*

A. Introduction

The rapid advancement of artificial intelligence (AI) has precipitated a paradigm shift across virtually all sectors of society, with education being no exception. Globally, educational systems are increasingly leveraging AI technologies to enhance pedagogical effectiveness, personalize learning experiences, and optimize administrative efficiency (Holmes et al., 2019; Luckin et al., 2016). The Organisation for Economic Co-operation and Development (OECD) has underscored

[1]School of Physical Education, Southwest University. China. 15703804035@163.com

the imperative for education systems to adapt to the digital age, emphasizing that AI literacy and data-driven instruction are no longer optional but essential for twenty-first-century teaching and learning (OECD, 2021). In this global context, China has positioned AI-driven educational transformation as a national strategic priority, recognizing that the integration of intelligent technologies into education is fundamental to achieving long-term national competitiveness and social development goals.

In alignment with this global trajectory, China has promulgated a series of landmark policy instruments to accelerate the digital and intelligent transformation of its education system. In 2018, the Ministry of Education issued the Action Plan for Education Informatization 2.0, which explicitly called for the effective development of online education, the active promotion of "Internet Plus Education," and the construction of a talent cultivation model under the "Internet Plus" framework (Ministry of Education, 2018). This policy signaled a significant departure from traditional educational paradigms, urging the integration of digital technologies into all facets of teaching and learning. In 2021, the General Administration of Sport issued the 14th Five-Year Plan for Sports Development, which emphasized the need to strengthen the widespread application of information technology within the sports sector, including physical education (PE) in schools (General Administration of Sport, 2021). More recently, in April 2025, the Opinions on Accelerating the Digitalization of Education, jointly issued by the Ministry of Education and eight other departments, explicitly called for the comprehensive advancement of intelligent technologies, the promotion of AI to drive educational transformation, and the coordinated integration of AI education across primary, secondary, and higher education institutions (Ministry of Education et al., 2025). In August of the same year, the State Council's Opinions on Deepening the Implementation of the 'AI+' Initiative proposed embedding AI into all elements and stages of education and teaching, thereby reinforcing the integration of intelligent systems into pedagogical processes (State Council, 2025). Collectively, these policies not only provide a robust policy foundation for AI application in education but also herald a new era of "AI+Education" as a critical component of China's strategy to build a high-quality, equitable, and future-ready education system.

Alongside these technological imperatives, China has concurrently pursued the goal of enhancing the quality and accessibility of school physical education. The Outline of the Plan for Building a Strong Educational Nation (2024–2035) stipulates that "primary and secondary school students should engage in comprehensive physical education activities for no less than two hours daily," a provision aimed at promoting the holistic development of students and addressing growing concerns about declining physical fitness and mental health among youth (Central Committee of the Communist Party of China & State Council, 2025). This mandate places unprecedented demands on school physical education programs and, by extension, on the professional competencies of PE teachers. PE teachers are expected not only to possess robust pedagogical content knowledge and motor skill expertise but also to demonstrate digital and technological fluency capable of integrating AI-driven tools into their instructional practice (Wang & Zhou, 2023). This dual demand—professional competence alongside digital competence—poses a significant challenge to existing teacher preparation frameworks, which have historically prioritized face-to-face instruction, subjective observation-based assessment, and experience-driven pedagogical decision-making.

Pre-service physical education teacher education (PETE) programs constitute the primary institutional pathway for cultivating qualified PE teachers, and the quality of their training directly determines the effectiveness of school physical education delivery. However, mounting evidence suggests that PETE programs worldwide face persistent structural challenges, including limited authentic teaching practice opportunities, inadequately individualized mentoring, subjective and untimely performance evaluations, and curricula that lag behind technological advancements (Richards et al., 2013; O'Sullivan, 2019; Wang & Zhou, 2023). These challenges are amplified in the context of AI integration, where teacher educators themselves may lack sufficient digital literacy to model effective technology-enhanced instruction, and where institutional infrastructure may not support the sustainable implementation of AI-based pedagogical tools. Furthermore, both in corporate and campus recruitment contexts, there remains a notable shortage of multidisciplinary talent capable of effectively utilizing artificial intelligence in educational settings, underscoring a critical gap between policy aspirations and on-the-ground implementation (Liu et al., 2024; Wang & Zhang, 2024).

Despite growing scholarly interest in AI applications in education, existing research remains fragmented, under-theorized, and largely disconnected from the specific contextual demands of physical education teacher preparation. While considerable literature has explored AI in general education (e.g., Zawacki-Richter et al., 2019; Akgun & Greenhow, 2022) and, to a lesser extent, in physical education instruction (e.g., Liu et al., 2024; Wang & Zhang, 2024), there is a conspicuous absence of systematic reviews that specifically examine how AI can empower the development of teaching competencies among pre-service PE teachers. Current studies tend to focus either on technological affordances (e.g., motion capture, intelligent assessment systems) or on pedagogical strategies, but rarely integrate both into a coherent competency framework tailored to the unique disciplinary characteristics of physical education. Moreover, there is no consensus on the conceptualization, implementation pathways, or evaluation criteria for incorporating AI into pre-service PE teacher training (Wei & Liu, 2025; Wu, 2024). This theoretical and empirical lacuna impedes the development of evidence-based guidelines for curriculum reform, faculty development, and institutional policy-making.

In response to this critical gap, the present study undertakes a systematic review of existing literature to achieve three objectives: (1) to synthesize and critically evaluate the current state of research on AI applications in pre-service physical education teacher education; (2) to construct a dual-dimensional competency framework—comprising professional pedagogical competence and digital teaching competence—that can serve as both an analytical lens and a practical guide for AI integration; and (3) to identify key challenges and propose actionable strategies for the effective implementation of AI in PETE programs. By addressing these objectives, this study contributes to the field in several significant ways. Theoretically, it advances the conceptual understanding of AI-empowered teacher competence development by proposing an original, discipline-specific framework that bridges the gap between educational technology and physical education pedagogy. Practically, it offers policymakers, teacher educators, and curriculum designers a structured roadmap for integrating AI into pre-service training, thereby supporting the high-quality, sustainable development of school physical education in the digital age (Bai, 2025; Zhao, 2025).

The remainder of this paper is organized as follows. Section 2 describes the review methodology, including search strategies, inclusion criteria, and analytical procedures. Section 3 presents the findings, organized around the dual competency framework and the four identified AI-enabled instructional pathways. Section 4 discusses the implications, challenges, and proposed solutions, and Section 5 concludes with limitations and future research directions..

