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Experiences of Teachers in the Utilization of Educational Technology in Selected Vocational Colleges

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A R T I C L E I N F O

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A B S T R A C T

This study investigates vocational college teachers' practical experiences, implementation barriers, and optimization strategies concerning the utilization of educational technology in Shaanxi Province, China. Employing a descriptive qualitative research design, the study conducts semi-structured interviews with nine teachers from three selected vocational colleges. The data are analyzed thematically, guided by the Technological Pedagogical Content Knowledge (TPACK) framework and the Unified Theory of Acceptance and Use of Technology (UTAUT) model. The findings reveal that although basic educational technology tools are widely adopted, the depth and effectiveness of their application vary considerably among teachers, particularly in integrating technology, pedagogy, and disciplinary content. Based on these findings, the study proposes targeted improvement strategies at the institutional, individual, and policy-industry levels to strengthen teachers' technological competencies and support the high-quality digital transformation of vocational education.

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INTRODUCTION

The integration of educational technology in vocational education has become increasingly significant in the global context,particularly as countries strive to enhance their workforce capabilities through improved teaching methodologies.Internationally,the rise of digital learning tools has transformed traditional educational paradigms,allowing for more interactive and engaging learning experiences.This trend is evident across nations,where governments and educational institutions are investing in technology to facilitate skill development and prepare students for the demands of modern industries(Seyffer, Hochmuth, & Frey, 2022).

UNESCO-UNEVOC further identifies digital competence as an essential qualification for TVET teachers and trainers in a digital world, yet it also warns that the gap between policy-level investment and actual classroom implementation remains a persistent global challenge, particularly in developing regional contexts where hardware access, teacher capacity and institutional support are unevenly distributed (UNESCO-UNEVOC, n.d.).

In China,the national emphasis on vocational education has intensified,especially in light of the country's economic transformation and the need for a skilled labor force.The Chinese government has implemented policies aimed at expanding vocational education,which includes the integration of technology in teaching practices.This initiative is crucial for addressing the skills gap and ensuring that graduates are equipped with the necessary competencies to thrive in a competitive job market(Han, Yang, & Zhou, 2023).The COVID-19 pandemic further accelerated this shift,as many vocational institutions adopted online learning platforms to maintain educational continuity,highlighting both the potential and challenges of technology in vocational training(Seyffer et al.,2022).

In 2022, China launched the National Vocational Education Digitalization Strategy, and the National Smart Education Platform for Vocational Education was officially put into operation on March 28, 2022, providing nationwide shared digital courses and teaching resources (Ministry of Education [MOE], 2022). According to the latest national statistics, China had 1,562 vocational colleges at the junior college level and 51 undergraduate-level vocational universities in 2024 (MOE, 2025). Despite this rapid expansion in infrastructure, empirical studies note that the quality of classroom technology integration still lags behind the popularization of hardware and platforms, and frontline teachers' real implementation experiences have not been sufficiently examined (Han et al., 2023).

At the local level,Shaanxi Province has made notable strides in modernizing its vocational education system.With an increasing number of vocational colleges and a focus on enhancing educational quality,the province aims to align its training programs with the needs of the local economy.However,challenges remain,such as the need for better teacher training in educational technology and the integration of practical skills into the curriculum,which aligns with common barriers identified in national vocational education digitalization research(Han et al.,2023).This study aims to explore the

experiences of teachers in selected vocational colleges in Shaanxi Province regarding their utilization of educational technology,providing insights into the effectiveness of current practices and identifying areas for improvement.

Official statistics show that Shaanxi had 39 vocational colleges at the junior college level and 2 undergraduate-level vocational universities in 2024, while the number of full-time students enrolled in the province's vocational colleges reached about 404,900 as early as 2022 (Shaanxi Provincial Department of Education [SPDE], 2022, 2025). These figures indicate a large teaching base that urgently needs teachers capable of high-quality technology use, while first-hand evidence from frontline teachers in this western province remains limited.

