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Teachers' digital competence and educational quality in rural vocational schools

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Abstract

Digital technology is increasingly important in vocational education, yet many rural schools continue to face challenges in integrating it into teaching and learning. This study explores how teachers in a rural vocational high school in Tanjung Jabung Barat, Jambi, Indonesia, develop and apply digital competence in their professional practice. A qualitative case study design was used, involving semi-structured interviews with seven school stakeholders and an analysis of relevant school documents. The findings show that teachers encounter a range of challenges, including limited infrastructure, uncertainty in using unfamiliar technologies, and restricted access to sustained professional support. At the same time, teachers who received encouragement from school leaders, collaborated with colleagues, and participated in ongoing learning activities demonstrated greater confidence in using digital tools. The study suggests that digital competence develops through the interaction of personal motivation, workplace support, and opportunities for continuous professional learning. Based on these findings, an integrated framework is proposed that connects technological pedagogical content knowledge (TPACK), human resource development, and digital leadership.

Keywords

Digital competence, digital leadership, educational quality, human resource development, vocational education

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Introduction

Vocational education reflects quality not only in students' academic achievement but also in their readiness to meet labor market demands. This issue is reflected in the high unemployment rate among vocational high school graduates in Indonesia, which reached 9.01%. This condition indicates a quality gap in vocational education, where graduates are not yet fully equipped with the competencies required by the labor market. Further, vocational schools play a strategic role in preparing graduates to meet labor market demands, particularly in a global environment characterized by volatility, uncertainty, complexity, and ambiguity (VUCA) (Pambudi & Harjanto, 2020).

The integration of digital technology has become a critical strategy for enhancing instructional effectiveness and improving educational quality. In vocational education, digital technologies can facilitate authentic learning experiences, strengthen industry alignment, and prepare students for the digital workplace. However, the successful integration of technology depends not merely on the availability of digital tools but on teachers' ability to use them pedagogically and contextually (Koehler et al., 2014; Mhlongo et al., 2023). When digital transformation is not accompanied by adequate teacher competence and institutional readiness, its potential to improve educational outcomes remains limited.

Despite ongoing efforts to promote digital transformation, vocational schools continue to face substantial challenges, particularly in developing countries. Limited infrastructure, unequal access to technology, inadequate professional development opportunities, and insufficient institutional support remain significant barriers (Deroncele-Acosta et al., 2023; Mukminin et al., 2019). These challenges are especially pronounced in Indonesia, where disparities in internet connectivity, digital devices, and reliable electricity continue to affect the quality of digital learning implementation (Bashir et al., 2021; Dhawan, 2020).

In vocational schools, the success of technology integration largely depends on how teachers incorporate digital tools into their daily teaching practices. Their digital competence influences not only classroom practices but also the overall quality of vocational education (Redecker, 2017). The TPACK framework has been widely recognized as a foundational framework for understanding teachers' ability to integrate technology, pedagogy, and content knowledge (Koehler et al., 2014; Mishra & Koehler, 2006). However, while TPACK offers a valuable knowledge-based perspective, it pays relatively limited attention to the organizational, structural, and psychological factors that shape teachers' actual implementation of digital practices.

In practice, many teachers possess basic technological knowledge but struggle to translate it into meaningful pedagogical action. Factors such as limited confidence, resistance to change, inadequate leadership support, and constrained institutional resources often hinder effective implementation (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017). The interviews and previous studies indicate that teachers develop digital competence within a broader school environment. Individual motivation matters, but support from colleagues, leaders, and available resources also shapes how technology is used in practice. From a management perspective, strengthening teachers' digital competence constitutes an essential component of educational human resource development (Darling-Hammond et al., 2020).

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Although previous studies have extensively examined teachers' digital competence, limited research explicitly explores how to manage, implement, and sustain it in the context of vocational schools, particularly in developing countries. Existing studies tend to emphasize technological proficiency while paying less attention to the institutional mechanisms that enable teachers to translate competence into practice (Instefjord & Munthe, 2017; Pettersson, 2021). This gap is particularly significant in vocational education, where technological relevance and workforce alignment are crucial.

To address this gap, this study examines teachers' digital competence at a vocational school in Tanjung Jabung Barat, Jambi, using a qualitative case study approach. The study attempts to develop a contextual management model that explains how individual, organizational, and contextual factors interact to shape teachers' digital competence.

Literature Review

Teachers' digital competence in vocational education

Teacher digital competence refers to the knowledge, skills, attitudes, and ethical awareness needed to use digital technologies effectively in teaching, assessment, professional collaboration, and lifelong learning (Redecker, 2017). It goes beyond mere technical proficiency to encompass the pedagogical capacity to select, adapt, and integrate digital tools in ways that enhance student learning, foster engagement, and promote meaningful educational experiences. Contemporary frameworks, particularly the European Digital Competence Framework for Educators (DigCompEdu), conceptualize digital competence as a multidimensional construct involving professional engagement, digital resource management, teaching and learning, assessment, learner empowerment, and the facilitation of students' own digital competence (Redecker, 2017).

For vocational teachers, digital competence is closely linked to their responsibility to prepare students for workplaces where digital technologies are routinely used. Industrial transformation, automation, artificial intelligence, and Industry 4.0 have fundamentally reshaped occupational demands, requiring graduates to possess advanced digital literacy and adaptive technological skills. Consequently, vocational teachers must not only master digital technologies themselves but also integrate them into authentic, industry-relevant learning environments that closely simulate workplace realities (Lucas et al., 2012; Mhlongo et al., 2023; Roll & Ifenthaler, 2021). This integration enables students to develop technical expertise, problem-solving skills, and workplace readiness aligned with contemporary labor-market expectations.