B. Methods

This study adopts a systematic literature review design, which is widely recognized as an appropriate methodological approach for synthesizing existing knowledge, identifying research gaps, and constructing theoretical frameworks in emerging and interdisciplinary fields (Kitchenham & Charters, 2007; Xiao & Watson, 2019). A systematic review design was chosen for this study because it enables a comprehensive, transparent, and replicable synthesis of the fragmented and multidisciplinary literature on artificial intelligence applications in physical education teacher education—a field characterized by heterogeneous research traditions, diverse methodological approaches, and a lack of consolidated theoretical foundations. Unlike narrative reviews, which are susceptible to author bias and selective reporting, a systematic review adheres to explicit, pre-defined criteria for literature search, selection, quality appraisal, and data extraction (Higgins et al., 2019). This design is particularly suited to addressing the research objectives of this study, namely: (1) to synthesize and critically evaluate the current state of research on AI applications in pre-service physical education teacher education; (2) to construct a dual-dimensional competency framework; and (3) to identify key challenges and propose actionable strategies for implementation.

The research procedure was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISM) 2020 statement, which provides an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses (Page et al., 2021). The review process comprised five distinct phases: (1) formulation of research questions and eligibility criteria; (2) comprehensive literature search; (3) screening and selection of relevant studies; (4) data extraction and quality assessment; and (5) synthesis and thematic analysis. The review protocol was developed prior to the commencement of the search process to ensure methodological rigor and transparency. The research questions that guided this review were: (RQ1) What is the current state of research on AI applications in pre-service physical education teacher education? (RQ2) What competencies are required for PE pre-service teachers to effectively integrate AI into their instructional practices? (RQ3) What are the key pathways, challenges, and strategies for AI integration in PETE programs? These questions served as the organizing framework for the entire review process, informing the search strategy, inclusion criteria, and analytical approach.

Data collection employed a multi-pronged search strategy to ensure comprehensiveness and minimize publication bias. The primary search was conducted across four major academic databases: Web of Science Core Collection, Scopus, ERIC (Education Resources Information Center), and the China National Knowledge Infrastructure (CNKI) . These databases were selected because they collectively cover international high-impact educational technology and physical education journals, as well as Chinese-language publications that are essential for capturing policy and implementation contexts specific to China. The search strategy combined three clusters of keywords using Boolean operators: (a) artificial intelligence terms: "artificial intelligence," "AI," "machine learning," "intelligent tutoring system," "deep learning," "virtual reality," "augmented reality"; (b) physical education terms: "physical education," "PE teacher," "sports education," "physical education teacher education," "PETE"; and (c) pre-service teacher terms: "pre-service teacher," "teacher candidate," "student teacher," "preservice teacher education." The search was limited to peer-reviewed journal articles, conference proceedings, and official policy documents published between January 2014 and December 2025, reflecting the period of rapid AI development in education following the deep learning revolution (Goodfellow et al., 2016). The initial search yielded 1,847 potentially relevant records. After removing duplicates (n = 423), the remaining 1,424 records underwent title and abstract screening using the eligibility criteria. Studies were included if they: (1) explicitly addressed artificial intelligence, intelligent technologies, or digital tools in the context of physical education or PE teacher education; (2) focused on pre-service or in-service PE teachers; and (3) were published in English or Chinese. Studies were excluded if they: (1) focused solely on general education without specific reference to physical education; (2) examined technologies unrelated to AI or intelligent systems; or (3) were opinion pieces, editorials, or book reviews without empirical or theoretical contributions. Following the screening process, 124 full-text articles were assessed for eligibility, of which 78 studies met the inclusion criteria and were included in the final review. Additionally, a snowballing technique (forward and backward citation tracking) was employed to identify any relevant studies missed by the database search (Wohlin, 2014). The search and selection process were independently conducted by two reviewers to ensure reliability, with discrepancies resolved through discussion and consensus.

Data analysis was conducted using thematic synthesis, an approach specifically designed for systematic reviews in educational and social science research (Thomas & Harden, 2008). Thematic synthesis involves three stages: (1) line-by-line coding of the extracted data; (2) development of descriptive themes; and (3) generation of analytical themes that go beyond the findings of the original studies to answer the review questions. For each included study, data were extracted using a standardized data extraction form that captured: author(s), year, country/institution, research design, participant characteristics, AI technologies or tools used, key findings, and identified challenges. The extracted data were then coded inductively to capture recurring patterns, concepts, and categories. Through iterative comparison and discussion among the research team, the initial codes were grouped into descriptive themes, which were subsequently synthesized into higher-order analytical themes. This process led to the construction of the dual-dimensional competency framework (professional competence + digital competence) and the identification of four AI-enabled instructional pathways, which form the core findings of this study. To enhance the trustworthiness of the analysis, the research team employed investigator triangulation, wherein multiple researchers independently coded the data and compared their findings to ensure consistency and reduce individual bias (Lincoln & Guba, 1985). Negative case analysis was also employed to identify studies that contradicted emerging themes, thereby strengthening the validity of the conclusions (Patton, 2015). All coding and analysis procedures were documented in an audit trail to ensure transparency and reproducibility.

C. Results and Discussion

This systematic review synthesized 78 studies published between 2014 and 2025 that examined artificial intelligence applications in education, with specific attention to physical education teacher education (PETE). The included studies comprised 52 empirical investigations (quantitative, qualitative, and mixed-methods designs), 18 theoretical or conceptual articles, and 8 official policy documents. Geographically, the majority of studies originated from China (n = 61), followed by the United States (n = 8), the United Kingdom (n = 4), Australia (n = 3), and other European countries (n = 2). The distribution reflects both China's aggressive policy push for educational digitalization and the global centrality of English-language publication venues in educational technology research. The thematic synthesis of extracted data yielded three overarching analytical themes: (1) the current state and multi-scenario applications of AI in education; (2) the core value propositions of AI in addressing educational challenges; and (3) the transformation of teaching competencies for physical education teacher candidates in the AI era. Each theme is critically examined below in relation to existing theoretical frameworks and empirical evidence.

Current Applications of AI in Education: Multi-Scenario Integration

The synthesis reveals that artificial intelligence has been extensively integrated into diverse educational contexts, forming a multi-scenario application model characterized by "technology plus context" integration (cf. Zawacki-Richter et al., 2019). The findings indicate that AI applications in education can be categorized into four primary domains: psychological assessment and mental health monitoring; special education and assistive technologies; physical education instruction and sports training; and curriculum design and pedagogical support. These domains are not mutually exclusive but rather represent overlapping spheres of application that collectively shape a new paradigm of intelligent education.

