

Digital Teaching Competence and Teaching Performance among University Physical Education Teachers: The Mediating Role of Work Engagement

Guo Xingren¹

Associate Professor Dr. Abu Bakar Bin Ibrahim²

Keywords:

digital teaching competence; teaching performance; physical education; higher education; teacher work engagement; TPACK

ABSTRACT

Digital transformation is changing how university physical education (PE) teachers plan lessons, demonstrate movement, organize practice, assess learning, and provide feedback. However, operating digital tools is not equivalent to using them pedagogically. This conceptual article develops a parsimonious model linking digital teaching competence with teaching performance among university PE teachers, with teacher work engagement as a mediator. Technological Pedagogical Content Knowledge explains how competence improves the alignment of technology, pedagogy, and PE content, whereas Job Demands-Resources theory explains how competence can function as a personal resource that promotes vigor, dedication, and absorption. Four hypotheses are proposed: digital teaching competence positively predicts teaching performance; digital teaching competence positively predicts work engagement; work engagement positively predicts teaching performance; and work engagement partially mediates the competence-performance relationship. A cross-sectional survey and structural equation modeling procedure are outlined for an initial test among full-time university PE teachers in Henan Province, China. The article contributes a discipline-sensitive definition of digital teaching competence, distinguishes competence from teaching performance, and identifies a focused mechanism through which capability may become sustained instructional action. It also offers practical directions for problem-centered professional development and institutional support. Longitudinal and multi-source studies are recommended to establish temporal order and reduce common-method bias.

1 INTRODUCTION

University physical education occupies a distinctive position in digital transformation because its learning processes are embodied, spatial, interactive, and safety-sensitive. Teachers must explain and demonstrate movement, organize practice, observe performance, correct errors, regulate workload, assess motor and cognitive learning, and protect students' physical and emotional safety. Video analysis, wearable sensors, learning management systems, mobile applications, and artificial intelligence can support these tasks. Yet technology can also reduce activity time, distract learners, widen access inequalities, or generate data that teachers cannot convert into useful feedback. The relevant professional question is therefore not whether a PE teacher uses technology, but whether the teacher can integrate it in ways that improve instruction.

Digital teaching competence is more specific than general digital literacy. It includes the professional

judgment required to align digital resources with learning objectives, content, pedagogy, assessment, inclusion, ethics, and reflection. DigCompEdu organizes educators' competence around professional engagement, digital resources, teaching and learning, assessment, learner empowerment, and the facilitation of learners' digital competence (Redecker, 2017). The Higher Education Digital Competence framework similarly emphasizes teaching practice, student empowerment, professional digital literacy, and continuing development (Tondeur et al., 2023). These dimensions are highly relevant to PE but must be interpreted through the demands of movement learning.

The focal outcome in this article is teaching performance, defined as the quality with which teachers enact instructional responsibilities. In PE, it includes lesson preparation, communication of objectives, demonstration, organization, safety management, differentiation, feedback, assessment, and reflection. SETEQ-PE was developed to represent this multidimensional domain (Kyrgiridis et al., 2014), and subsequent research has applied it to in-service PE

* Management and Science University, Shah Alam, Selangor, Malaysia
Email: 347191708@qq.com

teachers (Rojo-Ramos et al., 2023). Teaching performance is thus broader than technology-use frequency and closer to actual instructional practice than general job performance.

Existing evidence suggests that digital competence can support teaching quality, but studies often use overlapping constructs and focus on school teachers, preservice teachers, or general university faculty. Direct-effect models also do not explain why capability becomes sustained instructional action. This article, therefore, proposes teacher work engagement as a mediating mechanism. Work engagement is a positive work-related state characterized by vigor, dedication, and absorption (Schaufeli et al., 2006). Competence can reduce avoidable effort, increase control over digital tasks, and make innovation more meaningful; engagement can then support persistence, attention, and instructional follow-through.