Against this background, a clear research gap remains: most existing studies on educational technology in China concentrate on macro-level policy analysis, developed eastern regions, or student learning outcomes, whereas the authentic voices of frontline vocational teachers in under-researched western provinces—especially their stratified application experiences, perceived barriers and practical support needs—have rarely been documented. To address this gap, this study examines the experiences of teachers in selected vocational colleges in Shaanxi Province, and its findings offer empirical evidence and practical references for VET digitalization in western China and similar regional contexts.

THEORETICAL REVIEW

The integration of technology into education has become a major focus of research and pedagogical practice, particularly within the context of vocational education and training (VET). The growing adoption of digital platforms, virtual learning environments, and artificial intelligence (AI) has transformed teaching and learning processes while creating new demands for teachers' technological competencies and institutional readiness. This literature review synthesizes previous studies examining the adoption of educational technology, teachers' digital competencies, technology-enhanced instructional strategies, virtual learning environments, and AI-driven innovations in vocational education. It also highlights the pedagogical, institutional, and policy-related factors that influence the effective integration of technology into vocational teaching and learning.

Antonietti, Cattaneo, and Amenduni (2022) investigated the mechanisms through which teachers' digital competence influences technology acceptance in vocational education, drawing on a large sample of 2,011 vocational teachers. Their study validated the applicability of the Technology Acceptance Model (TAM) in VET contexts and demonstrated that teachers' self-assessed digital competence is positively and significantly associated with perceived ease of use and perceived usefulness of educational technology. Furthermore, perceived usefulness was found to be directly associated with teachers' intentions to adopt digital tools in their instructional practices. These findings emphasize that strengthening teachers' digital competencies is essential for promoting technology acceptance and facilitating meaningful technology integration in vocational education.

Beyond basic digital competence, recent research has increasingly emphasized the development of teachers' AI literacy and their ability to integrate emerging technologies into instructional practices. Shi, Gu, and Li (2025) developed an AI literacy framework for vocational college teachers based on empowerment theory. The framework identifies essential human–AI collaboration competencies, including the ability to use AI to identify industry demands, design instructional scenarios, and align curricula with workplace requirements. The study also examines barriers to AI literacy development from policy, institutional, and individual perspectives, offering recommendations for strengthening teachers' professional development in the digital era. Similarly, Setiyawan, Soeharto, Wijaya, Korenova, and Lavicza (2025) developed and validated an AI-integrated Technological Pedagogical Content Knowledge (AI-TPACK) scale for vocational teachers. Their findings support the use of an extended TPACK framework as an instrument for assessing teachers' competencies in integrating AI into educational practices across pre-service and in-service teaching contexts.

The effectiveness of technology integration also depends on the quality of instructional design and the alignment between digital learning activities and vocational learning objectives. Zgraggen (2021) explored teachers' perspectives and experiences regarding a conceptual blended learning framework in vocational hospitality training at an Australian institution. The study examined approaches to improving students' learning experiences and outcomes through student-centred instruction, technology-enhanced learning, and stronger connections between classroom activities and workplace learning. In engineering vocational education, Frady (2023) conducted a systematic review of virtual laboratories in engineering technology and VET programmes, synthesizing existing approaches to their pedagogical implementation. The review highlighted how virtual laboratories expand learning opportunities and support demand-oriented engineering instruction tailored to the needs of vocational learners at the sub-baccalaureate level.

In addition to blended learning and virtual laboratories, immersive technologies have demonstrated considerable potential for improving practical skills development in vocational training. Keller, Berger, Michot, Brucker-Kley, and Knaack (2023) introduced an immersive virtual reality application for training electrical assembly and installation technicians. Developed according to didactics-first and human-centred design principles, the application was evaluated through an A/B test conducted across multiple sites. The results indicated a significant positive effect on apprentices' learning outcomes and provided opportunities for independent examination preparation regardless of differences in workplace training conditions. Meanwhile, Kerimbayev, Nurym, Akramova, and Abdykarimova (2020) examined interactive communication in virtual educational environments using the Moodle learning management system (LMS). Their study emphasized the importance of structured online learning activities for monitoring students' progress and strengthening interaction between teachers and students in vocational education. Complementing these findings, Mavengere and Ruohonen (2018) investigated

user needs in virtual learning environments and highlighted the importance of aligning pedagogical approaches with learners' characteristics and course content to improve the overall quality of digital learning experiences.