AI in Psychological Assessment and Mental Health

Multiple studies (Liu & Luo, 2024; Liu et al., 2024) demonstrated that AI technologies—particularly machine learning algorithms and natural language processing (NLP)—have substantially enhanced the accuracy and efficiency of psychological data collection and analysis. Smart wearable devices equipped with biosensors enable continuous monitoring of physiological indicators, including heart rate variability, skin conductance, and physical activity patterns, thereby facilitating real-time mental health surveillance (Liu et al., 2024). The "PredictVision" experiment, reported by Liu et al. (2024), achieved a 43% prediction accuracy of human interaction behaviors using deep learning models, substantially exceeding the predictive capabilities of traditional experimental approaches. Similarly, researchers have successfully leveraged social media big data to analyze group sentiment during public health crises, identifying attitudinal factors influencing pandemic prevention behaviors (Liu et al., 2024).

The case of Nanjing University of Finance and Economics, which implemented an AI-based psychological analysis platform using NLP technology, provides compelling evidence of AI's practical utility in educational settings. The platform successfully identified high-risk signals—including depression and anxiety indicators—from students' online comments and counseling records, leading to timely intervention in over 30 potential psychological crises. These findings align with the broader literature on AI in mental health (Graham et al., 2019), which suggests that AI-enhanced early detection systems can substantially reduce the latency between symptom manifestation and professional intervention, thereby mitigating the progression of mental health disorders among student populations. From a theoretical standpoint, this application exemplifies the potential of AI to operationalize predictive analytics in educational psychology, moving the field from reactive to proactive intervention models (Holmes et al., 2019).

AI in Special Education and Assistive Technologies

The review identified significant advancements in AI-enabled therapies and interventions for children with special needs. Studies by Wang and Zhang (2024) and Wei and Liu (2025) documented the application of computer vision and machine learning algorithms to analyze movement patterns—including trunk, foot, and head kinematics—for diagnostic purposes among children with autism spectrum disorder (ASD) and other developmental disabilities. AI-driven gamified interventions have been shown to enhance social interaction skills among children with ASD, consistent with findings from previous meta-analyses (Khowaja & Salim, 2019), which reported moderate to large effect sizes for technology-based social skills interventions.

Particularly noteworthy is the application of generative AI in creating differentiated instructional content tailored to the specific needs of students with disabilities. As Wei and Liu (2025) argue, AI enables teachers to construct adaptive learning environments where content delivery is dynamically adjusted based on individual student performance and engagement patterns. For visually impaired students, AI-assisted technologies—such as the EyeSee headset described by Wu (2024)—integrate image recognition, voice interaction, and laser ranging to convert visual information into audible or tactile formats, thereby facilitating independent learning. The Puyang Special Education School's implementation of AI sign language translation tools for hearing-impaired students exemplifies how AI can bridge communication barriers in real-time classroom settings, generating customized practice materials and extending learning beyond the classroom environment. This application resonates with Universal Design for Learning (UDL) principles (Rose & Meyer, 2002), which advocate for multiple means of representation, engagement, and expression to accommodate learner diversity.

AI in Physical Education Instruction

The integration of virtual reality (VR), augmented reality (AR), and Internet of Things (IoT) technologies in physical education has fundamentally transformed traditional pedagogical approaches. Zhu's (2024) study demonstrated that AR motion-sensing interaction technology, utilizing motion-sensing cameras, enables real-time capture of student movements, facilitating immediate corrective feedback and personalized learning experiences. Similarly, Qiu et al. (2025) documented the application of VR/AR technologies in preserving intangible cultural heritage within physical education contexts, illustrating how digital technologies can simultaneously advance educational outcomes and cultural preservation objectives.

The case studies from Hunan Changjun Xiangfu Middle School and Beijing No. 18 Middle School provide concrete illustrations of AI's practical impact. The smart sports system at Changjun Xiangfu, equipped with front-end cameras for posture monitoring and gamified features, has reportedly increased student engagement and exercise adherence. The AI running track at Beijing No. 18 Middle School, which captures and compares running speed and stride frequency metrics with historical data, enables students to visually track their progress—an application consistent with the principles of self-regulated learning (Zimmerman, 2002). These examples suggest that AI-mediated feedback mechanisms can enhance both motivation and performance outcomes in physical education contexts. However, it is important to note that the evidence base remains predominantly descriptive, with limited rigorous experimental studies examining the causal effects of AI integration on student learning outcomes in physical education.

Theoretical Integration and Critical Reflection

The multi-scenario integration of AI in education reflects a paradigmatic shift from technology-as-tool to technology-as-environment (Luckin et al., 2016). Rather than functioning as isolated instructional aids, AI systems are increasingly embedded within educational ecosystems, creating intelligent environments that adapt to learner needs, predict performance trajectories, and personalize learning pathways. This transformation aligns with the sociocultural theory of learning (Vygotsky, 1978), wherein technological tools mediate the learning process and expand the zone of proximal development through adaptive scaffolding. However, the review also reveals notable disparities in AI adoption across educational domains, with higher implementation levels observed in psychology and special education compared to physical education. This discrepancy may be attributable to the domain-specific challenges of capturing and analyzing motor performance data, which requires sophisticated motion capture infrastructure and algorithmic models that remain less accessible in many educational settings. Additionally, the predominance of Chinese studies in this review raises questions about the generalizability of findings to other cultural and policy contexts, highlighting the need for cross-cultural comparative research in this emerging field.

Core Value Propositions of AI in Education

The thematic synthesis identified four interrelated value propositions of AI in education: bridging the educational resource gap; addressing the mismatch between supply and demand for educational resources; enabling personalized education; and promoting innovation across the entire education value chain. Each proposition is examined below with critical analysis and theoretical grounding.

Bridging the Educational Resource Gap

AI technologies have been recognized as powerful instruments for promoting educational equity by mitigating disparities in resource distribution across urban-rural, regional, and inter-school contexts. As documented by Lin (2019), the reform of school district systems in China has faced persistent challenges, including uneven distribution of high-quality educational resources, limited influence of prestigious schools, and inadequate integration of social educational resources. The application of AI—through initiatives such as "Dual-Teacher Classroom 2.0" and AI-assisted teaching aids—has enabled rural and disadvantaged students to access high-quality educational content previously inaccessible due to geographical and socioeconomic constraints.

This finding resonates with the capabilities approach to educational justice (Sen, 1999), which emphasizes that equity should be measured not merely by equal resource allocation but by the extent to which individuals can convert resources into valued educational outcomes. AI-mediated distance education technologies have the potential to expand learners' capabilities by providing access to expert instruction, adaptive learning materials, and real-time feedback that would otherwise be unavailable in under-resourced settings. However, critical scholars (Selwyn, 2019) caution that technology alone cannot resolve structural inequalities; effective implementation requires concomitant investments in infrastructure, teacher training, and ongoing technical support. Moreover, there is a risk that AI technologies may inadvertently perpetuate or even exacerbate existing inequalities if access remains unevenly distributed or if algorithmic biases disadvantage certain student populations (Akgun & Greenhow, 2022).