The model integrates Technological Pedagogical Content Knowledge (TPACK) with Job Demands-Resources (JD-R) theory and is situated in Henan Province, China. Henan has a large and diverse higher education system, while provincial policy calls for artificial intelligence to be integrated into teaching, resources, assessment, and management (Henan Provincial Department of Education, 2025). Policy expectations nevertheless produce instructional value only when teachers possess pedagogically grounded competence and supportive working conditions. By focusing on one antecedent, one mechanism, and one outcome, the article offers a concise framework suitable for empirical testing and professional development.

2 CONCEPTUAL BACKGROUND

2.1. Digital teaching competence in university physical education

Digital teaching competence is defined here as a university PE teacher's capacity to select, create, integrate, evaluate, and ethically govern digital technologies in accordance with PE content, pedagogical purposes, learner characteristics, and instructional context. This definition has four boundaries. First, it is professional rather than merely technical: operating a camera, platform, or wearable does not demonstrate an ability to improve learning. Second, it is enacted in planning, instruction, feedback, assessment, or reflection rather than being limited to declarative knowledge. Third, it is contextual because the value of a tool depends on content, facilities, class size, student needs, safety, and the phase of learning. Fourth, it is developmental because technologies and ethical expectations continue to change.

The definition is consistent with TPACK, which treats effective technology integration as the interaction of technological, pedagogical, and content knowledge (Mishra & Koehler, 2006), and with broader teacher digital competence frameworks that include professional, personal, pedagogical, and ethical

capacities (Falloon, 2020). In PE, the integration is readily observable. Slow-motion video has limited value if it hides the critical movement feature, is shown without an interpretive cue, or occupies time that should be spent practicing. The same tool becomes useful when a teacher records from an appropriate angle, connects the image to a concise cue, guides self-assessment, and returns students quickly to purposeful practice. Wearables may support load management, but their metrics must be valid, interpreted cautiously, and communicated without stigmatizing students. AI can help generate differentiated tasks, but the teacher remains responsible for accuracy, accessibility, privacy, and safety.

PE research shows both opportunity and uneven readiness. Teachers and students recognize potential benefits while reporting limited competence, insufficient support, distraction, and classroom-management concerns (Wallace et al., 2023). Reviews similarly identify knowledge, time, technical reliability, equity, and sustainable implementation as persistent issues (Østerlie et al., 2025). Chinese in-service PE teachers have reported relatively strong teaching efficacy but only moderate technology self-efficacy (Song & Cheong, 2024). A recent PE-specific digital literacy scale for Chinese teachers identified instructional design, resource integration, assessment and feedback, interaction and empowerment, and professional development as central dimensions (Wang et al., 2026). These findings support measuring competence through PE-specific instructional work rather than generic tool use.

Table 1 summarizes six operational domains. They represent related capabilities and should not be treated as a checklist requiring technology in every lesson.

Table 1. Operational domains of digital teaching competence in university physical education

Domain	PE-specific enactment	Instructional relevance
Professional engagement	Digital communication, collaboration, resource sharing, and professional learning	Supports coordination, reflection, and access to expertise
Digital resources	Selecting, creating, adapting, and organizing video, platform, sensor, mobile, or AI-supported materials	Improves fit among content, learners, and facilities
Teaching and learning	Integrating tools into demonstration, practice, collaboration, and differentiation	Supports clear instruction and adaptive task design
Assessment and	Collecting and interpreting evidence	Strengthens formative

Domain	PE-specific enactment	Instructional relevance
feedback	and providing timely, specific feedback	assessment and error correction
Learner empowerment	Improving accessibility, participation, autonomy, and responsible student use	Supports inclusion and self-regulated learning
Ethics, safety, and reflection	Protecting privacy, checking accuracy, managing distraction and risk, and reviewing instructional value	Prevents harmful or performative technology use

2.2. Teaching performance and work engagement

Teaching performance concerns what teachers accomplish through instructional behavior, not simply what they know or believe. In university PE, performance is demonstrated when teachers translate objectives and content into coherent lessons, organize time and space, communicate clearly, model skills, maintain safety, differentiate practice, monitor learning, provide feedback, and assess progress. It should not be equated with student fitness scores, competitive success, or visually sophisticated digital materials because these indicators are influenced by factors beyond the teacher's immediate control.

