

The Mediating Role of ICT Self-Efficacy in the Relationships Between Professional Development, Digital Literacy, ICT Attitudes, and ICT-Enabled Teaching Competencies in Higher Vocational Education

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Abstract – This conceptual paper examines the mediating role of ICT self-efficacy in the relationships between professional development, digital literacy, ICT attitudes, and ICT-enabled teaching competencies in higher vocational education. The rapid digital transformation of industries has increased expectations for vocational educators to integrate information and communication technology (ICT) into teaching practices. However, existing research indicates that the development of ICT-enabled teaching competencies is influenced by multiple factors and that the mechanisms underlying these relationships remain insufficiently understood, particularly in vocational education contexts. Drawing on Social Cognitive Theory and the Technological Pedagogical Content Knowledge (TPACK) framework, this paper proposes an integrated conceptual model in which ICT self-efficacy functions as a mediating variable. The model suggests that professional development, digital literacy, and ICT attitudes influence ICT-enabled teaching competencies both directly and indirectly through educators' confidence in using technology for pedagogical purposes. Prior literature indicates that professional development enhances pedagogical knowledge, digital literacy strengthens technical and instructional capabilities, and positive ICT attitudes encourage technology adoption. However, these factors may not translate into effective ICT integration unless educators possess sufficient ICT self-efficacy. The proposed methodology adopts a quantitative, theory-driven approach using survey data from higher vocational educators and covariance-based structural equation modelling to test the hypothesized relationships. The conceptual framework contributes to the literature by integrating multiple predictors of ICT-enabled teaching competencies and emphasizing the mediating role of ICT self-efficacy. The study also provides practical implications for vocational institutions, highlighting the importance of strengthening educators' confidence alongside professional development and digital skill training. Overall, this conceptual paper offers a comprehensive perspective for understanding how educators' digital readiness supports effective ICT-enabled teaching in higher vocational education.

Keywords – ICT self-efficacy; Professional development; Digital literacy; ICT attitudes; ICT-enabled teaching competencies

I. INTRODUCTION

The rapid digital transformation of industries has significantly reshaped workforce skill requirements, placing increasing demands on vocational education institutions to modernize teaching practices and prepare graduates for technology-rich workplaces. In this context, Information and Communication Technology (ICT) has become an essential component of teaching and learning, particularly in higher vocational education where applied skills, industry

alignment, and technological competence are central to educational outcomes. Governments worldwide have emphasized digital transformation in education, and initiatives such as China's Education Informatization 2.0 Action Plan and the Internet Plus strategy highlight the importance of integrating digital technologies across educational levels (Ministry of Education, 2022; Wang et al., 2020). Consequently, higher vocational institutions are expected to cultivate digitally competent graduates capable of adapting to rapidly evolving industrial environments.

Despite substantial policy support and investments in digital infrastructure, gaps remain between policy expectations and classroom practices. Many vocational educators continue to demonstrate limited ICT-enabled teaching competencies, often using technology in basic or procedural ways rather than integrating it meaningfully into pedagogy. ICT-enabled teaching competencies refer to educators' ability to effectively integrate digital technologies into instructional planning, delivery, and assessment to enhance learning outcomes. Prior research indicates that these competencies are influenced by multiple factors, including professional development, digital literacy, attitudes toward ICT, and ICT self-efficacy (Redecker, 2020; Tondeur et al., 2017). However, the relationships among these factors remain insufficiently examined in higher vocational education contexts.

Professional development is widely recognized as a key mechanism for supporting educators' ICT integration. Effective ICT-related professional development can enhance teachers' pedagogical knowledge, instructional strategies, and capacity to apply digital tools in teaching (Tondeur et al., 2017; Selwyn, 2023). Nevertheless, empirical findings suggest that professional development does not always lead to meaningful ICT integration, particularly when training is fragmented, short-term, or overly focused on technical skills rather than pedagogy (Ifinedo, 2020; Liu & Zhang, 2024). These inconsistencies indicate that additional factors may influence how professional development translates into ICT-enabled teaching competencies.