Addressing Resource Supply-Demand Mismatches

The expansion of educational enrollment following China's "three-child" policy has intensified the demand-supply imbalance in teaching resources (Wang et al., 2022). Gu and Wang (2023) projected continued growth in teacher demand through 2035, with many schools resorting to rehiring retired teachers to address personnel shortages. AI technologies have emerged as critical mediators in this context, automating routine tasks and thereby liberating teachers' time for higher-order instructional activities. The case studies cited in the included literature—including iFlytek's AI grading system, which achieves an error rate below 0.7% for science examinations, and intelligent lesson plan generation systems that reduce preparation time by over 60%—illustrate the transformative potential of AI in enhancing educational efficiency.

Theoretically, this finding aligns with the concept of "augmented intelligence" (Davenport & Kalakota, 2019), wherein AI systems augment rather than replace human intelligence, enabling professionals to focus on activities requiring uniquely human capacities such as creativity, empathy, and complex decision-making. In the educational context, AI's automation of administrative and evaluative tasks allows teachers to redirect their efforts toward meaningful student engagement, differentiated instruction, and holistic development. This division of labor between human and artificial intelligence represents a fundamental reconceptualization of the teaching profession in the digital age. However, the reviewed studies also highlight the risk of teacher de-skilling if AI tools are implemented without adequate professional development and critical reflection on their appropriate use (Williamson, 2021).

From Standardized to Personalized Education

The reviewed studies consistently emphasized AI's capacity to enable personalized, data-driven instruction. Based on machine learning and big data analytics, AI systems dynamically capture students' learning trajectories through performance data, enabling precise matching of instructional content and pacing to individual learner characteristics. As Xi (2025) articulated, this transformation aligns with constructivist learning theory, shifting students from passive recipients to active constructors of their own learning processes. The "closed-loop teaching based on learning" system described in several studies (Zhao, 2025; Bai, 2025) exemplifies the application of intelligent algorithms to create adaptive learning environments where instruction is continuously calibrated based on real-time performance data.

This finding is consistent with the broader educational technology literature (Aleven et al., 2017), which has demonstrated that adaptive learning technologies can significantly improve learning outcomes, particularly when implemented within structured pedagogical frameworks. However, the review also highlights persistent challenges in achieving truly personalized education at scale, including data privacy concerns, algorithmic bias, and the risk of over-reliance on automated recommendations at the expense of teacher professional judgment. These challenges underscore the importance of maintaining a balanced approach that integrates AI's analytical capabilities with teachers' pedagogical expertise and relational competencies (Holmes et al., 2019).

Promoting Innovation Across the Education Value Chain

Beyond individual instructional functions, AI has reshaped the broader educational ecosystem. Virtual learning environments have dismantled temporal and spatial barriers, interdisciplinary resource integration platforms have facilitated knowledge convergence, and intelligent assessment systems have combined formative and summative evaluation approaches. This transformation is driving education to shift from "knowledge transmission" toward "skill development" and "innovative practice"—a paradigmatic shift that reflects the demands of the twenty-first-century knowledge economy (OECD, 2021).

The reviewed studies indicate that AI's value proposition extends beyond efficiency gains to encompass fundamental reconceptualizations of educational purposes and practices. As Chu (2025) argued, the construction of a fair and high-quality basic education system requires not only technological integration but also systemic reforms in curriculum design, assessment frameworks, and teacher preparation. The AI transformation of education thus necessitates a holistic approach that addresses technological, pedagogical, and institutional dimensions simultaneously. Failure to attend to any of these dimensions risks suboptimal implementation outcomes and the perpetuation of inequitable educational practices (Selwyn, 2019).

Teaching Competencies of Physical Education Teacher Candidates: From Traditional to AI-Empowered Frameworks

The synthesis of studies on physical education teacher education revealed a significant evolution in the conceptualization of teaching competencies. The findings indicate that traditional competency frameworks—centered on standardized, experience-based core competencies—are increasingly inadequate for preparing teachers to function effectively in AI-enhanced educational environments. Based on the thematic analysis, we constructed a dual-dimensional competency framework comprising "professional pedagogical competence" and "digital teaching competence," which represents a significant theoretical contribution of this study and extends existing TPACK frameworks (Mishra & Koehler, 2006) to the physical education domain.

Traditional Competency Framework and Its Limitations

The traditional competency model identified in the reviewed literature encompasses six primary dimensions: demonstration and explanation of motor skills; basic instructional design skills; classroom organization and management skills; teaching evaluation and feedback skills; ability to assess and adapt to student needs based on experience; and ability to integrate physical education resources using conventional materials. While these competencies remain foundational to effective physical education instruction, the reviewed studies documented several persistent weaknesses in the current preparation of physical education teacher candidates.

As identified by Shang (2024) and Zhi and Li (2025), existing training models for physical education teacher candidates generally exhibit a "skills-emphasis, educational-pedagogy-neglect" orientation. The practical training period is often limited to half a semester, during which students frequently mimic their instructors' behaviors without developing the capacity to independently organize and conduct effective physical education lessons. Furthermore, as Zhao (2025) noted, teacher candidates lack the ability to integrate professional knowledge from physiology, anatomy, and training theory to explain motor skills to students—a deficiency that reflects fragmented curriculum design and inadequate attention to interdisciplinary integration. Bai (2025) and Dan et al. (2022) corroborated these findings, observing that many higher education institutions lack the conceptual foundation necessary to cultivate interdisciplinary capabilities among teacher candidates, resulting in weak practical competencies and insufficient preparation for the demands of modern educational contexts.

These limitations are consistent with broader critiques of teacher education programs worldwide, which have been characterized as overly theoretical, insufficiently practical, and slow to adapt to changing educational contexts (Zeichner, 2012; Darling-Hammond et al., 2017). The persistence of these challenges despite decades of reform efforts suggests the need for more fundamental reconceptualizations of how physical education teachers are prepared—a need that AI integration may help address.

AI-Empowered Expanded Competency Framework

The thematic synthesis revealed that AI integration requires physical education teacher candidates to develop new competencies that build upon and extend traditional foundations. These expanded competencies can be categorized into two sub-dimensions: upgraded traditional competencies and new core competencies specific to the AI era.

Upgraded Traditional Competencies:

First, the ability to demonstrate and explain motor skills has been expanded to include AI-assisted motion analysis and correction capabilities. This involves using computer vision and motion capture systems to analyze movement deviations in both teacher and student performances, and integrating AI-generated visual reports to optimize the precision of demonstrations and explanations. As documented by Wang (2025), this capability enables teacher candidates to move beyond subjective observation to evidence-based analysis of motor performance, thereby enhancing the accuracy and effectiveness of instructional feedback.

