

Digital-Age Competencies for Physical Education Teachers: An Integrated Development Framework for Vocational Education

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Abstract

This research examines the professional development needs of physical education teachers in vocational education institutions in the digital age. Using a sequential mixed-methods approach, we identified five core competency domains essential for effective teaching in contemporary vocational contexts. Data from 172 teachers revealed significant gaps between current competency levels and desired standards, particularly in pedagogical expertise and reflective practice. Based on these findings, we developed an integrated development framework that combines experiential learning (70%), social learning (20%), and theoretical training (10%). Expert evaluation confirms the applicability of this development framework across diverse institutional environments, presenting a scalable model for enhancing teacher competencies aligned with digital-age requirements.

Keywords: teacher competencies, physical education, vocational education, professional development, digital technology

1. Introduction

The landscape of vocational education is rapidly transforming amid digital disruption, technological advancement, and labor market restructuring. In this context, physical education faces unprecedented challenges and opportunities. Contemporary physical education not only focuses on developing physical skills and health but also plays a crucial role in fostering competencies essential for the modern workplace, such as teamwork, psychological resilience, and stress management skills (World Health Organization, 2020). Physical education teachers in vocational institutions must adapt to multiple challenges, including integrating digital technologies in teaching, responding to changing learning patterns of digital-native students, and developing instructional approaches aligned with labor market demands (European Commission, 2021). These changes call for a review and modernization of the competency framework for physical education teachers, consistent with Caena and Redecker's (2019) proposition that teacher competencies in the 21st century must integrate content knowledge, pedagogical skills, and digital capabilities.

From our study in China's vocational education system, we identified key challenges affecting physical education teacher effectiveness: (1) limitations in utilizing digital technologies to enhance teaching, (2) delayed adaptation to emerging physical activity trends and digital tools, (3) underdeveloped capacity for blended learning approaches in physical education, and (4) lack of professional development pathways aligned with digital-age requirements.

2. Objectives

This research pursued three primary objectives:

- 1) To analyze and define the essential competency components for physical education teachers in digital-age vocational institutions, considering content knowledge, pedagogical skills, and technological capabilities
- 2) To examine the gap between current and desired competencies of physical education teachers in vocational institutions, identifying high-priority development needs
- 3) To develop an integrated development framework emphasizing the combination of experiential learning, social learning, and theoretical knowledge that can address competency development needs and digital-age challenges

3. Scopes of Research

3.1 Content Scope

This research focuses on three primary areas: First, the identification and validation of digital-age competency components for physical education teachers in vocational settings, encompassing both traditional teaching skills and emerging technological capabilities. Second, the assessment of current competency levels, desired standards, and development priorities among practicing physical education teachers. Third, the development of an integrated framework that leverages experiential, social, and theoretical learning approaches to address identified competency gaps.

3.2 Conceptual Framework

The research is guided by a conceptual framework that integrates competency theory with digital transformation principles. This framework posits that effective physical education in contemporary vocational settings requires five interconnected competency domains:

- 1) Digital Pedagogical Expertise: The ability to integrate digital technologies effectively in physical education instruction
- 2) Professional Identity in Digital Contexts: The values and commitments that guide professional practice in technology-enhanced environments
- 3) Technical and Physical Literacy: The sport-specific skills and physical capabilities required for effective demonstration and instruction
- 4) Digital-Age Reflective Practice: The capacity for critical reflection enhanced by digital tools and online professional communities
- 5) Contextual Adaptability: The ability to navigate institutional environments while leveraging technological resources effectively

These domains form the foundation for examining competency gaps and developing an integrated enhancement framework that aligns with contemporary professional development approaches.

4. Research Methodology

4.1 Research Design

This study employed a sequential explanatory mixed-methods design, conducted in three interconnected phases. This approach enabled comprehensive exploration of both the breadth and depth of physical education teacher competencies in digital-age vocational settings.

Phase 1: Digital Competency Framework Synthesis

In this initial phase, we conducted a systematic literature review examining physical education teacher competencies in the digital age, encompassing international research, professional standards, and educational policy frameworks. The preliminary competency framework derived from this review was then subjected to expert validation through a Modified Delphi Technique involving five specialists with extensive experience in physical education pedagogy, vocational education administration, and educational technology integration. Through iterative feedback cycles, we refined the framework until reaching consensus on a comprehensive model of digital-age physical education competencies.

Phase 2: Competency Gap Analysis

The second phase focused on empirical assessment of current and desired competency levels. We collected quantitative data from 172 physical education teachers across six vocational institutions using a structured questionnaire with five-point Likert scales measuring self-assessed proficiency across identified competency domains. This quantitative assessment was supplemented with in-depth interviews with purposively selected participants to explore contextual factors affecting competency development, barriers to technology integration, and professional development experiences. The integration of quantitative and qualitative data provided a nuanced understanding of competency gaps within specific institutional contexts.