Digital literacy represents another critical factor shaping educators' use of ICT. It encompasses the ability to use digital tools, manage online platforms, conduct digital assessments, and design technology-supported learning environments (Redecker, 2020; Huang & Chiu, 2023). In higher vocational education, digital literacy is especially important for supporting simulations, virtual laboratories, and industry-oriented technologies. However, uneven levels of digital literacy among vocational educators often lead to superficial ICT use rather than meaningful pedagogical integration (Chai & Lam, 2022; Van Leeuwen, 2021).

In addition, educators' attitudes toward ICT influence their willingness to adopt and sustain technology-enhanced teaching. Positive attitudes toward ICT usefulness and relevance are associated with higher levels of engagement in digital teaching practices, whereas negative perceptions may hinder integration even when skills and resources are available (Chen & Zhang, 2021; Zhao & Xu, 2018). These motivational factors highlight the importance of psychological readiness alongside technical competence.

Importantly, ICT self-efficacy has been identified as a central psychological mechanism that connects knowledge, skills, and attitudes with actual teaching practice. ICT self-efficacy refers to educators' beliefs in their ability to effectively use digital technologies for instructional purposes (Bandura, 1997). Educators with higher ICT self-efficacy are more likely to experiment with digital tools, persist when encountering challenges, and integrate ICT more effectively into teaching (Chai & Lam, 2022; Yang & Huang, 2022). Therefore, ICT self-efficacy may serve as a mediating variable linking professional development, digital literacy, and ICT attitudes to ICT-enabled teaching competencies.

Based on these considerations, this study investigates the mediating role of ICT self-efficacy in the relationships between professional development, digital literacy, ICT attitudes, and ICT-enabled teaching competencies in higher vocational education. By examining these interrelationships, the study aims to provide a comprehensive understanding of how educators' digital readiness contributes to effective ICT integration and to offer empirical evidence for improving technology-enhanced teaching in vocational education.

II. PROBLEM STATEMENT

Despite substantial national investment and strategic initiatives such as the Education Informatization 2.0 Action Plan and Smart Education of China, the development of ICT-enabled teaching competencies among higher vocational educators remains uneven and underdeveloped (Dogara et al., 2020; Zhao et al., 2019). While digital infrastructure and platforms have expanded rapidly, the ability of educators to meaningfully integrate ICT into teaching practice has not progressed at the same pace. This gap suggests that the challenge of digital transformation in vocational education is no longer primarily technological, but fundamentally human and pedagogical in nature.

One critical issue concerns professional development. Although ICT-related training programs are widely implemented, many vocational educators report limited improvement in their actual teaching practices. Existing professional development initiatives are often short-term, fragmented, and predominantly focused on technical operation rather than pedagogical integration or vocational relevance (Chen & Zhang, 2021). As a result, educators may complete training programs without developing the capacity to design ICT-enabled lessons, align digital tools with learning outcomes, or evaluate students effectively in digital environments. This raises an important unresolved question: to what extent does professional development genuinely contribute to the development of ICT-enabled teaching competencies among higher vocational educators, rather than remaining a procedural or compliance-driven activity?

In addition to professional development, digital literacy presents a persistent and uneven challenge. Digital literacy extends beyond basic technical skills to include the ability to select appropriate tools, evaluate digital resources, adapt technology to instructional needs, and apply ICT in contextually meaningful ways. Although access to learning management systems, virtual laboratories, and industry-specific software has increased, many vocational educators continue to struggle with applying these tools effectively in teaching (Zhao et al., 2019). This gap suggests that access alone does not guarantee competence. However, existing research provides limited empirical clarity on whether higher levels of digital literacy directly translate into stronger ICT-enabled teaching competencies in vocational education, or whether digital literacy functions only as a necessary but insufficient condition for effective ICT integration.

ICT Attitudes further complicate the digital transformation process. Educators' perceptions, beliefs, and emotional responses toward technology significantly influence their willingness to adopt and sustain ICT-based teaching practices. In higher vocational contexts, negative attitudes are often shaped by concerns over increased workload, fear of technological failure, or doubts about the suitability of ICT for hands-on skills training (Siyam et al., 2025). While prior studies acknowledge the importance of attitudes, there remains limited quantitative evidence explaining how strongly educators' ICT attitudes influence their ICT-enabled teaching competencies, particularly when digital tools are perceived as peripheral rather than integral to vocational pedagogy. This raises the question of whether positive attitudes alone are sufficient to drive meaningful competency development, or whether other psychological mechanisms intervene.