Beyond technical applications, teachers' digital competence plays a vital role in fostering innovative pedagogical practices. Haleem et al. (2022) state that digital technologies enable teachers to customize learning experiences and promote collaborative learning. Digitally competent teachers can design collaborative learning experiences, personalize instruction, facilitate real-time feedback, and create interactive learning environments that enhance student motivation and achievement. In vocational settings, this capability is particularly important for implementing project-based learning, simulation-based instruction, virtual laboratories, augmented reality applications, and industry-linked assignments. Such approaches connect

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theoretical knowledge with practical application, thereby enhancing students' employability and professional preparedness. Therefore, teachers' stronger digital competence must be supported by adequate infrastructure to make learning more meaningful and effective (Loh et al., 2025; Luthfiani et al., 2026).

The digital transition in learning methods has emerged as a strategic and inevitable response that ensures the sustainability of education while maintaining the quality of learning outcomes (Imran et al., 2024; Maqbool et al., 2024). From an educational quality perspective, teachers' digital competence directly impacts teaching effectiveness, student engagement, and learning outcomes. Many vocational education graduates fail to meet industry expectations due to insufficient knowledge, skills, and personal development (Kholifah et al., 2025). As workplaces continue to adopt digital technologies, vocational graduates are increasingly expected to demonstrate both technical expertise and digital literacy. To achieve these goals, strengthening teachers' digital competence is a strategic priority. When teachers are confident in using digital tools, they are more likely to introduce new learning approaches that help students develop skills relevant to current workplace demands.

The TPACK framework

The TPACK framework, developed by Mishra and Koehler (2006), has become one of the most influential theoretical models for understanding the knowledge teachers require to integrate technology effectively into teaching and learning. Building upon Shulman's concept of pedagogical content knowledge, TPACK extends the framework by incorporating technological knowledge as an essential domain in contemporary education. It recognizes that effective technology integration is not achieved through isolated mastery of technology, pedagogy, or subject matter, but through the complex interaction among these domains.

Specifically, TPACK consists of three primary knowledge bases: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). These domains intersect to form four additional integrated knowledge areas: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and the overarching Technological Pedagogical Content Knowledge (TPACK).

Within vocational education, the relevance of TPACK is particularly pronounced. Vocational teachers must integrate industry-specific technologies into authentic learning environments while simultaneously applying appropriate instructional strategies and maintaining alignment with occupational competencies. For example, teaching automotive diagnostics, digital design, or accounting software requires a sophisticated combination of technological expertise, pedagogical adaptability, and domain-specific knowledge. TPACK, therefore, provides a robust conceptual lens for examining how vocational teachers design and implement technology-enhanced instruction that reflects workplace realities and supports students' employability.

A substantial body of empirical research has validated the usefulness of TPACK across diverse educational contexts. Studies consistently demonstrate positive relationships between teachers' TPACK levels and their confidence, instructional innovation, technology adoption, and student-centered pedagogical practices (Koehler et al., 2014; Valtonen et al., 2017). In vocational settings, higher TPACK has been associated with more effective integration of

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digital tools, improved instructional quality, and stronger alignment between classroom learning and industry expectations.

Despite its strengths, TPACK has several limitations when applied to real-world educational settings. The framework primarily conceptualizes technology integration as an individual cognitive capability, emphasizing teachers' personal knowledge and skills. As a result, it offers limited explanatory power regarding the organizational, structural, and contextual factors that often determine whether such knowledge can be effectively translated into classroom practice. Factors such as school leadership, institutional culture, access to technological infrastructure, professional development opportunities, peer collaboration, and policy support are not explicitly addressed within the original TPACK model (Pettersson, 2021; Tondeur et al., 2017).

Organizational support and human resource development

From an educational management perspective, teacher digital competence must be understood not simply as an individual capability but as an organizational asset that must be strategically developed, supported, and maintained. Davenport (2010) explains that knowledgeable workers are key to innovation and growth in today's organizations. While individual motivation, prior experience, and self-efficacy are important, teachers' ability to effectively integrate technology is strongly influenced by the institutional environment in which they work.

Effective schools cultivate teacher digital competence through a coherent strategic leadership system, continuous professional learning, a collaborative culture, and a robust technology infrastructure (Darling-Hammond et al., 2020; Pettersson, 2021). Strategic leadership is crucial, as school leaders establish the vision, priorities, and resource allocation necessary for successful digital transformation. Leaders who articulate clear expectations, model the use of technology, and align digital initiatives with school-improvement goals are more likely to foster meaningful, sustainable instructional innovation.

Professional development is another crucial component. Traditional, one-off workshops are often insufficient to change teaching practice sustainably. Instead, effective digital competency development requires ongoing, work-integrated, and contextually relevant professional learning opportunities. These can include mentoring, peer coaching, professional learning communities, learning studies, and collaborative action research. These approaches enable teachers to experiment with digital tools, reflect on their practice, and continually refine their teaching strategies (Darling-Hammond et al., 2020; Desimone & Garet, 2015).

A collaborative school culture further strengthens digital competency by promoting knowledge sharing, collective problem-solving, and peer support. Teachers are more likely to adopt innovative practices when they work within a professional community that encourages experimentation, reflection, and collaborative learning. Collegial interactions help reduce resistance to change, build confidence, and facilitate the spread of effective digital practices across the organization (Tondeur et al., 2017).

Mhlanga and Moloi (2020) stated that the success of digital transformation depends not only on the availability of technology but also on leadership principles, including a clear vision, human resource readiness, and a commitment to sustainable change. The study indicated that

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school leaders must act not only as instructional leaders but also as strategic managers capable of mobilizing resources and fostering external collaboration. Furthermore, Yukl (2020) emphasized that effective leadership in situations of change is characterized by the leader's ability to adapt to a dynamic environment, anticipate challenges, and drive organizational change effectively. Schools that successfully institutionalize this support are better equipped to improve teaching quality, foster innovation, and prepare students to participate in the increasingly digital economy.