Phase 3: Integrated Framework Development and Validation

In the final phase, we synthesized findings from the previous phases to develop an integrated development framework responsive to identified needs. This framework was structured around the principles of experiential learning (70%), social learning (20%), and theoretical knowledge acquisition (10%), with specific implementation strategies for each competency domain. The framework underwent rigorous validation by five experts in physical

education, vocational education, and educational technology, who assessed its theoretical soundness, practical feasibility, and contextual adaptability.

4.2 Participants and Sampling

The study utilized stratified random sampling to ensure representation across institutional types and geographical contexts. Six vocational institutions were selected based on governance structure (public/private), technological infrastructure (advanced/developing), and geographical location. Within these institutions, all physical education teaching faculty were invited to participate, resulting in a final sample of 172 educators (response rate: 87%). The sample demographics reflected diversity in gender distribution (58% male, 42% female), teaching experience (mean: 8.7 years), and technological proficiency levels.

4.3 Research Instruments

The study employed multiple complementary instruments:

Digital Competency Assessment Questionnaire

This instrument measured current and desired proficiency levels across five competency domains using parallel five-point Likert scales. The questionnaire demonstrated excellent psychometric properties (Cronbach's $\alpha = 0.87$), with domain-specific reliability coefficients ranging from 0.79 to 0.91.

Semi-Structured Interview Protocol

The qualitative component utilized an interview protocol exploring competency development experiences, technology integration challenges, and professional development preferences. This instrument underwent content validation through Item-Objective Congruence assessment, with all items achieving acceptable validity indexes (0.67–1.00).

Framework Evaluation Form

Expert assessment of the developed framework used a structured evaluation protocol examining theoretical foundations, practical applicability, technological integration, and implementation feasibility.

4.4 Data Analysis

Quantitative data analysis employed descriptive statistics, gap analysis, and Priority Need Index modified (PNI_{modified}) calculations to identify development priorities. Qualitative data underwent thematic analysis following Braun and Clarke's (2006) six-step process, with coding verification through investigator triangulation. The integration of quantitative and qualitative findings employed complementary integration, with qualitative insights explaining and contextualizing quantitative patterns.

5. Research Findings

5.1 Digital-Age Competency Domains for Physical Education Teachers

Our systematic analysis identified five essential competency domains for physical education teachers in contemporary vocational education contexts:

Digital Pedagogical Expertise

This domain encompasses the capacity to design and implement effective physical education instruction using digital technologies. It includes competencies in technology-enhanced instructional design, digital assessment methods, virtual and augmented reality applications in movement education, and online physical activity monitoring. Expert validation confirmed this domain's highest priority ($\bar{X} = 4.82$, S.D. = 0.39), reflecting its critical importance in contemporary educational environments.

Professional Identity in Digital Contexts

This domain addresses the values, ethical principles, and professional self-concept that guide teaching practice in technology-mediated environments. It encompasses digital ethics, understanding of privacy considerations in physical activity tracking, professional presence in online environments, and commitment to inclusive digital pedagogy. This domain received strong expert validation ($\bar{X} = 4.76$, S.D. = 0.43), highlighting its foundational importance for professional practice.

Technical and Physical Literacy

This domain focuses on sport-specific skills and movement capabilities, complemented by the ability to demonstrate and analyze movement using digital tools. It includes traditional physical proficiencies alongside competencies in movement analysis software, digital demonstration techniques, and technology-enhanced skill

development approaches. Expert assessment confirmed this domain's high relevance ($\bar{X} = 4.78$, S.D.= 0.41) for effective instruction.

Digital-Age Reflective Practice

This domain encompasses metacognitive capabilities enhanced by digital tools and professional learning networks. It includes competencies in data-informed practice, digital portfolio development, online professional learning communities, and technology-supported self-assessment. Expert validation confirmed its importance ($\bar{X} = 4.68$, S.D. = 0.47) for continuous professional growth.

Contextual Adaptability

This domain addresses the ability to function effectively within institutional environments while leveraging technological resources appropriately. It encompasses digital classroom management, virtual collaboration skills, technology resource optimization, and work-life integration in connected environments. Expert assessment confirmed its significance ($\bar{X} = 4.72$, S.D.= 0.45) for sustainable professional practice.

The five-domain competency framework received strong overall validation ($\bar{X} = 4.75$, S.D. = 0.43), confirming its comprehensive coverage of professional capabilities required for physical education instruction in digital-age vocational settings.