A particularly underexplored yet critical factor is ICT self-efficacy, defined as educators' belief in their ability to use ICT effectively in teaching contexts. Research consistently shows that educators with low ICT self-efficacy are less likely to experiment with digital tools, persist in overcoming technical challenges, or sustain technology use over time, regardless of available training or resources (Scherer & Teo, 2019). This suggests that ICT self-efficacy may play a pivotal role in determining whether professional development, digital literacy, and positive attitudes actually translate into ICT-enabled teaching competencies. However, most existing studies examine ICT self-efficacy in isolation, rather than as a psychological mechanism that links external supports to teaching outcomes.

Collectively, these issues highlight a significant research gap. Although professional development, digital literacy, ICT attitudes, and ICT self-efficacy have each been identified as important influences on ICT integration, prior studies have largely examined these factors independently or conceptually, offering limited quantitative evidence on their combined and interactive effects. In particular, empirical evidence remains limited regarding the relative influence of these factors on ICT-enabled teaching competencies within a single explanatory framework. Moreover, while ICT self-efficacy has been widely acknowledged as an important psychological factor, its mediating role in explaining how professional development, digital literacy, and ICT attitudes translate into ICT-enabled teaching competencies has not been sufficiently examined in higher vocational education

contexts. In addition, existing studies have rarely validated these relationships using an integrated, theory-driven structural model, particularly through covariance-based structural equation modelling.

Therefore, the central problem addressed in this study is the lack of empirical understanding of how professional development, digital literacy, and ICT attitudes influence ICT-enabled teaching competencies, and the extent to which ICT self-efficacy mediates these relationships. Addressing this problem is essential for informing targeted professional development strategies, strengthening institutional policy design, and supporting sustainable digital transformation in higher vocational education.

III. LITERATURE REVIEW

The growing integration of Information and Communication Technology (ICT) in education has generated extensive research on educators' ICT-enabled teaching competencies, particularly in higher vocational education where digital tools are closely aligned with industry-oriented learning. ICT-enabled teaching competencies refer to educators' ability to design, implement, and evaluate instruction through the pedagogically meaningful use of digital technologies (Koehler et al., 2014; Tondeur et al., 2018). These competencies extend beyond basic technical skills to include the integration of learning management systems, simulations, digital assessment tools, and discipline-specific software. Prior studies emphasize that ICT-enabled teaching competencies are influenced by multiple interrelated factors, including professional development, digital literacy, ICT attitudes, and ICT self-efficacy (Scherer et al., 2020; Bond et al., 2021). However, research focusing on higher vocational educators, particularly in less-developed regions of China, remains limited, and few studies have examined these variables within an integrated structural model.

Professional development has been widely identified as a critical driver of ICT-enabled teaching competencies. Effective ICT-related professional development enhances educators' pedagogical knowledge, instructional design skills, and ability to integrate digital tools into teaching practices (Desimone, 2009; Scherer et al., 2020). Empirical studies indicate that sustained, pedagogy-focused training significantly improves teachers' capacity to use technology for meaningful learning experiences (Bond et al., 2021; Zou et al., 2024). In vocational education, professional development is particularly important for supporting simulation-based learning, digital assessments, and workplace-oriented instructional approaches. Nevertheless, the effectiveness of professional development is inconsistent. Short-term or tool-focused training often fails to produce lasting changes in teaching practices (Ifinedo, 2020; Tondeur et al., 2019). Researchers have therefore suggested that the impact of professional development may depend on educators' psychological factors, such as confidence and beliefs about technology use, indicating the potential mediating role of ICT self-efficacy (Chai & Lam, 2022).