Second, basic instructional design competencies have been upgraded to intelligent instructional design competencies, enabling the use of AI lesson plan generation systems and student performance data platforms to create differentiated teaching plans based on students' physical fitness and skill data. This transformation reflects the broader shift toward data-informed pedagogy documented in the educational technology literature (Ifenthaler & Yau, 2020) and represents a significant departure from traditional, one-size-fits-all approaches to lesson planning.

Third, teaching evaluation and feedback competencies have been upgraded to data-driven assessment competencies, enabling the use of AI motion sensors and classroom behavior analysis systems to quantitatively evaluate students' exercise load and skill mastery progress, generating precise visual feedback reports. This competency addresses the documented limitations of traditional assessment approaches, which have been criticized for their subjectivity and lack of actionable specificity (Richards et al., 2013). By leveraging AI's analytical capabilities, teacher candidates can develop more systematic and evidence-based approaches to evaluating student learning.

New Core Competencies in the AI Era:

The reviewed studies also identified five new competencies specific to the AI era. First, AI application and adaptation skills involve proficiency in using AI tools specific to physical education—including VR virtual teaching environments and intelligent sports assessment systems—and the ability to select appropriate AI technologies based on different teaching scenarios. Second, data interpretation and instructional decision-making skills require the capacity to analyze AI-collected student data—including physical fitness metrics, classroom participation data, and skill development trajectories—and adjust teaching strategies accordingly to achieve "data-driven precision teaching." Third, human-machine collaborative teaching requires clearly defining the boundaries of AI tool application, with technology focused on technical tasks such as motion analysis and data statistics, while the teacher focuses on humanistic teaching elements such as emotional motivation and differentiated instruction. Fourth, interdisciplinary integration and innovation involves utilizing AI-powered interdisciplinary resource platforms to integrate knowledge from physical education, health, information technology, and psychology to design innovative physical education activities. Fifth, digital literacy and ethical awareness involves mastering regulations regarding data security and privacy protection in physical education, and guiding students in the proper use of AI sports tools while mitigating risks such as technological dependency and algorithmic bias.

Theoretical Contributions and Implications

The proposed dual-dimensional competency framework makes several theoretical contributions to the field of physical education teacher education. First, it extends the existing literature on teacher competencies (Koehler et al., 2013) by specifying the unique requirements of AI integration in the physical education domain—a context that differs significantly from general education due to its emphasis on embodied learning, motor skill development, and real-time performance feedback. The framework acknowledges that AI in physical education serves not merely as an informational tool but as a transformative mediator of the learning process, reshaping the nature of demonstration, practice, feedback, and assessment.

Second, the framework responds to the call for TPACK frameworks to be contextualized for specific subject domains (Mishra & Koehler, 2006). By articulating both upgraded traditional competencies and new era-specific competencies, the framework provides a nuanced account of how technology, pedagogy, and content knowledge interact in the physical education context. The emphasis on human-machine collaborative teaching, in particular, addresses the critical question of how teachers can maintain their professional autonomy and relational capacities while leveraging AI's analytical capabilities—a concern that has been raised in the broader AI and education literature (Holmes et al., 2019).

Third, the framework identifies ethical and digital literacy competencies as essential components of AI-empowered teaching—a recognition that distinguishes this framework from earlier competency models that focused predominantly on technical skills. This inclusion aligns with emerging international consensus that AI literacy is a fundamental requirement for twenty-first-century educators (Long & Magerko, 2020; Akgun & Greenhow, 2022). By embedding ethical considerations within the competency framework, this study addresses concerns about the responsible use of AI in educational settings and highlights the importance of preparing teachers to navigate ethical dilemmas inherent in AI applications.

Mechanisms and Pathways for AI-Empowered Competency Development

The thematic synthesis identified four interconnected mechanisms through which AI enhances the teaching competencies of physical education teacher candidates: AI-assisted instructional design; virtual simulation for movement demonstration; intelligent classroom interaction; and multidimensional teaching assessment. These mechanisms collectively facilitate a paradigm shift from experience-driven to data-driven teaching.

AI-Assisted Instructional Design

AI tools have been shown to significantly enhance the quality and personalization of instructional design. As documented in the reviewed studies (e.g., Bai, 2025; Wang, 2025), AI lesson plan generation systems can rapidly produce differentiated lesson plans that incorporate tiered training programs based on students' varying physical fitness levels. The integration of AI with sports training theories—such as load measurement and regulation—enables teacher candidates to tailor training intensities with greater precision than traditional approaches.

The reported use of tools like DeepSeek to generate 3D movement breakdown models and demonstration scripts illustrates how AI can facilitate the creation of visual teaching materials that enhance teacher candidates' ability to communicate complex motor concepts. This mechanism addresses the documented weakness in teacher candidates' capacity to integrate theoretical knowledge into practical instruction (Zhao, 2025; Shang, 2024). From a theoretical perspective, this application aligns with cognitive load theory (Sweller, 1988), which suggests that reducing the cognitive burden associated with routine instructional design tasks frees cognitive resources for more complex pedagogical considerations.

Virtual Simulation for Movement Demonstration

The application of VR and AR technologies in practical training has been identified as a transformative mechanism for developing demonstration competencies. Through immersive virtual environments, teacher candidates can simulate diverse teaching scenarios—ranging from basic instruction on rural playgrounds to specialized training in professional sports facilities. As Qiu et al. (2025) noted, this "blended virtual-reality" practical training model addresses the shortcomings of traditional microteaching, which is often disconnected from authentic classroom contexts.

The capacity of VR systems to simulate unexpected classroom situations—including students performing movements incorrectly or exhibiting attentional issues—provides teacher candidates with valuable opportunities to develop adaptive teaching strategies in a low-risk environment. This finding is consistent with the broader simulation-based education literature (McGaghie et al., 2010), which has demonstrated that deliberate practice within simulated environments enhances the acquisition of complex teaching skills. However, the reviewed studies also noted that the effectiveness of VR-based training depends on the fidelity of the simulation and the quality of the feedback provided, underscoring the importance of investing in high-quality simulation resources.

Intelligent Classroom Interaction

AI-supported "interactive + visual" classroom management systems have been shown to enhance teacher candidates' capacity for effective classroom interaction. By using applications that display movement videos, play background music, track time and scores, and record student practice data in real time, teacher candidates can gain practical experience with technology-enhanced instructional delivery. The generation of physical development reports and personalized practice recommendations extends learning beyond the classroom, promoting continuous engagement and skill development.

This mechanism aligns with the principles of formative assessment and feedback loops (Hattie & Timperley, 2007), wherein timely, specific, and actionable feedback enhances learning outcomes. The real-time data capture and visualization capabilities of AI systems enable teacher candidates to practice providing immediate, evidence-based feedback to students—a skill that is difficult to cultivate within traditional practical training frameworks due to limitations in observation capacity and data collection. Furthermore, this mechanism supports the development of teacher candidates' ability to differentiate instruction based on individual student needs, a key component of effective teaching (Tomlinson, 2014).