The emergence of generative AI has further expanded opportunities for transforming vocational teaching practices and strengthening teachers' instructional capabilities. Schmitt and Brutzer (2025) developed and evaluated a generative AI training programme for VET educators that combined theoretical instruction on AI functionality and data protection with practical prompt engineering exercises. Evaluation results involving 52 participants indicated improvements in teachers' abilities to formulate effective prompts and critically assess AI-generated outputs. However, participants also expressed the need for more extensive practical exercises and continuous professional guidance. In a related study, Pargmann, Berding, Rebmann, and Riebenbauer (2025) investigated the role of analytical AI feedback in supporting lesson planning within vocational business teacher education through a longitudinal intervention study. Their findings indicated that AI-generated feedback could achieve comparable or superior performance to human feedback in selected dimensions, including lesson structure, learner engagement, and technology integration.

Research has also begun to examine the broader implications of generative AI for teachers' workloads, students' learning behaviours, and educational outcomes. Yunus, Gay, and Lee (2025) evaluated a generative AI chatbot co-designed with vocational lecturers in Singapore, focusing on its influence on teaching processes and student learning behaviours. The findings suggested that the chatbot could streamline instructional workflows and reduce teachers' cognitive workload. Nevertheless, the study also identified potential challenges, including reduced student metacognitive engagement and widening performance differences among students with varying ability levels. Similarly, Xu and Chen (2026) explored an innovative approach to integrating generative AI into vocational education through human-centred pedagogy. Their findings highlighted the potential of AI as a pedagogical co-pilot that enhances instructional efficiency, supports creativity, and facilitates personalized learning when appropriately integrated into discipline-specific educational contexts.

At the institutional and policy levels, sustainable technology integration requires systematic competency development, adequate infrastructure, and supportive governance mechanisms. Phakamach, Supap, Pangthai, Sommartdejsakul, and Phomdee (2025) proposed structured guidelines for developing AI competencies among vocational education teachers based on the Thailand Vocational Qualifications Framework. Their proposed development pathway encompasses cognitive, psychomotor, and affective competency domains, emphasizing the importance of a comprehensive approach to AI-related professional development. In addition, UNESCO-UNEVOC highlights cross-institutional resource sharing and policy guidance as important strategies for accelerating digital transformation in vocational education. Such approaches can minimize the duplication of educational resources, strengthen institutional collaboration, and improve the efficiency of educational investment.

Overall, the reviewed literature demonstrates that educational technology integration in vocational education is a multidimensional process involving teachers' digital competencies, pedagogical readiness, instructional design capabilities, institutional resources, and policy support. Previous studies have established the importance of technology acceptance, TPACK-based competencies, blended learning, virtual laboratories, immersive learning environments, and AI-supported instructional practices. However, the effectiveness of these technologies ultimately depends on how well they are aligned with vocational curricula, industry requirements, teachers' professional capacities, and students' learning needs. Despite the growing body of research on technology adoption and AI-driven innovation, further investigation is needed into teachers' actual experiences, implementation barriers, and strategies for optimizing educational technology in different vocational education contexts. Addressing these issues is essential for developing sustainable, inclusive, and pedagogically meaningful models of digital transformation in vocational education and training.

METHODOLOGY

Research Design

This study employed a descriptive qualitative research design, with semi-structured interviews serving as the primary data collection method. This approach was considered appropriate for exploring teachers' experiences in utilizing educational technology in vocational colleges, as it enabled an in-depth examination of their perceptions, practical experiences, implementation challenges, and strategies for optimizing technology integration. Through this design, the study sought to obtain rich and contextual information regarding how teachers incorporate educational technology into their instructional practices.