In the context of digital transformation in education, the concept of digital leadership is gaining increasing attention. Ridho et al. (2023) stated that digital leadership is crucial in today's education system. Effective digital leaders provide technological resources and inspire teachers to experiment, collaborate, and continuously improve their digital pedagogical practices (Dasruth, 2024). In vocational education, digital leadership is a crucial factor in integrating technology into institutional goals, instructional innovation, and workforce preparation. As stated by Zhong (2017), digital leadership is not only about leadership style and motivation for digital change but also about creating and sustaining a professionally developed, technology-based digital learning culture.

Overall, the literature indicates that teachers' digital competence in vocational education is interconnected with various factors. Various factors must be considered, not just the teacher's individual abilities. Particularly in vocational education, preparing graduates relevant to industry demands is crucial. This means a sound understanding of the synergy between individual competencies and institutional support is needed to foster a sustainable digital transformation that improves the quality of education. Therefore, researchers are interested in examining teachers' digital competence and the interactions among factors that enable them to optimize meaningful digital pedagogy, thereby improving teaching quality and strengthening vocational education outcomes.

Methodology

Research design, site, and participants

This study employed a qualitative case study design to explore how teachers' digital competence is developed, implemented, and supported within the organizational context of vocational education. A qualitative approach was considered appropriate because it allows for an in-depth understanding of complex social phenomena from the perspectives of those directly involved (Creswell & Poth, 2018). Specifically, the case study design enabled the researcher to examine teachers' digital competence in its real-life setting, considering the interplay among individual capabilities, institutional support, and contextual factors (Yin, 2018).

The study was conducted at a public vocational high school located in Tanjung Jabung Barat, Jambi Province, Indonesia. The school was purposively selected because it has actively implemented digital technologies in teaching and learning while operating within a geographically and infrastructurally challenging context. This setting offered a valuable opportunity to explore how vocational schools outside major urban centers foster and manage teachers' digital competence. The school's commitment to digital transformation, combined

with its contextual challenges, made it an information-rich case for investigating the phenomenon.

Participants were selected using purposive sampling, a widely recommended qualitative research strategy for identifying individuals with substantial knowledge and experience relevant to the research problem (Patton, 2014). The participants consisted of the school principal, the vice principal for curriculum, the vice principal for facilities and infrastructure, the head of the expertise program, and vocational teachers. These participants were chosen because they occupy strategic roles in the planning, implementation, and evaluation of digital learning initiatives. Furthermore, it aims to capture diverse perspectives and provide a comprehensive understanding of how teachers' digital competence is developed and supported within the vocational school context. This diversity also strengthened the credibility of the findings through triangulation across leadership, management, and instructional perspectives.

Data collection and analysis

Data were collected through semi-structured interviews and document analysis. These methods were selected because they are well-suited to exploring participants' experiences, perceptions, and institutional practices related to teachers' digital competence within the organizational context of vocational education (Creswell & Poth, 2018; Merriam & Tisdell, 2016). Semi-structured interviews served as the primary data source. This approach allowed participants to share their experiences openly while enabling the researcher to explore issues aligned with the study's objectives.

The interview protocol was developed based on the study's conceptual framework, covering teachers' digital competence, TPACK, organizational support, human resource development, and digital leadership. Individual interviews were conducted with the principal, vice principals, head of the expertise program, and vocational teachers. Each interview lasted approximately 45 to 60 minutes and was audio-recorded with participants' consent. Document analysis was employed to complement and corroborate the interview data. Relevant documents included school strategic plans, teacher professional development records, digital policy documents, lesson plans, and records of technology-related programs and activities. These documents provided important context for the school's digital initiatives, institutional support, and efforts to strengthen teachers' digital competence.

Data were analyzed using thematic analysis, following the six-phase procedure proposed by Braun and Clarke (2006). First, interview recordings were transcribed verbatim, and all transcripts and documents were read repeatedly to achieve data familiarization. Second, initial codes were generated by identifying significant statements, recurring ideas, and patterns relevant to the research questions. Third, related codes were grouped into broader categories and subsequently developed into overarching themes. Fourth, the themes were reviewed and refined to ensure coherence and consistency across the dataset. Fifth, each theme was clearly defined and named to capture its meaning accurately. Finally, the themes were interpreted to develop a contextual understanding of how teachers' digital competence is fostered, implemented, and supported in vocational education.

To enhance trustworthiness, data triangulation and member checking were employed. Triangulation was achieved by comparing findings across interviews and documents, while

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member checking allowed participants to verify the accuracy of the interpretations. These procedures helped ensure the credibility, dependability, and confirmability of the study's findings.

Findings

The thematic analysis identified four major themes and ten subthemes related to teachers' digital competence in rural vocational high schools. These themes reflect the multifaceted challenges faced by teachers, the factors influencing competence development, their professional learning needs, and the broader implications for educational quality. Table 1 summarizes the themes and subthemes identified in this study.

Table 1. *Themes and subthemes of teachers' digital competence development*

Themes	Subthemes
Challenges in teachers' digital competence	Limited integration of technology into vocational instruction; reliance on basic digital applications; psychological barriers and technology anxiety
Factors influencing digital competence development	Internal factors: motivation, confidence, and experience; external factors: infrastructure, leadership, and institutional support
Professional development needs	Continuous and practical training; mentoring and follow-up support; peer collaboration and professional learning communities
Implications for educational quality in vocational schools	Enhancing student engagement and learning experiences; strengthening workplace readiness; improving school competitiveness and educational relevance

Theme 1. Challenges in teachers' digital competence

Limited integration of technology into vocational instruction, participants reported considerable difficulty in integrating digital technologies into vocational teaching, particularly in practical and competency-based subjects. Although teachers recognized the importance of technology, many struggled to align digital tools with hands-on learning activities and workplace-oriented instruction.

> "We actually want to use technology, but we're often confused about where to start, especially for practical subjects." *(P6)*

The interview data show that teachers need support not only in using technology but also in applying it effectively during practical learning activities.