5.2 Competency Gap Analysis

Our assessment of 172 physical education teachers revealed significant insights into current competency levels, desired standards, and development priorities.

Current competency levels demonstrated an overall moderate rating ($\bar{X} = 3.68$, S.D.= 0.85), indicating substantial room for professional growth. Among the five domains, Technical and Physical Literacy emerged as the strongest existing capability ($\bar{X} = 4.02$, S.D.= 0.88), reaching the "High" classification level. The remaining domains showed lower current proficiency: Contextual Adaptability ($\bar{X} = 3.76$, S.D.= 0.84), Professional Identity in Digital Contexts ($\bar{X} = 3.70$, S.D. = 0.83), Digital-Age Reflective Practice ($\bar{X} = 3.65$, S.D. = 0.86), and Digital Pedagogical Expertise ($\bar{X} = 3.27$, S.D.= 0.92).

Desired competency levels were consistently rated "Very High" across all domains ($\bar{X} = 4.37$, S.D.= 0.48), demonstrating substantial professional aspirations. Digital Pedagogical Expertise received the highest desired rating ($\bar{X} = 4.45$, S.D. = 0.51), followed by Digital-Age Reflective Practice ($\bar{X} = 4.39$, S.D. = 0.48), Contextual Adaptability ($\bar{X} = 4.36$, S.D. = 0.49), Professional Identity in Digital Contexts ($\bar{X} = 4.33$, S.D. = 0.47), and Technical and Physical Literacy ($\bar{X} = 4.32$, S.D. = 0.46).

The Priority Need Index modified (PNI_{modified}) calculation identified the most critical development priorities. Digital Pedagogical Expertise emerged as the highest priority (PNI = 0.265), followed by Digital-Age Reflective Practice (PNI = 0.169), Professional Identity in Digital Contexts (PNI = 0.145), and Contextual Adaptability (PNI = 0.138). Technical and Physical Literacy showed the lowest development priority (PNI = 0.070), consistent with its relatively strong current assessment.

Qualitative findings complemented these quantitative results, revealing that teachers experienced particular challenges in integrating emerging technologies into physical education instruction, analyzing movement performance using digital tools, and facilitating online physical activity engagement. Many participants expressed confidence in traditional instruction but uncertainty about transforming these practices for digital environments.

5.3 Integrated Development Framework

Based on our competency assessment findings, we developed an integrated framework for enhancing physical education teacher competencies that addresses identified gaps while leveraging digital affordances. This framework structures professional development through three complementary learning pathways:

Experiential Learning (70%)

This component focuses on authentic application in professional contexts, including:

- Technology-enhanced teaching demonstrations
- Action research on digital pedagogy in physical education
- Guided implementation of blended learning approaches
- Digital portfolio development documenting professional growth
- Peer observation and feedback using digital collaboration tools

Social Learning (20%)

This component emphasizes collaborative knowledge construction through:

- Digital professional learning communities
- Virtual mentoring relationships
- Online collaborative lesson planning
- Cross-institutional virtual exchanges
- Social media-based professional networks

Theoretical Learning (10%)

This component provides structured knowledge acquisition through:

- Microlearning modules on digital pedagogy
- Webinars on emerging technologies for physical education
- Online courses on data-informed practice
- Video libraries demonstrating technology integration
- Research literature discussions in virtual journal clubs

The framework incorporates a modular structure aligned with the five competency domains, with differentiated learning pathways based on individual development needs. Each module includes clearly defined learning objectives, implementation methodologies, digital resources, assessment protocols, and success indicators.

Expert evaluation confirmed the high theoretical soundness ($\bar{X} = 4.82$, S.D. = 0.39), practical applicability ($\bar{X} = 4.76$, SD = 0.43), and technological integration quality ($\bar{X} = 4.78$, S.D. = 0.41) of this framework. Evaluators particularly valued the framework's flexible implementation pathways, emphasis on authentic application, and integration of digital tools throughout the development process.

6. Discussion and Implications

6.1 Theoretical Implications of the Digital Competency Framework

The five-domain competency framework identified in this research contributes significantly to our understanding of professional capabilities required for physical education teachers in technology-enhanced vocational settings. This framework extends traditional competency models by explicitly addressing the digital transformation challenges facing educators today.

The Digital Pedagogical Expertise domain aligns with Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the integration of content, pedagogy, and technology knowledge. Our findings indicate that physical education teachers require specific support in integrating emerging technologies such as movement analysis software, wearable fitness technology, and virtual reality applications into their instructional practices. This domain's identification as the highest development priority suggests that technological integration remains a significant challenge despite widespread technology availability.