Sample Population and Locale of the Study

This study employed purposive sampling to select participants who met specific criteria relevant to the research objectives. The participants consisted of nine teachers from three selected higher vocational colleges in Shaanxi Province, China. These institutions were selected based on their established educational reputation and institutional standing within the province. Three teachers were recruited from each institution, resulting in a total of nine participants. The selected institutions were Shaanxi Polytechnic Institute, Shaanxi Institute of Technology, and Shaanxi Railway Institute.

To ensure the relevance and diversity of participants' experiences, the following inclusion criteria were established:

1. **Teaching Experience:** Participants were required to have at least three years of teaching experience in vocational education to ensure sufficient familiarity with instructional practices, educational technology, and the challenges associated with its implementation.
2. **Subject Area:** Teachers were selected from different academic and vocational disciplines, including information technology, engineering, and business, to

capture diverse perspectives on educational technology integration across subject areas.

3. **Age and Gender:** Participants represented different age groups and genders, ensuring the inclusion of both male and female teachers and capturing a variety of experiences and perspectives regarding technology utilization.
4. **Technological Proficiency:** Participants were selected based on their self-reported levels of technological proficiency. The sample included teachers with relatively high levels of confidence in using educational technology as well as those with more limited experience, allowing the study to examine differences in technological adoption and the challenges encountered at different competency levels.

The selection of participants from three different vocational colleges enabled the study to capture diverse institutional and individual experiences related to educational technology utilization. The variation in teaching backgrounds, subject areas, demographic characteristics, and technological proficiency provided a broader understanding of the factors influencing technology integration in vocational education. These sampling considerations also supported the collection of rich and relevant qualitative data, contributing to the depth and contextual understanding of the research findings.

Teachers who did not meet the established inclusion criteria were excluded from participation. Only individuals who fulfilled the selection requirements and were willing to participate in the interviews were included in the study.

RESULTS AND DISCUSSION

Experiences of Teachers in the Use of Educational Technology in Vocational Colleges

Teachers' Experiences with Educational Technology in Their Classrooms

All nine participants reported integrating educational technology into their daily teaching activities, although the depth and complexity of its application varied considerably. Basic digital tools, such as PowerPoint presentations and online learning platforms like Xuexi Tong, were universally adopted for presenting instructional materials, recording attendance, and distributing assignments. However, the use of specialized educational technologies differed according to teachers' disciplinary backgrounds and levels of technological proficiency.

Teachers with higher levels of technological proficiency demonstrated more advanced integration of specialized tools into their instructional activities. T1, an information technology teacher, explained, “For programming courses, we use an online evaluation system. Students get immediate results after submitting their code, and we carry out group project teaching with collaborative documents.” Similarly, T7, who teaches railway operation management, stated, “For railway dispatching training, we use a simulation system where students can practice procedures repeatedly without occupying physical equipment.” In contrast, teachers with more basic technological proficiency primarily used digital tools as substitutes for conventional teaching methods. T4 explained, “I only use PPT instead of blackboard writing and assign homework via Xuexi

Tong. There is no need for complex functions, and basic teaching requirements can be met."

From the perspective of the Technological Pedagogical Content Knowledge (TPACK) framework, these differences reflect varying levels of integration among technological, pedagogical, and content knowledge (Mishra & Koehler, 2006). Teachers with stronger technological competencies demonstrated greater capacity to combine these three knowledge domains, enabling them to redesign instructional activities and create more interactive learning experiences. Conversely, teachers with basic technological proficiency tended to focus on isolated technical applications without substantially transforming their pedagogical approaches. This pattern is consistent with the broader digital transformation challenges in vocational education, where access to digital tools does not necessarily translate into meaningful pedagogical integration (Han et al., 2023). It also corresponds with Antonietti et al. (2022), who highlighted differences in teachers' digital competencies and technology acceptance across vocational education contexts.

The present findings further extend this discussion by identifying discipline-specific differences in technology integration. Engineering teachers primarily encountered limitations related to aging hardware and restricted access to simulation software licenses, whereas management teachers experienced greater difficulties in connecting available technologies with appropriate instructional designs. These differences demonstrate that technology integration is not solely determined by individual digital competence but is also shaped by the practical requirements and pedagogical characteristics of different vocational disciplines. Thus, the TPACK framework provides a useful perspective for understanding how teachers' technological knowledge must be aligned with specific instructional and professional contexts.