Reliance on basic digital applications, most participants indicated that their use of technology remained limited to basic applications, such as presentation software, messaging platforms, and simple online resources. More advanced tools, including learning management systems, simulations, and interactive applications, were rarely utilized.

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> "Usually, I only use PowerPoint and WhatsApp because they are the easiest for both teachers and students." *(P2)*

The responses suggest that technology was mainly used to share information and communicate with students, while more interactive or innovative applications were used less frequently.

Psychological barriers and technological anxiety, psychological factors also emerged as significant obstacles. Several participants, particularly senior teachers, expressed anxiety, hesitation, and fear of making mistakes when using unfamiliar digital tools.

> "Sometimes we are afraid of making mistakes, especially when trying new applications in front of students." *(P3)*

Several teachers explained that fear of making mistakes discouraged them from trying unfamiliar digital tools during lessons.

Theme 2. Factors influencing digital competence development

Internal factors: Motivation, confidence, and experience, teachers' motivation, self-confidence, and prior technological experience strongly influenced their development of digital competence. Participants who demonstrated curiosity and initiative were more likely to explore new technologies independently.

> "Young teachers usually adapt faster, while senior teachers need more time and guidance." (*P4)*

Although age was mentioned, participants emphasized that willingness to learn and professional commitment were more influential than age itself.

External factors: Infrastructure, leadership, and institutional support, external conditions significantly shaped teachers' opportunities to develop and apply digital competence. Participants frequently cited unstable internet connectivity, limited access to digital devices, and inadequate technological facilities as major barriers.

> "I support digital learning, but the tools are limited. The budget for procurement is also limited." *(P1)*

School leadership also emerged as a critical enabling factor. Teachers reported greater motivation when principals actively encouraged technology integration, provided necessary resources, and fostered a supportive environment for innovation.

> "Our principal is very supportive of digital transformation. Not only are we learning, but the principal is also enthusiastic. It's just a shame our school doesn't have the complete technology to support it." *(P7)*

Institutional policies, funding support, and access to professional development further influenced teachers' digital growth.

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Theme 3. Professional development needs

Continuous and practical training, participants consistently stressed the importance of ongoing, practice-oriented professional development. Existing training programs were often perceived as too brief, overly theoretical, and insufficiently aligned with classroom realities.

> "After attending training, we often return to school without further guidance, so sometimes we forget how to apply what we learned." (P5)

Teachers preferred hands-on workshops that directly addressed vocational teaching contexts.

Mentoring and follow-up support, beyond formal training, participants highlighted the importance of sustained mentoring and post-training assistance. Without continued guidance, transferring newly acquired knowledge into classroom practice remained challenging.

> "We attended the training, but it was useless if the equipment at school did not support it." *(P3)*

Teachers expressed a strong need for coaching, classroom support, and constructive feedback during implementation.

Peer collaboration and professional learning communities, collegial collaboration emerged as an important informal learning mechanism. Participants frequently relied on fellow teachers for technical assistance, instructional ideas, and emotional support.

> *"*Usually, we learn from friends who understand better, and it's easier to understand." *(P4)*

Collaborative learning reduced anxiety, fostered experimentation, and encouraged the sharing of effective practices.

Theme 4. Implications for educational quality in vocational schools

Enhancing student engagement and learning experiences, participants believed that effective technology integration significantly improved student engagement. Digital media, simulations, and interactive learning resources increased students' interest, participation, and motivation.

> "Students are more interested and active when learning uses digital media, especially simulations and videos." *(P6)*

Strengthening workplace readiness

Teachers emphasized that digital competence is essential for preparing vocational students for contemporary workplaces. Students require familiarity with industry-relevant software, digital communication, and technology-based problem-solving.

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> "Our students need digital skills because the workplace now requires technology in almost every field." *(P7)*

Improving school competitiveness and educational relevance, participants also perceived teachers' digital competence as contributing to institutional quality. Schools that successfully integrate technology are better positioned to meet industry expectations, attract prospective students, and maintain educational relevance in an increasingly digital society.

> "Our school is actually quite popular. Job opportunities suitable for our graduates are available, but limited." (P5)

Overall, the findings indicated that strengthening teachers' digital competence is fundamental to improving instructional quality, graduate employability, and institutional competitiveness in vocational education.

Discussions

Interpreting teachers' digital competence through TPACK

Findings indicate that many vocational high school teachers, particularly those working in rural areas, continue to experience significant difficulties integrating digital technology into classroom practice. Teachers' reliance on basic applications, such as presentation software and messaging platforms, indicates that technology is often used primarily for content delivery and communication rather than for transformative pedagogical purposes. These findings suggest that many teachers are still learning how to connect technology with teaching strategies and vocational subject content in a meaningful way (Koehler et al., 2014; Mishra & Koehler, 2006).

The challenges reported by participants, particularly in adapting digital tools for practice-based and competency-based vocational teaching, highlight the complexity of integrating technology into vocational education. Unlike general academic subjects, vocational learning requires authentic, practice-oriented experiences that closely resemble the realities of the workplace. Therefore, teachers must not only possess technical skills but also understand how digital tools can support hands-on learning, simulations, project-based teaching, and industry-relevant assignments. Similar observations have been reported in earlier studies, which found that teachers with stronger TPACK tend to integrate technology more effectively into classroom instruction (Valtonen et al., 2017).

Furthermore, the findings suggested that teachers often possess technological knowledge in isolation, without fully integrating it with pedagogical strategies and vocational subject matter. Many participants reported confidence in using basic digital tools, but struggled when asked to design interactive, student-centered, technology-enabled learning experiences. This indicates that teachers can use technology, but struggle to integrate it to deliver the knowledge their students need.

Teachers' difficulties with advanced technology use indicate that many are still at the early stages of digital integration, using technology only to replicate traditional teaching practices. This pattern is consistent with research showing that teachers often begin with low-level technology adoption before gradually progressing to more transformative and student-centered uses (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017). However, the

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demands of vocational education differ from other forms of education. Particularly in the context of Industry 4.0, vocational teachers are expected to prepare students for work in a digital world characterized by automation, data analytics, and interconnected technologies (Chaka, 2020; Shahroom & Hussin, 2018).