The Professional Identity in Digital Contexts domain extends Sachs' (2016) work on teacher professionalism by addressing the unique ethical considerations and identity formation processes that occur in digitally mediated educational environments. The finding that teachers demonstrate moderate confidence in this domain highlights the ongoing negotiation of professional identity as education transitions toward more technology-enhanced models.

The Technical and Physical Literacy domain affirms the continued importance of discipline-specific skills while recognizing their evolution in technology-rich environments. This domain's relatively high current assessment suggests that teachers maintain confidence in their traditional physical education expertise but require support in translating these capabilities to digital contexts. This finding supports Ward's (2013) assertion that content knowledge remains fundamental to teaching effectiveness even as pedagogical approaches evolve.

The Digital-Age Reflective Practice domain builds upon Schön's (1983) foundational work on reflective practice by incorporating the affordances of digital tools and networks for enhanced professional reflection. The identification of this domain as a high development priority indicates that educators need structured support in leveraging digital technologies to deepen their reflective capabilities, consistent with Prestridge's (2017) research on technology-enhanced professional learning.

The Contextual Adaptability domain represents a valuable contribution to competency literature by explicitly addressing the organizational and environmental factors that influence technology integration. This domain

acknowledges the complex interplay between individual capabilities and institutional contexts, supporting findings by Ertmer and Ottenbreit-Leftwich (2010) regarding the importance of school culture and support systems in technology adoption.

6.2 Practical Implications for Professional Development

The competency gap analysis provides valuable guidance for professional development programming in vocational education contexts. The identification of Digital Pedagogical Expertise as the highest priority need suggests that professional development initiatives should emphasize practical applications of technology in physical education settings rather than general technology skills. This finding aligns with research by Armour and Makopoulou (2012) indicating that subject-specific technology integration is more effective than generic technology training.

The integrated development framework represents a significant departure from traditional professional development approaches that rely primarily on workshop-based training. By emphasizing experiential learning (70%) and social learning (20%), this framework acknowledges research by Webster-Wright (2009) demonstrating that authentic workplace learning and collaborative knowledge construction yield more substantial improvements in professional practice than isolated training events.

The modular structure of the framework enables personalized development pathways based on individual needs assessment, consistent with research by Darling-Hammond et al. (2017) on effective professional learning characteristics. This personalization allows institutions to address the varied competency profiles revealed in our assessment, where some teachers demonstrate strength in technical skills but require development in digital pedagogy, while others show the opposite pattern.

The framework's integration of digital tools throughout the professional development process models the technology practices it aims to develop. This embedded approach addresses the "practice what you preach" principle identified by Ertmer and Ottenbreit-Leftwich (2010) as crucial for technology-focused professional development.

6.3 Policy Implications for Vocational Education

Our findings suggest several important implications for educational policy in vocational contexts. The identified competency framework provides a comprehensive foundation for standards development, evaluation systems, and career progression pathways for physical education teachers. By articulating specific, observable competencies across five domains, this framework can inform recruitment, induction, and advancement decisions.

The substantial gaps between current and desired competency levels indicate a need for systematic investment in professional development infrastructure. Policy initiatives should prioritize sustained funding for technology resources, dedicated professional learning time, and technical support systems that enable teachers to develop and apply digital competencies effectively.

The study demonstrates the value of evidence-based approaches to professional development planning. Rather than implementing generic technology initiatives, educational authorities should consider conducting similar competency assessments to identify specific development needs within their contexts, enabling more targeted and efficient resource allocation.

The integrated development framework illustrates the importance of institutional infrastructure in supporting professional growth. Policy frameworks should address both individual teacher development and organizational capacity building, creating environments that support innovation and continuous improvement in technology-enhanced physical education.

6.4 Limitations and Future Research Directions

While providing valuable insights, this study has several limitations that should inform future research.

Generalizability constraints: The most significant limitation is that this study specifically focused on physical education teachers in higher vocational colleges in Henan Province, China. The educational structure, cultural context, and policy environment in China differ substantially from other countries' systems, which significantly limits the direct applicability of these findings to non-Chinese educational contexts. The competency model and enhancement program developed reflect China's unique educational characteristics and requirements, which may not align with vocational education approaches in other countries or regions.

Methodological limitations: The self-assessment methodology, while providing comprehensive coverage across multiple institutions, may be subject to response biases affecting accuracy. Future research should incorporate observational assessments of teaching practice and student outcomes to triangulate self-reported competency levels.

Temporal constraints: The cross-sectional design captures competency status at a single point in time, limiting understanding of developmental trajectories. Longitudinal research tracking competency development through the implementation of the integrated framework would provide insights into effective development pathways and the time required for substantial competency enhancement.