Digital literacy is another essential predictor of ICT-enabled teaching competencies. Digital literacy

encompasses technical skills, information evaluation, communication, and ethical technology use (Ng, 2012; UNESCO, 2018). Educators with higher digital literacy are more capable of designing interactive learning activities, implementing online assessments, and supporting student-centred pedagogies (Ventivani et al., 2024; Siyam et al., 2025). In vocational education, digital literacy is particularly relevant for using virtual laboratories, industry simulation software, and digital performance assessments. However, research consistently reports uneven digital literacy levels among vocational educators, even within technologically advanced institutions (Chai & Lam, 2022). Limited digital literacy often leads to procedural technology use rather than transformative digital pedagogy (Tondeur et al., 2017). Recent studies also suggest that digital literacy alone may not guarantee effective ICT integration, as educators' motivation, attitudes, and self-efficacy influence whether digital skills are translated into meaningful teaching practices (Yang & Huang, 2022).

Educators' ICT attitudes also play a significant role in shaping ICT-enabled teaching competencies. ICT attitudes refer to beliefs, perceptions, and emotional responses toward technology use in teaching (Ajzen, 1991; Teo, 2019). Positive attitudes toward ICT are associated with greater willingness to experiment with digital tools and adopt innovative teaching strategies (Zhen & Wu, 2024). Conversely, negative attitudes such as anxiety or skepticism may hinder ICT integration even when resources and skills are available. In higher vocational education, ICT attitudes are particularly important because instructors must align technology use with practical and industry-based learning tasks (Liu & Zhang, 2024). However, empirical evidence suggests that ICT attitudes may influence ICT-enabled teaching indirectly rather than directly, highlighting the importance of examining mediating variables such as ICT self-efficacy (Yang & Huang, 2022).

ICT self-efficacy has been widely recognized as a key psychological mechanism influencing technology integration in teaching. Derived from Social Cognitive Theory, self-efficacy refers to individuals' beliefs in their capability to perform specific tasks (Bandura, 1997). ICT self-efficacy specifically reflects educators' confidence in using digital technologies for instructional purposes (Compeau & Higgins, 1995). Teachers with high ICT self-efficacy are more likely to experiment with digital tools, persist in overcoming challenges, and implement innovative technology-supported instruction (Sang et al., 2010; Paraskeva et al., 2008). Structural equation modelling studies have demonstrated that ICT self-efficacy mediates the relationships between professional development, digital literacy, ICT attitudes, and ICT integration outcomes (Scherer et al., 2020; Siyam et al., 2025). These findings suggest that ICT self-efficacy serves as a bridge that translates knowledge, skills, and attitudes into actual ICT-enabled teaching competencies.

Several theoretical frameworks further support these relationships. The Technological Pedagogical Content Knowledge (TPACK) framework emphasizes the integration of technological, pedagogical, and content knowledge as the foundation of ICT-enabled teaching competencies (Mishra & Koehler, 2006; Koehler et al., 2012). Social Cognitive Theory highlights the role of self-efficacy in shaping

behaviour and performance outcomes (Bandura, 1997). Additionally, the Technology Acceptance Model (TAM) explains how perceived usefulness and ease of use influence educators' attitudes toward technology adoption (Davis, 1989), while the Unified Theory of Acceptance and Use of Technology (UTAUT) incorporates contextual factors such as social influence and facilitating conditions (Venkatesh et al., 2003). Together, these models emphasize that ICT-enabled teaching competencies are shaped by cognitive, psychological, and contextual factors.

Despite growing research, limited studies have simultaneously examined professional development, digital literacy, ICT attitudes, and ICT self-efficacy within a single structural model in higher vocational education. This gap is particularly evident in non-metropolitan regions of China, where ICT integration levels vary and educators' digital readiness remains uneven. Therefore, the present study proposes an integrated model in which ICT self-efficacy mediates the relationships between professional development, digital literacy, ICT attitudes, and ICT-enabled teaching competencies. This approach provides a comprehensive understanding of how educators' digital readiness translates into effective technology-enhanced teaching in higher vocational education.