SETEQ-PE provides a useful measurement foundation through dimensions such as content application, learning environment, and teaching strategies, lesson implementation, technology use, and assessment (Kyrgiridis et al., 2014). For the present model, however, predictor and outcome must remain distinct. Technology-use items embedded in a performance scale could inflate the association with digital teaching competence. A focused measure should therefore assess preparation, communication, organization, differentiation, safety, feedback, and assessment while excluding items that merely repeat digital-tool use. Self-report is practical for an initial survey but should later be supplemented with student ratings, observation, peer review, or teaching portfolios.

Work engagement offers a motivational bridge between competence and performance. Vigor refers to energy and persistence, dedication to significance and enthusiasm, and absorption to concentrated involvement (Schaufeli et al., 2006). These qualities are relevant to PE because teachers manage movement, equipment, safety, group organization, and diverse learner responses simultaneously. Engagement may determine whether a teacher persists with lesson redesign, interprets captured evidence, and applies feedback consistently rather than using a digital tool once and abandoning it.

3 THEORY AND HYPOTHESES

Figure 1 summarizes the proposed direct and mediated relationships.

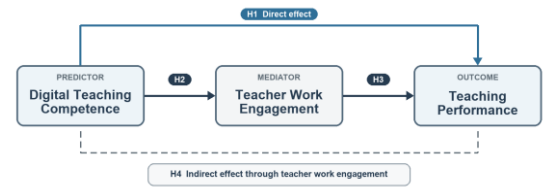


Figure 1. Conceptual framework linking digital teaching competence, teacher work engagement, and teaching performance. H4 denotes the indirect effect through teacher work engagement.

3.1. TPACK and the competence-performance relationship

TPACK explains why digital teaching competence should improve performance. Technological knowledge concerns the possibilities and limitations of tools; pedagogical knowledge concerns task progression, feedback, differentiation, interaction, and assessment; content knowledge concerns movement principles, tactics, health concepts, training, and safety. Competence is demonstrated when these forms of knowledge guide a coordinated instructional decision. Technical skill alone should therefore have an inconsistent relationship with performance; a teacher may operate an application but lack the pedagogical judgment to determine when it adds value or the content knowledge to interpret its output.

Digital teaching competence can improve performance through four main processes. First, it supports instructional design by helping teachers select resources that fit objectives and decide when technology should precede, accompany, or follow physical practice. Second, it improves representation by making timing, sequence, and spatial relations visible when direct demonstration is insufficient. Third, it strengthens formative assessment by enabling teachers to capture evidence, identify patterns, and provide specific feedback. Fourth, it supports differentiation and inclusion through alternative representations, individualized cues, and flexible communication.

Evidence from higher education supports the expected direction. Digital competence has been linked with task-technology fit, system use, and performance (Hizam et al., 2021). University teachers' digital teaching skills have also been associated with teaching quality through instructional interaction and student motivation (Zhang & Wu, 2025), while TPACK has been identified as a mechanism connecting AI competence with teaching performance (Tan et al., 2025). PE studies continue to report digital competence as a meaningful professional-development need (Martínez-Rico et al., 2022; Wallace et al., 2023). The relationship is conditional on access, support, and classroom management, but integrated competence

should predict performance more strongly than simple usage frequency.

H1: Digital teaching competence positively predicts teaching performance among university physical education teachers.

3.2. Digital teaching competence and work engagement

JD-R theory distinguishes job demands that require sustained effort from job and personal resources that help employees achieve goals, manage demands, and develop professionally. Resources stimulate work engagement, which can improve performance (Bakker et al., 2023). Digital transformation produces demands through new platforms, data requirements, privacy concerns, rapidly changing tools, and expectations of continuous availability. Competence changes how teachers experience these demands. A competent teacher can identify suitable tools more quickly, anticipate problems, create reusable resources, interpret evidence, and recover when technology fails. Competence may therefore function as a personal resource by increasing control and reducing avoidable effort.