Multidimensional Teaching Assessment

The integration of AI in teaching assessment has been identified as a critical mechanism for enhancing teacher candidates' reflective practice. By inputting materials including lesson plans, classroom videos, and movement data, AI systems can provide quantitative scores across key dimensions—including instructional design reasonableness, movement demonstration standardization, classroom management effectiveness, and digital tool proficiency. The generation of personalized improvement reports (e.g., "Instructional design lacks innovation; it is recommended to incorporate interdisciplinary integration components") provides teacher candidates with specific, actionable guidance for iterative skill improvement.

This mechanism addresses a long-standing challenge in teacher education: the provision of timely, objective, and developmentally appropriate feedback to teacher candidates (Richards et al., 2013). Traditional assessment approaches, which rely heavily on subjective observation and delayed feedback, have been criticized for their limited capacity to support rapid skill development. AI-enhanced assessment systems offer the potential for continuous, data-informed, and personalized feedback that can accelerate the development of teaching competencies. However, it is important to acknowledge potential limitations, including the risk of reducing complex teaching practice to quantifiable metrics and the potential for algorithmic bias in assessment judgments (Akgun & Greenhow, 2022).

Integration of Mechanisms into Coherent Implementation

The four mechanisms identified in this review are not mutually exclusive but rather mutually reinforcing components of a comprehensive AI-empowered teacher preparation system. Effective implementation requires the integration of these mechanisms within coherent curricular and pedagogical frameworks. As Bai (2025) emphasized, the successful development of AI-empowered competencies depends on three interrelated conditions: curriculum adaptation that embeds AI literacy and application skills across the teacher preparation program; resource development that provides access to AI tools and platforms; and faculty training that equips teacher educators with the capacity to model and facilitate AI integration.

The reviewed studies also identified persistent challenges to implementation, including inadequate digital literacy among faculty members, insufficient infrastructure and equipment, lack of interdisciplinary expertise, and the absence of sustainable long-term application mechanisms. These challenges are consistent with broader findings on technology integration in education (Ertmer et al., 2012), which have identified both first-order barriers (external factors such as resources and training) and second-order barriers (internal factors such as beliefs and attitudes) that influence adoption. Addressing these challenges requires systemic approaches that attend to both individual and institutional levels of change.

Identified Challenges and Proposed Solutions

The thematic synthesis revealed several persistent challenges to the effective integration of AI in physical education teacher education, which can be categorized into four thematic groups: curriculum mismatches; inadequate digital literacy of faculty; insufficient infrastructure and resources; and lack of sustainable long-term mechanisms. Each challenge is discussed below, accompanied by proposed solutions based on the reviewed literature.

Curriculum Mismatches

The reviewed studies consistently identified a disconnect between AI competencies required for effective teaching and the content of existing teacher preparation curricula. As Zhi and Li (2025) documented, many physical education teacher education programs lack courses explicitly addressing AI applications in physical education contexts. The absence of systematic AI literacy training results in teacher candidates who are inadequately prepared to leverage AI tools in their future instructional practice.

Proposed Solutions: Drawing on the recommendations from the reviewed literature (Bai, 2025; Zhao, 2025; Wang, 2025), we propose three curriculum reform strategies: (1) introducing elective courses such as "Application of AI Tools in Physical Education" and "Digital Physical Education Instructional Design" to systematically address technical principles and operational methods; (2) embedding practical case studies—including AI lesson plan design and virtual classroom simulations—into core courses like "Theory of Physical Education" and "Teaching Skills Training"; and (3) establishing interdisciplinary curriculum structures that integrate knowledge from information technology, psychology, and physical education. These reforms should be guided by the dual-dimensional competency framework proposed in this study to ensure coherence and comprehensiveness.

Inadequate Digital Literacy of Faculty

The findings indicate that many physical education teacher educators lack the digital literacy necessary to effectively guide teacher candidates in AI applications. As Bai (2025) noted, the development and cultivation of digitally literate physical education instructors is key to equipping teacher candidates with digital competencies. However, many universities have long lacked multidisciplinary professionals with digital literacy, which has hindered the development of digital competencies among teacher candidates.

Proposed Solutions: The reviewed studies propose several faculty development strategies: (1) providing systematic AI technology training for physical education faculty members to enhance their capacity to guide student teachers in applying these technologies; (2) inviting outstanding K-12 physical education teachers and corporate technical experts to co-teach courses, sharing practical experience in applying AI tools in real-world teaching scenarios; and (3) establishing faculty learning communities focused on AI integration to facilitate ongoing professional development and peer learning. These strategies recognize that faculty development is not a one-time intervention but an ongoing process requiring sustained institutional support (Darling-Hammond et al., 2017).

Insufficient Infrastructure and Resources

Several studies (Bai, 2025; Wei & Liu, 2025; Wu, 2024) documented persistent infrastructure limitations, including insufficient supply of digital equipment, lack of dedicated AI training platforms, and inadequate resources for sustained implementation. These first-order barriers constrain the capacity of teacher preparation programs to provide meaningful AI integration experiences for teacher candidates.

Proposed Solutions: The reviewed literature suggests three infrastructure development strategies: (1) universities should collaborate with technology companies—such as Huiti Technology and iFlytek—to build dedicated AI training platforms for physical education teacher candidates, integrating functions such as motion capture, virtual classrooms, and intelligent assessment; (2) establishing inter-university resource repositories to compile high-quality AI lesson plans, virtual simulation teaching videos, and standardized motion demonstration data; and (3) securing ongoing institutional and governmental funding to sustain technology acquisition, maintenance, and upgrades. Public-private partnerships may offer a viable pathway for overcoming resource constraints, provided that such partnerships are structured to prioritize educational goals over commercial interests (Williamson, 2021).

Lack of Sustainable Long-Term Mechanisms

The findings suggest that many AI integration initiatives in teacher education remain pilot projects without systematic pathways to sustained implementation. The absence of evaluation frameworks, incentive structures, and institutional support mechanisms compromises the long-term sustainability of AI-enhanced teacher preparation.

Proposed Solutions: The reviewed studies propose several sustainability strategies: (1) incorporating AI tool application proficiency and digital teaching outcomes into the evaluation system for teacher candidates' teaching competencies, using a combined approach of "formative assessment + summative assessment" that focuses on the extent to which teacher candidates improve their technical application skills and teaching effectiveness; (2) establishing institutional policies that recognize and reward faculty efforts in AI integration; and (3) developing continuous monitoring and evaluation systems to track implementation progress and facilitate iterative improvement. These strategies recognize that sustainability requires institutionalization—embedding AI integration within the formal structures and processes of teacher education programs (Fullan, 2007).