IV. PROPOSE METHODOLOGY

This study adopts a quantitative, theory-driven methodology to examine the mediating role of ICT self-efficacy in the relationships between professional development, digital literacy, ICT attitudes, and ICT-enabled teaching competencies among higher vocational educators. A quantitative approach is appropriate because the study aims to test theoretically derived relationships and evaluate mediation effects among multiple latent constructs within an integrated conceptual framework. Quantitative designs allow researchers to examine relationships systematically across larger samples and provide greater generalizability compared with qualitative approaches (Creswell & Creswell, 2018; Castellan, 2010). The present study therefore employs a cross-sectional survey design and covariance-based structural equation modelling (CB-SEM) to evaluate both direct and indirect relationships among variables.

The study focuses on educators working in higher vocational institutions in Henan Province, China. This context was selected due to the large number of vocational institutions and the diversity of educational and socio-economic environments across the region. The target population consists of full-time teachers, as they are directly responsible for curriculum delivery, instructional design, and ICT integration in teaching. To ensure representation across institutional contexts, a stratified random sampling approach is adopted, where participating institutions represent different geographical regions. Stratified sampling helps reduce sampling bias and improves representativeness by ensuring proportional participation from each subgroup (Creswell & Creswell, 2018). This approach is also suitable for structural equation modelling, which requires heterogeneous samples to evaluate relationships among latent constructs (Kline, 2016).

Sample size considerations follow established recommendations for structural equation modelling. Prior

studies suggest that a minimum of 200 responses is required for stable parameter estimation in CB-SEM models of moderate complexity (Hair et al., 2019; Kline, 2016). In addition, population-based calculations using a 95% confidence level and 5% margin of error indicate a minimum sample of approximately 383 respondents. Statistical power analysis further confirms that this sample size provides sufficient power to detect meaningful relationships among constructs (Cohen, 1988). Accordingly, the study targets a minimum sample size of 383 participants to ensure reliability and robustness of the structural model.

Data are collected using a structured self-administered questionnaire adapted from previously validated instruments. The questionnaire measures five constructs: professional development, digital literacy, ICT attitudes, ICT self-efficacy, and ICT-enabled teaching competencies. Items are measured using a five-point Likert scale ranging from strongly disagree to strongly agree. The use of validated instruments enhances content validity and reliability, while minor wording adjustments ensure contextual relevance to higher vocational education settings (DeVellis, 2017). The questionnaire is distributed through an online survey platform, which enables efficient data collection across geographically dispersed institutions. Participation is voluntary, and respondents are informed of anonymity, confidentiality, and the academic purpose of the study.

Prior to full-scale data collection, a pilot study is conducted with a small group of educators to evaluate clarity, reliability, and usability of the instrument. Pilot testing is widely recommended in survey-based research to identify ambiguous wording and ensure internal consistency of measurement scales (Creswell & Creswell, 2018). Feedback from pilot participants is used to refine item wording and improve questionnaire clarity without altering the theoretical structure. This procedure enhances the reliability and validity of the measurement model.

Data analysis follows a two-step structural equation modelling approach. First, the measurement model is assessed to evaluate reliability and validity. Internal consistency reliability is examined using Cronbach's alpha and composite reliability, while convergent validity is assessed using factor loadings and average variance extracted. Discriminant validity is evaluated using the Fornell-Larcker criterion (Fornell & Larcker, 1981). After establishing satisfactory measurement properties, the structural model is tested to examine hypothesized relationships among constructs. Model fit is evaluated using multiple goodness-of-fit indices, including comparative fit index, Tucker-Lewis index, root mean square error of approximation, and standardized root mean square residual (Hu & Bentler, 1999).

To examine the mediating role of ICT self-efficacy, bootstrapping procedures are employed to test indirect effects. Bootstrapping generates bias-corrected confidence intervals and is widely recommended for mediation analysis in structural equation modelling (Preacher & Hayes, 2008). Mediation is considered significant when confidence intervals do not include zero. This analytical strategy enables comprehensive examination of both direct and indirect relationships within the proposed conceptual model. Ethical considerations are addressed by ensuring voluntary participation, anonymity, and confidentiality of responses.

These methodological procedures provide a rigorous foundation for testing the conceptual relationships among professional development, digital literacy, ICT attitudes, ICT self-efficacy, and ICT-enabled teaching competencies in higher vocational education.