Competence may also strengthen professional meaning. Teachers are more likely to invest in digital innovation when it supports their identity as PE educators rather than appearing as compliance with a generic initiative. Using video to improve movement awareness or data to regulate workload connects technology with an immediate educational purpose. Successful integration also creates mastery experiences that make later experimentation less threatening.

Evidence from Chinese universities supports this pathway. Sang et al. (2023) found that instructors' digital competence was positively associated with work engagement and that effort expectancy helped explain the relationship. The effect may be weaker when infrastructure is unreliable or institutional expectations are excessive, but the parsimonious model first tests the average association.

H2: Digital teaching competence positively predicts teacher work engagement among university physical education teachers.

3.3. Work engagement, teaching performance, and mediation

Teaching performance requires discretionary effort beyond minimum task completion. PE teachers must monitor students continuously, adapt tasks, provide individualized feedback, and reorganize lessons when conditions change. Vigor supports active monitoring and persistence; dedication sustains attention to instructional goals; and absorption supports careful interpretation of movement and assessment evidence. Engaged teachers should consequently demonstrate stronger preparation, organization, responsiveness, and follow-through. A weekly study of starting teachers found that job resources predicted engagement and

engagement predicted weekly performance (Bakker & Bal, 2010), consistent with the motivational process proposed by JD-R theory.

H3: Teacher work engagement positively predicts teaching performance among university physical education teachers.

The model also proposes an indirect pathway. Competence improves the quality of technology-pedagogy-content decisions, while engagement supplies the energy and dedication needed to enact those decisions consistently. A teacher may design an appropriate digital assessment yet fail to use the evidence when frustration or low dedication prevents follow-through. A similarly competent but more engaged teacher may invest the effort required to interpret the evidence, provide feedback, and redesign the next lesson. Some effects of competence are immediate and cognitive, whereas others depend on motivational investment; partial rather than complete mediation is therefore expected.

H4: Teacher work engagement partially mediates the positive relationship between digital teaching competence and teaching performance.

4 PROPOSED METHODOLOGY

4.1. Design and sampling

An initial test can use a quantitative, cross-sectional survey of full-time PE teachers in regular undergraduate, vocational undergraduate, and higher vocational institutions in Henan Province. Administrators without teaching duties, part-time teachers, and teachers outside PE should be excluded. Because a complete list of individual teachers may be unavailable, institutions can be sampled as clusters, and all eligible PE teachers within selected institutions invited. Provincial statistics indicate approximately 5,290 full-time PE teachers (Henan Provincial Bureau of Statistics, 2024). Using Cochran's (1977) assumptions and finite-population correction gives a minimum of near 359 valid responses; inviting at least 450 teachers allows for nonresponse and unusable cases.

A cross-sectional design is suitable for testing associations and an indirect effect at an early stage, but it cannot establish temporal order. Any findings should be described as consistent with the theoretical model rather than proof of causality. A later time-lagged study could measure competence first, engagement second, and teaching performance from another source third.

4.2. Measures and instrument development

Digital teaching competence can be assessed with approximately 14 items adapted from DigCompEdu self-assessment work, higher education frameworks, and PE-specific evidence (Ghomi & Redecker, 2019; Redecker, 2017; Tondeur et al., 2023; Wang et al., 2026). Items should cover professional engagement, resource selection and creation, lesson integration, movement demonstration, collaborative learning, digital assessment, accessibility, participation, and responsible use. The six domains may form competence rather than reflect interchangeable manifestations of one trait; theory and preliminary factor analysis should therefore guide whether a higher-order or composite specification is more appropriate.

Work engagement can be assessed with six items adapted from the short Utrecht Work Engagement Scale, representing vigor, dedication, and absorption (Schaufeli et al., 2006). Teaching performance can be assessed with approximately 12 items adapted from SETEQ-PE and subsequent applications (Kyrgiridis et al., 2014; Rojo-Ramos et al., 2023). Items should cover planning, objectives, demonstration, differentiation, safety, communication, student-centered methods, and assessment, while excluding direct measures of technology use.