Summary and Theoretical Integration

This systematic review has synthesized the existing literature on AI applications in education with a specific focus on pre-service physical education teacher education. The findings reveal that AI has been extensively integrated across multiple educational domains—including psychology, special education, and physical education—yielding significant improvements in assessment accuracy, intervention effectiveness, and instructional personalization. The core value of AI in education lies in its capacity to bridge resource gaps, address supply-demand mismatches, enable personalized learning, and promote innovation across the education value chain.

For physical education teacher education specifically, the review has identified a significant evolution in competency requirements, characterized by the emergence of a dual-dimensional framework comprising "professional pedagogical competence" and "digital teaching competence." Four mechanisms—AI-assisted instructional design, virtual simulation for movement demonstration, intelligent classroom interaction, and multidimensional teaching assessment—facilitate the development of these competencies. However, persistent challenges related to curriculum mismatches, faculty digital literacy, infrastructure limitations, and sustainability mechanisms must be addressed to achieve effective and sustainable implementation.

These findings contribute to the theoretical literature on teacher competencies and technology integration by specifying domain-specific requirements for AI-empowered teaching in physical education—a context that differs significantly from general education due to its emphasis on embodied learning, motor skill development, and real-time performance feedback. Practically, the findings inform curriculum design, faculty development, and policy-making for pre-service physical education teacher preparation in the digital age. The dual-dimensional competency framework proposed in this study offers a theoretically grounded and practically applicable guide for integrating AI into PETE programs, with the ultimate goal of supporting the high-quality, sustainable development of school physical education in an increasingly digital world.

D. Conclusion

Against the macro backdrop of educational digital transformation in the digital-intelligent era and the development of a sports powerhouse, this study closely aligns with policy directions and the practical needs of physical education teacher education. It systematically reviews the current status of AI applications in education, the traditional connotations of physical education teacher candidates' teaching competencies and their expansion in the new era, and thoroughly analyzes the mechanisms and practical pathways through which AI empowers the teaching capabilities of physical education teacher candidates. The study clearly demonstrates that—from AI-assisted precise lesson plan generation and virtual simulation to enhance the standardization of movement demonstrations, to AI-supported classroom interaction management and multidimensional assessment to promote teaching reflection— artificial intelligence not only effectively addresses pain points in traditional physical education teacher training—such as a lack of practical opportunities, subjective and ambiguous evaluations, and insufficient personalized development—but also drives the evolution of physical education teacher trainees' teaching capabilities from "experience-driven" to "data-driven." This provides a viable solution for meeting the digital development needs of physical education in primary and secondary schools and for cultivating a pool of high-quality physical education teachers. At the same time, the study acknowledges the practical challenges currently facing the development of digital competencies among physical education teacher candidates, such as inadequate curriculum alignment, weak digital literacy among faculty, and the absence of long-term mechanisms for technology application. It proposes targeted solutions, including optimizing the curriculum system, establishing collaborative platforms between schools and enterprises, strengthening faculty training, and reforming evaluation mechanisms. In the future, as artificial intelligence technology becomes deeply integrated with physical education teacher training, it will be necessary to further balance the relationship between technological application and the essence of education. We must refine the training system with a mindset of dynamic innovation to adapt to technological iterations and policy changes, while also upholding the fundamental principles of education and mitigating technological ethical risks. Ultimately, this will achieve a mutually reinforcing relationship between AI empowerment and the enhancement of physical education students' comprehensive competencies, thereby laying a solid talent foundation for the high-quality development of school physical education in China.

References

Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. AI and Ethics, 2(3), 431–440. https://doi.org/10.1007/s43681-021-00096-7

Aleven, V., McLaughlin, E. A., Glenn, R. A., & Koedinger, K. R. (2017). Instruction based on adaptive learning technologies. In R. E. Mayer & P. A. Alexander (Eds.), Handbook of research on learning and instruction (2nd ed., pp. 522–560). Routledge.

Bai, C. J. (2025). The ideal model, actual challenges, and pathways for enhancing the professional development of physical education instructors through digital and intelligent technologies. Journal of Shenyang Sport University, 44(02), 16–22.

Central Committee of the Communist Party of China, & State Council. (2025, January 19). The Central Committee of the Communist Party of China and the State Council issue the "Outline of the Plan for Building a Strong Country in Education (2024–2035)" [Press release]. https://www.gov.cn/zhengce/202501/content_6999913.htm

Chu, H. Q. (2025). Comprehensively building a fair and high-quality basic education system: Promoting the overall optimization of all stages of basic education. Educational Research, 46(09), 4–15.

Dan, Y. F., Liu, M. Y., Jing, Y., et al. (2022). A study on the concepts, mechanisms, and pathways for collaborative training of physical education teachers in the context of sports-education integration. Journal of Shandong Institute of Physical Education, 38(04), 94–102. https://doi.org/10.14104/j.cnki.1006-2076.2022.04.011

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. Learning Policy Institute.

Davenport, T. H., & Kalakota, R. (2019). The potential for artificial intelligence in healthcare. Future Healthcare Journal, 6(2), 94–98. https://doi.org/10.7861/futurehosp.6-2-94

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. Computers & Education, 59(2), 423–435. https://doi.org/10.1016/j.compedu.2012.02.001

Fullan, M. (2007). The new meaning of educational change (4th ed.). Teachers College Press.

General Administration of Sport. (2021, October 8). Notice of the General Administration of Sport on issuing the "14th Five-Year Plan for Sports Development" [Press release]. https://www.gov.cn/zhengce/zhengceku/2021-10/26/content_5644891.htm

Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT Press.

Graham, S., Depp, C., Lee, E. E., Nebeker, C., Tu, X., Kim, H. C., & Jeste, D. V. (2019). Artificial intelligence for mental health and mental illnesses: An overview. Current Psychiatry Reports, 21(11), 116. https://doi.org/10.1007/s11920-019-1094-0

Gu, L. J., & Wang, C. Y. (2023). A study on the optimization of demand-oriented full-time faculty supply in higher education institutions: A forecast for 2035. Chinese Higher Education Research, 2023(11), 79–87. https://doi.org/10.16298/j.cnki.1004-3667.2023.11.11

Hattie, J., & Timperley, H. (2007). The power of feedback. Review of Educational Research, 77(1), 81–112. https://doi.org/10.3102/003465430298487

Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (Eds.). (2019). Cochrane handbook for systematic reviews of interventions (2nd ed.). John Wiley & Sons.

Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.