Perceived Benefits and Challenges of Integrating Technology into Vocational Education

All participants acknowledged the potential benefits of educational technology in improving teaching and learning processes. Three major benefits emerged from the interviews. First, educational technology enhanced classroom engagement, particularly in management-related subjects. T5, an e-commerce teacher, stated, "Using interactive tools for group competitions in e-commerce courses has significantly increased students' engagement in class." This finding is consistent with Zgraggen (2021), who emphasized the contribution of interactive digital tools to student participation and learning experiences in vocational training programmes.

Second, technology helped reduce training costs and potential safety risks, particularly in engineering-related disciplines. T2, a mechanical engineering teacher, explained, "For mechanical processing, students practice procedures proficiently in the simulation system before operating real machines, which significantly lowers error rates and equipment loss." This observation supports Frady's (2023) findings that virtual laboratories can expand practical learning opportunities while reducing certain risks associated with conventional technical training.

Third, educational technology facilitated flexible and self-paced learning. T8 explained, "Students with weak foundations can watch recorded lectures repeatedly to fill learning gaps, instead of always asking teachers for help." This suggests that recorded instructional materials and digital learning platforms can accommodate differences in students' learning speeds and provide additional opportunities for independent study.

Despite these benefits, participants identified three major barriers to deeper technology integration. The first was inadequate technological infrastructure. T4 complained, "Computers in the training room have been used for many years and freeze frequently when running simulation software, wasting a lot of time on loading." T7 similarly reported that limited simulation software licenses required students to undertake training in separate groups, creating difficulties in managing instructional time.

The second barrier involved teachers' limited capacity to integrate technology into instructional design. T8 admitted, "New software has a high learning cost, and daily teaching tasks are heavy, so there is not enough time to study them thoroughly." The third barrier concerned the additional workload associated with technology-enhanced teaching. T5 stated, "Designing a blended course takes 2–3 times longer than preparing a traditional course, but the workload is calculated the same as ordinary courses, so there is little motivation to persist long-term."

Differences in perceptions also emerged regarding classroom management. T4 argued that electronic devices could increase classroom management difficulties, whereas T5 maintained that carefully designed learning activities could help students remain focused. Furthermore, all participating engineering teachers emphasized that virtual technologies could not completely replace practical training. T2 stressed, "No matter how realistic the simulation is, it cannot replicate the tactile feel and emergency-handling experience of real machines. Technology can only be an auxiliary."

These findings can be interpreted through the Unified Theory of Acceptance and Use of Technology (UTAUT) model, particularly its facilitating conditions and effort expectancy dimensions (Venkatesh et al., 2003). Inadequate infrastructure represents a limitation in facilitating conditions, while the time and effort required to master unfamiliar technologies contribute to higher perceived effort. Together, these factors may discourage teachers from expanding their technology use. The findings are also consistent with Antonietti et al. (2022), who identified digital competence and institutional support as important factors influencing technology integration, and Yunus et al. (2025), who highlighted the additional workload associated with adopting intelligent educational technologies.

Beyond confirming these broader challenges, the present study identifies institutional arrangements as an additional factor shaping teachers' willingness to integrate technology. Participants highlighted administrative responsibilities, heavy teaching schedules, and the limited recognition of technology-related instructional work in professional title evaluations. These findings suggest that facilitating conditions should be understood not only in terms of technological

infrastructure but also in relation to institutional workload arrangements, professional recognition, and organizational support. This provides a context-specific contribution to understanding technology acceptance in Chinese vocational colleges.

Professional Development Opportunities and Support Received for Technology Use

The findings indicate that existing institutional support primarily takes the form of general training programmes focused on basic platform operations. However, teachers expressed substantially different evaluations of these programmes depending on their technological proficiency. For teachers with limited technological experience, introductory training provided practical assistance. T4 commented, "Basic operation training is very useful for me and solves entry-level problems." In contrast, teachers with higher technological proficiency considered repetitive introductory sessions less beneficial. T1 stated, "Every training covers basic functions I mastered years ago. Attending is just a waste of time."