All items can use a five-point agreement scale. When Chinese and English versions are required, translation and back-translation should be followed by expert review for content relevance, clarity, and contextual fit. A pretest with about 30 PE teachers can identify ambiguous language and unrealistic assumptions. Table 2 summarizes the measurement plan.

Table 2. Proposed measurement plan

Construct	Proposed indicators	Source basis	Main validity concern
Digital teaching competence	About 14 items across six domains	Redecker (2017); Ghomi and Redecker (2019); Tondeur et al. (2023); Wang et al. (2026)	Distinguish integrated teaching competence from basic tool use and performance
Teacher work engagement	6 items covering vigor, dedication, and absorption	Schaufeli et al. (2006)	Compare plausible factor structures and avoid content redundancy
Teaching performance	About 12 PE-specific instructional behavior items	Kyrgiridis et al. (2014); Rojo-Ramos et	Remove technology-use overlap and later supplement self-report

Construct	Proposed indicators	Source basis	Main validity concern
		al. (2023)	

4.3. Data collection and analysis

Ethics approval and institutional permission should be obtained before recruitment. The questionnaire should state the purpose, inclusion criteria, completion time, voluntary nature of participation, confidentiality, and withdrawal rights. No direct identifiers should be collected. Institutional contacts may distribute the survey but should not know who participates or access individual responses. Duplicate records, implausible completion times, and invariant patterns should be screened using preregistered rules.

Analysis should begin with confirmatory factor analysis. Reliability can be assessed through Cronbach's alpha and composite reliability; convergent validity through standardized loadings and average variance extracted; and discriminant validity through construct correlations, the Fornell-Larcker criterion, and the heterotrait-monotrait ratio where available (Fornell & Larcker, 1981). Model evaluation should use several fit indices, including chi-square/degrees of freedom, comparative fit index, Tucker-Lewis index, root mean square error of approximation, and standardized root mean square residual (Kline, 2023).

The structural model should estimate the three direct paths and the indirect path. Bias-corrected bootstrapping with 5,000 resamples can provide a 95% confidence interval for the indirect effect. Direct, indirect, and total effects should be reported with standardized coefficients and uncertainty intervals. Demographic controls should be included only when theory justifies their connection with the outcome.

Common-method variance requires attention because all constructs may be collected from one respondent. Procedural remedies should include anonymity, neutral wording, separation of predictor and outcome sections, and assurance that there are no correct answers. Statistical checks cannot substitute for a stronger design (Podsakoff et al., 2003). Future studies should combine teacher-rated competence and engagement with student-rated or observer-rated performance.

5 DISCUSSION AND IMPLICATIONS

The model makes a focused claim: digital teaching competence should be associated with stronger teaching performance because it improves pedagogical decision quality and strengthens work engagement. This claim avoids technological determinism. More devices, more data, or more frequent platform use do not necessarily improve instruction. The decisive issue is whether teachers can integrate technology with PE content, pedagogy, assessment, inclusion, ethics, and reflection. The first contribution is construct clarity. Digital teaching competence is more applied than general

digital literacy and more directly measurable than the full TPACK knowledge architecture. Its PE-specific enactment includes movement demonstration, practice guidance, motor assessment, safety, and protection of active learning time. Separating competence from teaching performance also reduces conceptual and measurement overlap.

The second contribution is the integration of capability and motivation. TPACK explains how competence improves instructional decisions; JD-R theory explains why competence may increase the energy and dedication required to implement them. Work engagement provides explanatory depth without adding many loosely connected variables. The model also creates a practical diagnostic distinction: low competence calls for training and coached practice, whereas adequate competence combined with low engagement points toward workload, autonomy, recognition, infrastructure, or support.