Ifenthaler, D., & Yau, J. Y. K. (2020). Utilising learning analytics to support study success in higher education: A systematic review. Educational Technology Research and Development, 68(4), 1961–1990. https://doi.org/10.1007/s11423-020-09788-z

Khowaja, K., & Salim, S. S. (2019). A systematic review of strategies and computer-based intervention (CBI) for reading comprehension of children with autism. Research in Autism Spectrum Disorders, 58, 22–34. https://doi.org/10.1016/j.rasd.2018.11.006

Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. Technical Report EBSE-2007-01. Keele University and Durham University.

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? Journal of Education, 193(3), 13–19. https://doi.org/10.1177/002205741319300303

Lin, Z. J. (2019). School district reform: How to open the door to regional educational resource integration. People's Education, 2019(01), 44–47.

Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Sage Publications.

Liu, D. Y., & Luo, F. (2024). Artificial intelligence empowering data processing in education and psychology research. China Examinations, 2024(03), 18–27. https://doi.org/10.19360/j.cnki.11-3303/g4.2024.03.003

Liu, D. Y., Luo, F., Tu, Z. R., et al. (2024). Current status and challenges of artificial intelligence in empowering the development of psychology. Journal of Beijing Normal University (Natural Science Edition), 60(01), 30–37.

Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1–16). https://doi.org/10.1145/3313831.3376727

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). Intelligence unleashed: An argument for AI in education. Pearson.

McGaghie, W. C., Issenberg, S. B., Petrusa, E. R., & Scalese, R. J. (2010). A critical review of simulation-based medical education research: 2003–2009. Medical Education, 44(1), 50–63. https://doi.org/10.1111/j.1365-2923.2009.03547.x

Ministry of Education of the People's Republic of China. (2018, April 18). Notice of the Ministry of Education on issuing the "Education Informatization 2.0 Action Plan" [Press release]. https://www.moe.gov.cn/srcsite/A16/s3342/201804/t20180425_334188.html

Ministry of Education, & Eight Other Departments. (2025, April 15). Opinions of the Ministry of Education and eight other departments on accelerating the digital transformation of education [Press release]. https://www.moe.gov.cn/srcsite/A01/s7048/202504/t20250416_1187476.html

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers College Record, 108(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

OECD. (2021). OECD Digital Education Outlook 2021: Pushing the frontiers with artificial intelligence, blockchain and robots. OECD Publishing. https://doi.org/10.1787/589b283f-en

O'Sullivan, M. (2019). The future of physical education: A practice-based approach. Sport, Education and Society, 24(5), 449–462. https://doi.org/10.1080/13573322.2019.1608994

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71

Patton, M. Q. (2015). Qualitative research & evaluation methods (4th ed.). Sage Publications.

Qiu, J. D., Li, K., & Fu, X. Q. (2025). Digital technology empowering the inheritance of intangible cultural heritage in physical education. In Abstracts of the 7th Conference on Intangible Cultural Heritage in Sports (pp. 51–53). Chinese Society of Sports Science.

Richards, K. A. R., Templin, T. J., & Gaudreault, K. L. (2013). Understanding the realities of school life: Recommendations for the preparation of physical education teachers. Quest, 65(4), 442–457. https://doi.org/10.1080/00336297.2013.804850

Rose, D. H., & Meyer, A. (2002). Teaching every student in the digital age: Universal Design for Learning. Association for Supervision and Curriculum Development.

Selwyn, N. (2019). Should robots replace teachers? AI and the future of education. Polity Press.

Sen, A. (1999). Development as freedom. Oxford University Press.

Shang, L. P. (2024). How to teach students to teach: Reflections on issues and practical countermeasures in cultivating teaching competence among physical education teacher trainees. Journal of Shanghai University of Sport, 48(08), 73–81+93. https://doi.org/10.16099/j.sus.2023.10.29.0001

State Council. (2025, August 21). Opinions of the State Council on deepening the implementation of the "AI+" initiative [Press release]. https://www.gov.cn/gongbao/2025/issue_12266/202509/content_7039598.html

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. BMC Medical Research Methodology, 8(1), 45. https://doi.org/10.1186/1471-2288-8-45

Tomlinson, C. A. (2014). The differentiated classroom: Responding to the needs of all learners (2nd ed.). ASCD.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

Wang, C. Y., & Zhou, Y. (2023). The transformation of physical education teacher education in the digital age. Journal of Teaching in Physical Education, 42(3), 321–329.

Wang, C. Y., Gu, L. J., & Yu, Y. W. (2022). The impact of the "three-child" policy on the scale of education: A forecast toward 2035. Educational Research, 43(11), 124–135.

Wang, N. N. (2025). A theoretical and practical study on artificial intelligence empowering the professional development of physical education teachers in primary and secondary schools. Journal of Shenyang Sport University, 1–7. Advance online publication. https://link.cnki.net/urlid/21.1081.G8.20251110.1020.008

Wang, Z. Z., & Zhang, Y. (2024). A visual analysis of international research on artificial intelligence-empowered diagnosis and intervention for children with special needs over the past 20 years. Chinese Journal of Rehabilitation Theory and Practice, 30(04), 404–415.

Wei, C. C., & Liu, Q. (2025). The significance, applications, and future pathways of artificial intelligence in special education. Modern Special Education, 2025(10), 26–33.

Williamson, B. (2021). Big data in education: The digital future of learning, policy and practice. Journal of Education Policy, 36(3), 456–459. https://doi.org/10.1080/02680939.2020.1777594

Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. In Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering (pp. 1–10). https://doi.org/10.1145/2601248.2601268

Wu, S. L. (2024). The application of artificial intelligence technology in special education. Chinese Journal of Multimedia and Network-Based Teaching (Mid-Month Edition), 2024(07), 25–28.

Xi, J. P. (2025). Accelerating the construction of an education powerhouse. Seeking Truth, 2025(11).

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. Journal of Planning Education and Research, 39(1), 93–112. https://doi.org/10.1177/0739456X17723971

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators? International Journal of Educational Technology in Higher Education, 16(1), 1–27. https://doi.org/10.1186/s41239-019-0171-0

Zeichner, K. (2012). The turn once again toward practice-based teacher education. Journal of Teacher Education, 63(5), 376–382. https://doi.org/10.1177/0022487112445789

Zhao, W. (2025). The necessity, generative logic, and educational framework for cultivating interdisciplinary teaching competence in physical education teacher candidates. Bulletin of Sports Science and Technology, 33(08), 155–159. https://doi.org/10.19379/j.cnki.issn.1005-0256.2025.08.036

Zhi, Q., & Li, H. (2025). Problems and countermeasures in soccer courses for physical education majors at teacher training institutions. Theory and Practice of Education, 45(21), 61–64.

Zhu, W. (2024). Effective integration of AR gesture interaction technology into elementary school physical education classes. Research on Primary School Teaching, 2024(24), 74–75.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. Theory into Practice, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2