The results show that the TPACK framework remains useful for explaining why some teachers find it easier than others to integrate technology into vocational learning activities. TPACK relates not only to teachers' ability to use technology but also to their ability to integrate learning outcomes meaningfully. However, the implementation of TPACK will be particularly prominent in rural vocational schools with limited technological resources (Mukminin et al., 2019). Consequently, Kholifah et al. (2025) predict that teaching quality, student engagement, and graduate employability will suffer. Therefore, teachers must receive training and professional development that integrates knowledge of technology, pedagogy, and vocational content.

Human resource development and sustainable professional learning

These findings highlight that training sessions alone cannot develop teachers' digital competence. Participants consistently emphasized the limitations of workshops, particularly when the programs lack contextual relevance, mentoring, and systematic follow-up. These findings strongly support the Human Resource Development (HRD) perspective, which conceptualizes professional competence as a process of continuous learning, performance improvement, and organizational capacity building, rather than a single training event (Garavan & Carbery, 2012). As Svoboda and Knihova (2025) noted, teachers are aware of technology but receive inadequate support.

The participants' experiences indicate that professional learning should be continuous and closely connected to classroom practice. This aligns with adult learning theory, which emphasizes that meaningful professional learning occurs when adults engage in relevant, problem-centered, and experiential activities (Knowles et al., 2015). Therefore, teachers need access to practical workshops, instructional coaching, peer mentoring, collaborative inquiry, and reflective learning experiences that align with their pedagogical responsibilities. Consistent with Darling-Hammond et al. (2020), high-quality professional development is ongoing, collaborative, content-focused, and embedded in teachers' professional practice. These characteristics are particularly important in developing digital competencies, where technology is rapidly evolving and instructional applications are constantly changing.

Effective human resource development in educational settings means providing teachers with systematic and ongoing professional learning opportunities. Alanoglu et al. (2022) argued that resistance to change often arises when teachers are not actively engaged in the change process and do not receive ongoing guidance. Therefore, effective human resource development in educational settings requires systematic and ongoing professional learning opportunities. Teachers need access to practical workshops, instructional coaching, peer mentoring, collaborative inquiry, and reflective learning experiences that align with their pedagogical responsibilities. Consistent with Darling-Hammond et al. (2020), high-quality professional development is ongoing, collaborative, content-focused, and embedded in

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teachers' professional practice. These characteristics are critical to acquiring digital competencies, as technology and learning applications are rapidly evolving.

Further findings revealed that training transfer remains a critical challenge. Many participants reported that knowledge gained during formal workshops was difficult to implement without ongoing support. This observation is consistent with training transfer theory, which suggests that learning is unlikely to translate into improved performance unless supported by conducive workplace conditions, supervisory encouragement, and opportunities for direct application (Baldwin & Ford, 1988). In other words, attending training is only the beginning, as true competence emerges through application and reinforcement. As Matuscheck and Hackenberg (2023) note, disjointed and context-inappropriate training fails to build teacher confidence and competence. This indicates that teachers need ongoing support to implement the knowledge they have received fully.

Peer-to-peer collaboration has emerged as one of the most powerful forms of professional learning. Informal collegial interactions enable teachers to share practical strategies, resolve technical difficulties, and build confidence in using unfamiliar technologies. These findings align with research on professional learning communities, which shows that collaborative cultures significantly enhance teacher learning, innovation, and instructional improvement (Stoll et al., 2006). In rural vocational schools, where access to external expertise may be limited, internal collegial networks become even more important. Mentoring also plays a crucial role in the ongoing development of digital competencies. Mentoring reduces anxiety, accelerates skill acquisition, and fosters a culture of mutual support. Reciprocal mentoring, in which younger teachers support older colleagues while simultaneously learning pedagogical skills, can be particularly effective in bridging the generational gap in digital literacy (Hobson et al., 2009; Trust et al., 2016).

The findings indicate that improving digital competence is not only a matter of individual learning; schools also need systems that support continuous professional growth. Schools that strategically invest in teacher learning develop stronger institutional capacity, greater adaptability, and greater readiness for educational innovation. Kholifah et al. (2025) stated that investment in education, training, and skills development will increase individual productivity and economic value. From this perspective, teachers' digital competence becomes a form of organizational capital that directly contributes to school effectiveness, innovation capacity, and long-term competitiveness (Garavan et al., 2012). This means that schools, as learning organizations, must be able to respond to technological change more adaptively and sustainably.

For vocational schools in rural areas, continuous professional learning should adopt an integrated approach that combines formal training, school-based workshops, peer mentoring, online learning communities, and action research. This blended professional learning approach allows teachers to continue learning while overcoming the geographic, infrastructure, and funding constraints often faced by rural schools (Desimone & Garet, 2015; Philipsen et al., 2019). Furthermore, technology-based professional learning communities are particularly beneficial for teachers in remote areas who have limited access to high-quality face-to-face training (Carpenter & Krutka, 2015). Therefore, teacher development should not be an occasional intervention, but an integral part of organizational life, school culture, and ongoing efforts to improve the quality of education (Avalos, 2011).

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The role of digital leadership in rural vocational schools

These findings suggest that school leadership plays a crucial role in developing teachers' digital competencies. Participants consistently reported that principals who actively encourage technology use, provide adequate resources, and model innovative practices create an organizational environment conducive to digital transformation. Leadership support not only influences teachers' willingness to adopt technology but also shapes the broader school culture that enables digital innovation to thrive. This aligns with Zhong's (2017) explanation that digital leadership focuses not only on leading and motivating digital change but also on creating and sustaining a digital learning culture that fosters technology-based professional development.