Technical support was also largely restricted to equipment maintenance and operational troubleshooting, with limited assistance in pedagogical design. T6 explained, "The technology department can quickly fix computer failures and platform login issues, but they don't understand how to design teaching activities with software either, so I have to figure it out myself." Participants further indicated that centralized training sessions rarely included sufficient follow-up assistance. T2 reflected, "I understood everything during the centralized training, but forgot it when applying it in class. Without follow-up guidance, I gradually fall back on old methods."

These findings reveal a gap between technical training and the development of integrated teaching competencies. From the TPACK perspective, effective technology integration requires teachers to combine technological knowledge with pedagogical approaches and subject-specific content knowledge rather than simply mastering individual software applications (Koehler & Mishra, 2009). Similarly, Kerimbayev et al. (2020) emphasized that effective ICT integration requires both technical support and pedagogical guidance tailored to specific educational contexts.

The findings also correspond with Schmitt and Brutzer (2025), who highlighted the importance of practical exercises and continuous guidance in developing teachers' AI-related competencies. Pargmann et al. (2025) likewise demonstrated the value of embedding technological support within authentic lesson-planning activities rather than relying exclusively on general technical instruction. Taken together, these studies suggest that professional development is more effective when it addresses teachers' actual instructional needs and provides opportunities to apply newly acquired knowledge in classroom settings.

The present study further identifies a proficiency-based mismatch in existing professional development arrangements. While introductory training is beneficial for teachers with limited technological experience, it provides insufficient opportunities for more advanced users to develop discipline-specific

instructional innovations. Therefore, a differentiated professional development pathway is necessary, consisting of foundational digital skills training, discipline-oriented pedagogical integration, and advanced technology-based instructional innovation. Such an approach would make professional development more responsive to teachers' varying competencies and instructional requirements.

Strategies Employed to Engage Students with Technology

The interviews identified four major strategies used by teachers to facilitate students' engagement with educational technology. The first strategy involved linking technology-based participation to assessment. All participants reported using attendance records, online assignments, or other digital learning activities as components of students' course assessments. T4 explained, "Online attendance and assignments count for 30% of the usual grade, so students will participate for the scores."

The second strategy involved task-driven learning activities, which were particularly preferred by teachers with higher technological proficiency. T5 described this approach by stating, "Students run a simulated store independently, from decoration to operation. They show high interest and take the initiative to explore platform functions." This strategy encouraged students to learn through practical activities that resembled real workplace situations.

The third strategy involved demonstrations and instructional scaffolding to support students in completing complex technical operations. T7 explained, "For complex simulation operations, I record step-by-step demonstration videos for students to follow, lowering the entry threshold." The fourth strategy involved peer-assisted learning, in which technologically proficient students supported classmates experiencing difficulties. T2 stated, "I select tech-savvy students as group leaders. Students with weaker foundations can ask leaders first, which reduces the teaching burden on me."

However, the effectiveness of these strategies varied according to students' learning characteristics and motivation. For relatively self-disciplined learners, demonstration videos and peer support helped accelerate the acquisition of practical skills. T7 confirmed the positive contribution of these approaches to students' learning progress. Nevertheless, their effectiveness was more limited among students with low learning motivation. T8 admitted, "For students who don't want to learn, even with grade constraints, they just copy homework or hang up the course without really learning."

These findings suggest that technology-based engagement strategies should be adapted to students' learning needs rather than implemented uniformly. Task-driven learning can strengthen participation by connecting digital activities with practical vocational competencies, consistent with Zgraggen (2021), who emphasized the value of student-centred and technology-enhanced learning in vocational education. Xu and Chen (2026) similarly highlighted the importance of human-centred and task-oriented approaches in maximizing the educational benefits of generative AI.