Future research directions: To address these limitations, we recommend comparative studies examining physical education teacher competencies across diverse vocational education systems internationally. Such research would enhance understanding of both universal and contextual factors influencing competency development and allow for the creation of more adaptable frameworks that can be meaningfully applied across different educational systems and cultural contexts.

7. Conclusion and Recommendations

This research contributes to our understanding of the evolving competency requirements for physical education teachers in digital-age vocational education. Through systematic investigation, we identified five essential competency domains, assessed current and desired proficiency levels, and developed an integrated framework addressing identified gaps. Our findings reveal that while physical education teachers maintain strength in traditional sport-specific skills, they require significant development in digital pedagogical expertise, reflective practice enhanced by technology, and professional identity formation in digital contexts.

7.1 Key Findings Summary

The research identified five interconnected competency domains essential for physical education teachers in contemporary vocational settings: Digital Pedagogical Expertise, Professional Identity in Digital Contexts, Technical and Physical Literacy, Digital-Age Reflective Practice, and Contextual Adaptability. Assessment of current competency levels revealed a moderate overall proficiency ($M = 3.68$) with particular strength in Technical and Physical Literacy but significant development needs in Digital Pedagogical Expertise.

The integrated development framework addresses these needs through a balanced approach combining experiential learning (70%), social learning (20%), and theoretical knowledge acquisition (10%). This framework provides structured yet flexible pathways for enhancing teacher competencies across all five domains, with particular emphasis on high-priority areas identified through gap analysis.

7.2 Policy Recommendations

Educational authorities should update professional standards for physical education teachers in vocational settings to explicitly incorporate digital competencies across all five domains identified in this research. These standards should recognize the multidimensional nature of teaching effectiveness in digital environments, extending beyond technical skills to encompass professional identity, reflective practice, and contextual effectiveness.

Funding mechanisms should be aligned with evidence-based development priorities, directing resources toward enhancing digital pedagogical expertise and reflective practice enhanced by technology. This targeted approach ensures efficient use of professional development resources while addressing critical gaps in educator capabilities.

Professional certification and career advancement systems should incorporate digital competency assessment, creating clear pathways for recognition and reward of technology-enhanced teaching expertise. This approach establishes tangible incentives for continuous professional improvement while ensuring that advancement criteria reflect contemporary educational requirements.

7.3 Implementation Recommendations

Educational institutions should implement the integrated development framework through structured programs that combine workplace application, collaborative learning, and focused training. Implementation should prioritize the following strategies:

First, institutions should establish technology-enhanced professional learning communities focused on collaborative exploration of digital pedagogy in physical education. These communities provide structured opportunities for social learning while addressing identified needs in pedagogical expertise and reflective practice.

Second, administrators should create mentoring programs pairing digitally proficient educators with colleagues seeking development in specific competency areas. These mentoring relationships facilitate contextualized knowledge transfer while providing personalized development support.

Third, institutions should implement competency-based evaluation systems that assess performance across all five domains, providing educators with comprehensive feedback on current capabilities and specific development targets. These evaluations should inform personalized development plans while maintaining alignment with

institutional priorities.

Fourth, educational leaders should develop digital resource libraries that support self-directed development in specific competency areas, creating accessible pathways for continuous improvement that accommodate diverse schedules and learning preferences. These resources extend development opportunities beyond formal programs while supporting individualized learning pathways.

7.4 Future Research Directions

Future research should examine the implementation effectiveness of the integrated development framework, assessing its impact on teacher competencies and student outcomes through rigorous mixed-methods evaluation. This research should employ multiple assessment approaches including self-reporting, observation, and performance assessment to provide comprehensive evidence of effectiveness.

Longitudinal studies should track competency development trajectories over extended periods, identifying critical development periods, plateaus, and acceleration points. These studies would provide valuable insights into the temporal aspects of digital competency development while informing the optimal timing and sequencing of interventions.

Comparative analyses across different educational contexts would enhance understanding of how cultural, institutional, and policy factors influence digital competency development for physical education teachers. These analyses would identify universally applicable principles while highlighting context-specific considerations for framework implementation.

Investigation of the relationship between specific teacher digital competencies and student engagement, physical literacy, and health outcomes would strengthen the empirical foundation for professional development investments. This outcomes-focused research would demonstrate the educational value of enhanced teacher competencies while identifying high-impact development priorities.

By pursuing these research directions while implementing the integrated development framework, educational institutions can systematically enhance physical education teacher competencies for the digital age, ultimately improving educational experiences and outcomes for students in vocational education settings.

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