V. CONCLUSION

This conceptual paper examined the mediating role of ICT self-efficacy in the relationships between professional development, digital literacy, ICT attitudes, and ICT-enabled teaching competencies in higher vocational education. Drawing on existing literature and theoretical perspectives, the study proposed an integrated conceptual model to explain how educators' digital readiness translates into effective technology-enhanced teaching practices. The findings from the reviewed literature suggest that ICT-enabled teaching competencies are shaped not only by external factors such as training opportunities and digital skills but also by internal psychological factors, particularly educators' confidence in using technology for instructional purposes.

The review of prior studies indicates that professional development plays a foundational role in improving educators' capacity to integrate ICT into teaching. Effective ICT-related training enhances pedagogical knowledge, supports instructional innovation, and promotes the meaningful use of digital tools in vocational education (Tondeur et al., 2018; Scherer et al., 2020). However, research also highlights that professional development alone does not consistently lead to effective ICT integration. Fragmented or technically oriented training may fail to produce sustained changes in teaching practice unless educators possess sufficient confidence and motivation to apply newly acquired skills. This suggests that the relationship between professional development and ICT-enabled teaching competencies may be indirect, operating through ICT self-efficacy.

Similarly, digital literacy has been identified as an essential prerequisite for technology-enhanced teaching. Educators with higher levels of digital literacy are better able to design interactive learning environments, implement digital assessments, and utilize industry-relevant technologies in vocational education contexts (Ng, 2012; Redecker, 2020). Nevertheless, the literature indicates that digital literacy alone does not guarantee effective ICT integration. Teachers may possess technical skills but remain hesitant to apply them in classroom settings. This gap between competence and practice highlights the importance of ICT self-efficacy as a mechanism that transforms digital literacy into ICT-enabled teaching competencies.

ICT attitudes also influence educators' willingness to adopt and sustain technology-enhanced pedagogies. Positive attitudes toward ICT usefulness and relevance encourage experimentation with digital tools and promote student-centred learning approaches (Teo, 2019; Zhen & Wu, 2024). Conversely, negative attitudes may constrain ICT adoption even in well-equipped institutions. The literature further suggests that attitudes often exert indirect effects on technology integration through confidence and behavioural intention, reinforcing the mediating role of ICT self-efficacy.

Grounded in Social Cognitive Theory and supported by the TPACK framework, this conceptual paper positions ICT

self-efficacy as a central psychological mechanism linking professional development, digital literacy, and ICT attitudes to ICT-enabled teaching competencies. Self-efficacy influences individuals' persistence, motivation, and performance outcomes, particularly when adopting new technologies (Bandura, 1997). Educators with higher ICT self-efficacy are more likely to experiment with digital tools, overcome technical challenges, and implement technology-supported instructional strategies. Consequently, ICT self-efficacy serves as a bridge that translates external resources and individual competencies into effective ICT-enabled teaching practices.

This conceptual model contributes to the literature in several ways. First, it integrates multiple predictors of ICT-enabled teaching competencies within a single framework, addressing the fragmented nature of previous research. Second, it highlights the mediating role of ICT self-efficacy, offering a more nuanced understanding of how digital readiness influences teaching practices. Third, it extends existing research by focusing on higher vocational education, where ICT integration is closely aligned with industry-oriented learning and practical skill development.

The proposed framework also has practical implications. Educational institutions should not only provide professional development and digital infrastructure but also design interventions that enhance educators' confidence in using ICT. Training programs should emphasize hands-on practice, peer collaboration, and reflective teaching experiences to strengthen ICT self-efficacy. Additionally, policymakers should consider integrating psychological readiness into digital transformation initiatives in vocational education.

In conclusion, ICT-enabled teaching competencies in higher vocational education are shaped by a combination of professional development, digital literacy, ICT attitudes, and ICT self-efficacy. Among these factors, ICT self-efficacy plays a pivotal mediating role by transforming knowledge, skills, and attitudes into effective teaching practices. Future empirical studies are needed to test the proposed conceptual model and further explore the mechanisms influencing ICT integration in vocational education.

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