Nevertheless, the limited effectiveness of technology-based strategies among students with low motivation indicates that digital tools alone cannot guarantee meaningful learning engagement. This observation is consistent with Yunus et al. (2025), who identified potential risks of reduced metacognitive engagement and widening performance differences associated with generative AI applications. The present findings reinforce the importance of combining technological resources with deliberate pedagogical strategies, active teacher guidance, and appropriate learning support. Consequently, educational technology should be regarded as an instructional facilitator rather than a standalone solution to students' learning difficulties.

Overall, the findings demonstrate that teachers' experiences with educational technology in vocational colleges are shaped by the interaction of individual competencies, disciplinary requirements, institutional support, and student characteristics. Although digital tools provide opportunities to enhance classroom engagement, improve practical training, and facilitate flexible learning, their effective utilization remains constrained by infrastructure limitations, insufficient pedagogical integration, generic professional development, and unrecognized additional workloads. Addressing these challenges requires a comprehensive approach that strengthens teachers' TPACK competencies, improves institutional facilitating conditions, provides differentiated professional development, and promotes student-centred instructional practices.

CONCLUSIONS AND RECOMMENDATIONS

This study explored vocational college teachers' practical experiences, perceived barriers, and instructional strategies regarding educational technology utilization across three selected vocational colleges in Shaanxi Province, China. Grounded in the TPACK framework and UTAUT model, the qualitative findings reveal that while basic digital tools such as presentation software and learning management platforms have been universally adopted, the depth of meaningful integration among technology, pedagogy and disciplinary content remains highly uneven.

The study identifies four core constraints limiting deeper technology integration: aging and insufficient technical infrastructure, uneven teacher competencies in pedagogical-technology design, generic and one-size-fits-all professional development, and unrecognized additional workload associated with technology-enhanced teaching. It also confirms that engagement strategies such as assessment linkage, task-driven learning, instructional scaffolding and peer assistance can improve student participation, but their effectiveness is mediated by students' learning motivation and foundational ability.

Based on the findings, the following recommendations are proposed to advance high-quality digital transformation in vocational education:

Institutional level: Vocational colleges should prioritize upgrading discipline-specific simulation hardware and software licenses, and establish a tiered professional development system that distinguishes foundational digital skill training from advanced pedagogical innovation workshops. Workload

evaluation mechanisms should be adjusted to recognize the extra input required for technology-integrated course design, and sustained pedagogical-technical support should be provided beyond basic equipment maintenance.

Teacher level: Frontline teachers are encouraged to develop discipline-specific TPACK competencies through departmental peer learning communities and workplace-based iterative practice, rather than only mastering generic software operations. Tech-proficient teachers can serve as internal mentors to promote incremental, context-appropriate technology adoption within their disciplines.

Policy and industry level: Educational authorities should expand digital infrastructure funding for vocational education in western China and promote cross-institutional sharing of high-quality digital resources. Closer industry-college collaboration is recommended to co-develop technology-integrated training modules that closely align with real workplace skill requirements.

FURTHER STUDY

Several limitations of this study should be acknowledged. First, the sample comprises only nine teachers from three vocational colleges in Shaanxi Province, so the findings cannot be generalized to broader regional or national vocational education contexts. Second, as a descriptive qualitative inquiry, the study relies on teachers' self-reported perceptions and does not quantitatively measure the causal relationship between technology integration and student learning outcomes. Third, the study focuses on general educational technology adoption and does not examine the application of emerging tools such as generative AI and immersive virtual reality in depth.

For future research, the following directions are suggested:

Large-scale quantitative studies: Future studies can use geographically diverse samples to verify the influencing factors and mechanism of technology integration among vocational teachers across China.

Comparative studies: Comparisons between eastern and western provinces, or across different vocational disciplines, can identify context-specific barriers and effective implementation practices.

Longitudinal intervention studies: Tracking the sustained impact of targeted professional development programs can clarify how such interventions shape teachers' TPACK competencies and classroom practices over time.

Emerging technology research: Empirical investigations into the pedagogical design, implementation effects and challenges of generative AI and immersive technologies in vocational education settings are needed.

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