Professional development should therefore begin with authentic instructional problems rather than software demonstrations. A useful cycle is to identify a PE learning challenge, select a pedagogical strategy, evaluate digital support, design a brief application, enact it, collect evidence, and reflect with peers. Examples include using slow-motion video to improve a specific cue, designing a low-burden formative assessment, or checking AI-generated task variations for accuracy and safety. This approach builds integrated competence and produces mastery experiences that can strengthen engagement.

Institutions must also treat time, technical assistance, governance, and access as teaching-quality resources. Teachers cannot translate competence into performance when networks are unreliable, platforms are imposed without consultation, privacy rules are unclear, or innovation adds invisible labor. Peer mentoring, shared resource libraries, protected development time, and responsive technical support can reduce demands and increase the instructional return on competence. Evaluation systems should reward

pedagogical value and student learning rather than visible technological novelty.

6 LIMITATIONS AND FUTURE RESEARCH

This article presents a conceptual model and research agenda rather than completed hypothesis tests. The proposed cross-sectional design is feasible but cannot establish causality. Longitudinal, intervention, and weekly-diary studies should test whether changes in competence precede changes in engagement and performance. Institutional support, technostress, infrastructure, teacher self-efficacy, and student digital readiness may also condition the proposed relationships, but future extensions should add variables only when they answer a clear theoretical question.

Self-assessed competence can reflect confidence as well as capability, and self-assessed performance may share the same response tendencies. Scenario tasks, teaching artifacts, student feedback, observation, and measurement-invariance tests would strengthen validity. The framework must also evolve with AI, sensors, and data governance while keeping pedagogy and PE content primary.

7 CONCLUSION

Digital teaching competence is a professional resource for university PE teachers only when technology is used with pedagogical and disciplinary judgment. Integrating TPACK with JD-R theory explains how competence may improve teaching performance directly through better instructional decisions and indirectly through stronger work engagement. The four-hypothesis model and proposed methodology provide a concise basis for research in Henan and comparable higher education contexts. For practice, institutions should develop competence through authentic PE problems and create conditions in which teachers can translate capability into safe, responsive, and effective instruction.

References:

- Bakker, A. B., & Bal, P. M. (2010). Weekly work engagement and performance: A study among starting teachers. *Journal of Occupational and Organizational Psychology*, 83(1), 189-206. <https://doi.org/10.1348/096317909X402596>
- Bakker, A. B., Demerouti, E., & Sanz-Vergel, A. I. (2023). Job demands-resources theory: Ten years later. *Annual Review of Organizational Psychology and Organizational Behavior*, 10, 25-53. <https://doi.org/10.1146/annurev-orgpsych-120920-053933>
- Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). Wiley.
- Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. *Educational Technology Research and Development*, 68(5), 2449-2472. <https://doi.org/10.1007/s11423-020-09767-4>
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39-50. <https://doi.org/10.1177/002224378101800104>