These findings align strongly with the concept of digital leadership, which emphasizes the strategic role of school leaders in articulating a clear vision for technology integration, fostering innovation, and facilitating organizational learning (Dexter, 2018; Pettersson, 2021). Participants described effective principals as leaders who encouraged experimentation, provided support, and helped teachers connect technology use with classroom needs. As educational institutions increasingly face rapid technological change, leadership becomes a key determinant of successful digital transformation.

In rural vocational schools, where limited infrastructure, budget constraints, and limited access to professional development are common, effective leadership becomes even more crucial. This aligns with Mhlanga and Moloi (2020), who stated that the success of digital transformation relies heavily on strong leadership principles, including a clear vision and commitment to change. Principals must act as strategic problem-solvers, identifying local opportunities, mobilizing available resources, and building partnerships with external stakeholders, including industry and government agencies. Research shows that leadership is often the most influential internal factor in the successful implementation of educational technology initiatives (Leithwood et al., 2020).

Digital leaders help teachers navigate change by reducing uncertainty, encouraging experimentation, and legitimizing innovation within the school environment. Change often creates anxiety, especially among teachers who lack confidence in their technological abilities. Yukl (2020) asserts that adaptive leaders help organizational members cope with the difficulties of change through strategic adjustment, emotional management, and continuous learning. Supportive principals can reduce this resistance by fostering psychological safety, recognizing effort, and promoting a culture where experimentation and occasional failure are considered natural components of professional growth (Fullan, 2016).

Leadership support also extends beyond providing hardware and internet access. Knight et al. (2023) stated that the success of technology integration in education is largely determined by human capacity and leadership, not solely by the availability of technology. Furthermore, allocating time for collaboration, facilitating professional development, implementing supportive policies, and establishing structures that promote continuous learning are crucial. School leaders who prioritize collaborative inquiry, peer mentoring, and professional learning communities are more likely to foster continuous improvement in teachers' digital competencies (Hallinger & Heck, 2011; Harris et al., 2022).

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Digital leadership contributes to the development of organizational culture. Ridho et al. (2023) stated that digital leadership is relevant to school systems. Schools with strong digital leaders tend to demonstrate greater openness to innovation, stronger staff collaboration, and higher levels of collective efficacy. Such a culture encourages teachers to share knowledge, experiment with new teaching strategies, and collectively address implementation challenges (Schein & Schein, 2017). Without strong leadership, even well-designed professional development programs may struggle to produce meaningful or sustainable changes in classroom practices. This is because leadership serves as a bridge between technology investment and learning transformation (Dexter, 2018).

Integrating TPACK, HRD, and digital leadership

From this research, teachers' digital competencies cannot stand alone; they must be assessed holistically and integrated. No single framework can fully capture the complexity of digital competency development, particularly in the unique context of rural vocational schools, where instructional, organizational, and contextual challenges intersect. The emergence of TPACK clarifies the knowledge base teachers need to integrate technology effectively into vocational learning. Specifically, TPACK highlights the importance of integrating technological, pedagogical, and content knowledge to support authentic and industry-relevant teaching (Koehler et al., 2014; Mishra & Koehler, 2006). In vocational education, this integration is crucial because teachers must align digital tools with practical skills, workplace simulations, and competency-based learning.

In human resource (HR) development, teachers, as sources of knowledge for students, must continuously develop themselves. As stated by Lui and Bonner (2016), teacher professional development requires regulations that encourage innovative teaching and provide practical insights to improve teaching practices. Through continuous professional learning, mentoring, collaboration, and reflective practice, teachers gradually transform technological knowledge into instructional expertise (Garavan et al., 2012). Human Resource (HR) development emphasizes that digital competence is not static but develops through continuous on-the-job learning and institutional support. In line with Barak (2023), teachers must receive effective professional development that emphasizes pedagogical competence, practices, and academic concepts related to teaching and classroom processes.

Rapid technological advancements have transformed traditional school leadership into digital leadership (Aksal, 2015). Digital leadership provides the organizational conditions for teachers to apply, experiment with, and continuously refine their competencies. Principals set the vision, allocate resources, encourage innovation, and create a collaborative culture that enables continuous technology integration (Dexter, 2018; Pettersson, 2021). Without supportive leadership, teachers may struggle to translate professional learning into classroom practice. Therefore, principal leadership plays a crucial role in providing access to digital tools and fostering an organizational climate that supports the development of teachers' digital competencies and continuous educational innovation (Yukl, 2020).

These three perspectives operate at complementary and interrelated levels. TPACK focuses on individual instructional competencies, HR emphasizes the process of professional growth, and digital leadership shapes the institutional environment in which competencies

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develop. Therefore, teachers' digital competencies are most likely to develop when these dimensions are aligned and mutually reinforcing. This integrated perspective aligns with the contemporary view that educational technology adoption is fundamentally systemic rather than simply individual (Pettersson, 2021; Tondeur et al., 2021). Effective digital transformation requires coordinated action at multiple organizational levels, including teacher capacity, professional learning structures, and leadership practices.

Conclusions

This study demonstrates that teachers' digital competence in rural vocational schools is a multidimensional construct shaped by the interaction of individual capabilities, professional learning systems, and organizational leadership. Although teachers recognize the importance of digital technology, many continue to face substantial challenges in meaningfully integrating it into vocational instruction. Their technology use remains largely at the substitution level, constrained by limited confidence, inadequate infrastructure, and insufficient institutional support.

The findings reveal that sustainable digital competence development requires more than technical training alone. Continuous professional learning, mentoring, peer collaboration, and supportive school leadership are critical to promoting long-term growth. This study proposes an integrated framework combining technological pedagogical content knowledge, human resource development, and digital leadership. TPACK explains the instructional knowledge required for effective technology integration; human resource development highlights the processes through which competence is continuously cultivated; and digital leadership provides the organizational conditions necessary for innovation and sustained implementation.

The results of this study suggest that improvements in teachers' digital competence can support better learning experiences and stronger educational outcomes. Digitally competent teachers are better able to design engaging, student-centered, and industry-relevant learning experiences that enhance instructional effectiveness. In vocational education, they can better simulate workplace environments, use authentic digital tools, and prepare students for evolving labor-market demands. Based on the findings, stronger teacher digital competence can help students develop skills that are relevant to modern workplaces while supporting ongoing improvement within vocational schools.

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No potential conflict of interest was reported by the authors.

References

Aksal, F. A. (2015). Are headmasters digital leaders in school culture? *Education and Science, 40, 182,* 77–86. https://doi.org/10.15390/EB.2015.4534

Alanoglu, M., Aslan, S., & Karabatak, S. (2022). Do teachers' educational philosophies affect their digital literacy? The mediating effect of resistance to change. *Education and Information Technologies, 27*, 3447–3466. https://doi.org/10.1007/s10639-021-10753-3

Avalos, B. (2011). Teacher professional development in teaching and teacher education over ten years. *Teaching and Teacher Education, 27*, 10-20. https://doi.org/10.1016/j.tate.2010.08.007

Baldwin, T., & Ford, J. (1988). Transfer of training. a review and directions for future research. *Personnel Psychology, 4,* 63-105. https://doi.org/10.1111/j.1744-6570.1988.tb00632.x

Barak, M. (2023). Educational ideals and classroom realities: Developing teachers' concepts of dialogic pedagogy in real-world contexts. *Teaching and Teacher Education 138*, 3. https://doi.org/10.1016/j.tate.2023.104401

Bashir, A., Bashir, S., Rana, K., Lambert, P., & Vernallis, A. (2021). Post-COVID-19 adaptations: The shifts towards online learning, hybrid course delivery, and the implications for biosciences courses in the higher education setting. *Frontiers in Education, 6*. https://doi.org/10.3389/fpsyg.2020.00918

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Chaka, C. (2020). Skills, competencies and literacies attributed to 4ir/industry 4.0: Scoping review. *IFLA Journal*, *46,* 369-399. https://doi.org/10.1177/0340035219896376

Creswell, J. W., & Poth, C. N. (2024). *Qualitative inquiry and research design choosing among five approaches*. Sage Publication.

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2020). *Effective teacher professional development*. Learning Policy Institute.

Dasruth, J., Naicker, S. R., & Smith, C. (2024). Teachers' perceptions of principals' digital leadership practices in a school district in a developing country. *Social Sciences & Humanities*, *10*(6), 101192. https://doi.org/10.1016/j.ssaho.2024.101192

Davenport, T. H. (2014). *Process management for knowledge work*. Berlin, Heidelberg: Springer.

Deroncele-Acosta, A., Palacios-Núñez, M. L., & Toribio-López, A. (2023). Digital transformation and technological innovation in higher education post-COVID-19. *Sustainability*, *15*(3). https://doi.org/10.3390/su15032466

Desimone, L. M., & Garet, M. S. (2015). Best practices in teachers' professional development in the United States. *Psychology, Society & Education; Cordoba, 7*(3), 252-263. https://doi.org./10.25115/psye.v7i3.515

Dexter, S. (2018). *The role of leadership for information technology in education: Systems of practices*. Springer. https://doi.org/10.1007/978-3-319-53803-7_32-1

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems, 49*(1), 5–22. https://journals.sagepub.com/doi/pdf/10.1177/0047239520934018

Ertmer, P. A., & Ottenbreit-Leftwich, A. (2010). Teacher technology change: How knowledge, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255-284. https://doi.org/10.1080/15391523.2010.10782551

Fullan, M. (2016). *The new meaning of educational change*. Teachers College Press.

Garavan, T. N., & Carbery, R. (2012). Mapping talent development: Definition, scope, and architecture. *European Journal of Training and Development, 36*(1), 5-24. https://doi.org/10.1108/03090591211192601

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Hallinger, P., & Heck, R. H. (2011). *Leadership and student learning outcomes*. Sage Publications. https://doi.org/10.4135/9781446288931.n5

Harris, A., Jones, M., & Ismail, N. (2022). Distributed leadership: Taking a retrospective and contemporary view of the evidence base. *School Leadership & Management*, *42*(5), 438-456. https://doi.org./10.1080/13632434.2022.2109620

Hobson, A. J., Ashby, P., Malderez, A., & Tomlinson, P. D. (2009). Mentoring beginning teachers: What we know and what we don't. *Teaching and Teacher Education, 25*(1), 207-216. https://doi.org/10.1016/j.tate.2008.09.001

Imran, M., Almusharraf, N., & Abbasova, M. Y. (2025). Digital learning transformation: A study of teachers' post-Covid-19 experiences. *Social Sciences & Humanities*, *11*, 101228. https://doi.org/10.1016/j.ssaho.2024.101228

Instefjord, E. J., & Munthe, E. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and Teacher Education, 67*, 37-45. https://doi.org/10.1016/j.tate.2017.05.016

Kholifah, N., Nurtanto, M., Sutrisno, V. L. P., Majid, N. W. A., Subakti, H., Daryono, R.W., & Achmadi, A. (2025). Unlocking workforce readiness through digital employability skills in vocational education graduates: A PLS-SEM analysis based on human capital theory. *Social Sciences & Humanities, 11*(4), 101625. https://doi.org/10.1016/j.ssaho.2025.101625

Knight, S., Dickson-Deane, C., Heggart, K., Kitto, K., Çetindamar Kozanoglu, D., Maher, D., Narayan, B., & Zarrabi, F. (2023). Generative AI in the Australian education system: An open data set of stakeholder recommendations and emerging analysis from a public inquiry. *Australasian Journal of Educational Technology, 39*(5), 101–124. https://doi.org/10.14742/ajet.8922

Knowles, M. S., Holton, E. F., & Swanson, R. A. (2015). *The adult learner. The definitive classic in adult education and human resource development.* Oxon: Routledge.