- Ghomi, M., & Redecker, C. (2019). Digital competence of educators (DigCompEdu): Development and evaluation of a self-assessment instrument for teachers' digital competence. In *Proceedings of the 11th International Conference on Computer Supported Education* (Vol. 1, pp. 541-548). SciTePress. <https://doi.org/10.5220/0007679005410548>
- Henan Provincial Bureau of Statistics. (2024). *Henan statistical yearbook 2024*. China Statistics Press. [In Chinese].
- Henan Provincial Department of Education. (2025, March 28). *Henan Province "Artificial Intelligence + Education" Three-Year Action Plan (2025-2027)* [In Chinese]. https://www.ha.edu.cn/indexfront/NewFile_Detail.aspx?Index=9&id=13336
- Hizam, S. M., Akter, H., Sentosa, I., & Ahmed, W. (2021). Digital competency of educators in the virtual learning environment: A structural equation modeling analysis. *IOP Conference Series: Earth and Environmental Science*, 704(1), Article 012023. <https://doi.org/10.1088/1755-1315/704/1/012023>
- Kline, R. B. (2023). *Principles and practice of structural equation modeling* (5th ed.). Guilford Press.
- Kyrgiridis, P., Derri, V., Emmanouilidou, K., Chlapoutaki, E., & Kioumourtzoglou, E. (2014). Development of a questionnaire for self-evaluation of teacher effectiveness in physical education (SETEQ-PE). *Measurement in Physical Education and Exercise Science*, 18(2), 73-90. <https://doi.org/10.1080/1091367X.2013.866557>
- Martínez-Rico, G., Alberola-Albors, M., Pérez-Campos, C., & González-García, R. J. (2022). Physical education teachers' perceived digital competences: Are they prepared for the challenges of the new digital age? *Sustainability*, 14(1), Article 321. <https://doi.org/10.3390/su14010321>
- 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>
- Østerlie, O., Kristensen, G. O., Holland, S. K., Camacho Miñano, M. J., & Whatman, S. (2025). Digital technology use in physical education teacher education: A scoping review. *Sport, Education and Society*. Advance online publication. <https://doi.org/10.1080/13573322.2025.2474631>
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879-903. <https://doi.org/10.1037/0021-9010.88.5.879>
- Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu* (Y. Punie, Ed.). Publications Office of the European Union. <https://doi.org/10.2760/159770>
- Rojo-Ramos, J., Mendoza-Muñoz, M., Denche-Zamorano, Á., Contreras-Barraza, N., Gomez-Paniagua, S., & Galán-Arroyo, C. (2023). Physical education teachers' perception of teaching effectiveness related to gender and center location in the Community of Extremadura. *International Journal of Environmental Research and Public Health*, 20(3), Article 2199. <https://doi.org/10.3390/ijerph20032199>
- Sang, G., Wang, K., Li, S., Xi, J., & Yang, D. (2023). Effort expectancy mediates the relationship between instructors' digital competence and their work engagement: Evidence from universities in China. *Educational Technology Research and Development*, 71(1), 99-115. <https://doi.org/10.1007/s11423-023-10205-4>
- Schaufeli, W. B., Bakker, A. B., & Salanova, M. (2006). The measurement of work engagement with a short questionnaire: A cross-national study. *Educational and Psychological Measurement*, 66(4), 701-716. <https://doi.org/10.1177/0013164405282471>
- Song, X.-L., & Cheong, J. P. G. (2024). An examination of Chinese physical education teachers' teaching efficacy and technology self-efficacy at the time of the COVID-19 pandemic. *SAGE Open*, 14(2), 1-12. <https://doi.org/10.1177/21582440241241933>
- Tan, X. J., Cheng, G., & Ling, M. H. (2025). Investigating the mediating role of TPACK on teachers' AI competency and their teaching performance in higher education. *Computers and Education: Artificial Intelligence*, 9, Article 100461. <https://doi.org/10.1016/j.caeai.2025.100461>
- Tondeur, J., Howard, S., Van Zanten, M., Gorissen, P., Van der Neut, I., Uerz, D., & Kral, M. (2023). The HeDiCom framework: Higher education teachers' digital competencies for the future. *Educational Technology Research and Development*, 71(1), 33-53. <https://doi.org/10.1007/s11423-023-10193-5>
- Wallace, J., Scanlon, D., & Calderón, A. (2023). Digital technology and teacher digital competency in

physical education: A holistic view of teacher and student perspectives. *Curriculum Studies in Health and Physical Education*, 14(3), 271-287. <https://doi.org/10.1080/25742981.2022.2106881>

Wang, J., Zhang, X., Shao, Q., Li, X., Yang, Y., Wu, J., & Xue, F. (2026). Psychometric validation of a digital literacy scale for physical education teachers in China. *Frontiers in Psychology*, 17, Article 1871523. <https://doi.org/10.3389/fpsyg.2026.1871523>

Zhang, J., & Wu, Y. (2025). Impact of university teachers' digital teaching skills on teaching quality in higher education. *Cogent Education*, 12(1), Article 2436706. <https://doi.org/10.1080/2331186X.2024.2436706>