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). *The technological pedagogical content knowledge framework*. New York: Springer. https://doi.org/10.1007/978-1-4614-3185-5_9

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management, 40,* 5-22. https://doi.org/10.1080/13632434.2019.1596077

Loh, R. S. M., Kraaykamp, G., & van Hek, M. (2025). Plugging in at school: Do schools nurture digital skills and narrow digital skills inequality?. *Computers & Education*, *226*, 105195. https://doi.org/10.1016/j.compedu.2024.105195

Lucas, B., Spencer, E. M., & Claxton, G. (2012). *How to teach vocational education: A theory of vocational pedagogy*. University of Winchester. https://doi.org/10.13140/RG.2.1.4538.3446

Lui, A. M., & Bonner, S. M. (2016). Preservice and in-service teachers' knowledge, beliefs, and instructional planning in primary school mathematics. *Teaching and Teacher Education, 56*, 1-13. https://doi.org/10.1016/j.tate.2016.01.015

Luthfiani, L., Madhakomala, M., & Utama, H. B. (2026). Determinants of educational quality in vocational schools: the role of principal leadership, teacher competence, and school well-being in Merlung, Indonesia. *Journal of Social Work and Science Education*, *7*(2), 983–996. https://doi.org/10.52690/jswse.v7i2.1391

Maqbool, M. A., Asif, M., Imran, M., Almusharraf, N., & Bibi, S. (2024). Emerging e-learning trends: A study of faculty perceptions and impact of collaborative techniques using fuzzy interface system. *Social Sciences and Humanities, 10,* 101035. https://doi.org/10.1016/j.ssaho.2024.101035

Matuschek, L., & Hackenberg, T. (2025). Exploring conditional factors in digital instructional development: insights from qualitative interviews with German teachers. *Teaching and Teacher Education, 167*(5), 10522. https://doi.org/10.1016/j.tate.2025.105224

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research.* San Francisco: Jossey Bass.

Mhlanga, D., & Moloi, T. (2020). COVID-19 and the digital transformation of education: What are we learning on 4IR in South Africa? *Education Sciences, 10*(7), 180. https://doi.org/10.3390/educsci10070180

Mhlongo, S., Mbatha, K., Ramatsetse, B., & Dlamini, R. (2023). Challenges, opportunities, and prospects of adopting and using smart digital technologies in learning environments: An iterative review. *Heliyon, 9*(6), 1-11. https://doi.org/10.1016/j.heliyon.2023.e16348

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Mukminin, A., Habibi, A., Muhaimin, A., Haryanto, E., Setiono, P., & Sofyan. (2019). Vocational technical high school teachers' beliefs towards ICT for the 21st century education: Indonesian context. *Problems of Education in the 21st Century, 77*(1), 22–38. https://doi.org/10.33225/pec/19.77.22

Pambudi, N. A., & Harjanto, B. (2020). Vocational education in Indonesia: History, development, opportunities, and challenges. *Children and Youth Services Review*, *115*, 105092. https://doi.org/10.1016/j.childyouth.2020.105092

Patton, M. Q. (2014). *Qualitative research & evaluation methods integrating theory and practice*. Sage Publications.

Pettersson, F. (2021). Understanding digitalization and educational change in school by means of activity theory and the levels of learning concept. *Education and Information Technologies*, *26*(1), 187-204. https://doi.org/10.1007/s10639-020-10239-8

Philipsen, B., Tondeur, J., Pareja Roblin, N., Vanslambrouck, S., & Zhu, C. (2019). Improving professional teaching techniques for online and blended learning: A systematic meta-aggregative review. *Educational Technology Research and Development, 67*, 1145-1174. https://doi.org/10.1007/s11423-019-09645-8

Redecker, C. (2017). *European Framework for the Digital Competence of Educators: DigCompEdu.* Luxembourg: Publications Office of the European Union.

Ridho, M. R., Lesmana, I., Safitri, H. D. A., Meirani, R. K., & Prestiadi, D. (2023). *Digital leadership in the scope of education.* Atlantis Press. https://doi.org/10.2991/978-2-494069-95-4_7

Roll, M. J., & Ifenthaler, D. (2021). Multidisciplinary digital competencies of pre-service vocational teachers. *Empirical Research in Vocational Education and Training*, *13*(1), 7. https://doi.org/10.1186/s40461-021-00112-4

Schein, E. H., & Schein, P.A. (2017). *Organizational culture and leadership*. San Francisco: Wiley & Sons.

Shahroom, A. A., & Hussin, N. (2018). Industrial revolution 4.0 and education. *International Journal of Academic Research in Business and Social Sciences*, *8*(9), 314-319. https://doi.org/10.6007/IJARBSS/v8-i9/4593

Stoll, L., Bolam, R., McMahon, A., & Wallace, M. (2006). Professional learning communities: A review of the literature. *Journal of Education Change, 7*(4), 221-258. https://doi.org/10.1007/s10833-006-0001-8

Svoboda, P., & Knihova, L. (2025). Exploring the future of education: Integrating metaverse and AI tools to enhance learning experiences. *TEM Journal, 14*(1), 631-643. https://doi.org/10.18421/TEM141-56

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Education Technology Research and Development. 65,* 555–575. https://doi.org/10.1007/s11423-016-9481-2

Trust, T., Krutka, D.G., & Carpenter, J.P. (2016) "Together we are better": Professional learning networks for teachers. *Computers & Education, 102,* 15-34. https://doi.org/10.1016/j.compedu.2016.06.007

Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology*, *33*(3). https://doi.org/10.14742/ajet.3518

Yin, R. K. (2017). *Case study research and applications design and methods*. Sage Publication.

Yukl, G. (2020). *Leadership in organizations*. Pearson.

Zhong, L. (2017). Indicators of digital leadership in the context of k-12 education. *Journal of Educational Technology Development and Exchange, 10*(1), 26–40. https://doi.org/10.18785/jetde.1001.03