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Digital Competence of Vocational Teachers in the Industrial Era 4.0: Literature Analysis with the PRISMA Approach

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ABSTRACT

Rapid technological development has changed many aspects of education, including learning in vocational schools. Vocational teachers are required to have digital skills to support the learning process and meet the needs of the evolving workforce. However, the digital competence of vocational teachers in many regions is still uneven and often limited.This study aims to systematically review research on teachers' digital competence in vocational education. The study focuses on identifying the main themes, trends, and challenges discussed in current literature to provide a clearer understanding of the field. The method used in this study is a Systematic Literature Review (SLR). A total of 1,250 articles were identified through database searches and manual references. After removing duplicate and irrelevant studies, 10 articles were selected for further analysis. The selection process followed the PRISMA framework to ensure transparency and reliability.The findings show that vocational teachers are becoming more aware of the importance of developing digital skills. However, many teachers still face challenges such as limited access to digital devices, lack of training opportunities, and low institutional support. The competencies most frequently discussed include digital pedagogy, the use of educational technology, and the ability to create digital learning content.In conclusion, improving the digital competence of vocational teachers does not depend only on individual efforts. Strong institutional support, regular training programs, and closer collaboration between schools and industry are highly needed.

Introduction

The application of digital technology in education has significantly revolutionized the planning, implementation, and evaluation of learning by teachers. The use of digital devices has changed teaching methods, teaching and learning processes, and assessment systems at all levels of

education Alenezi et al., (2023) . Recent developments require educators to adapt to the development and implementation of learning methods that optimally integrate information and communication technology (ICT) Haleem et al., (2022) .

Technological developments demand the integration of increasingly crucial digital competencies in vocational education and training (VET). Vocational education not only focuses on developing technical skills, but also prepares students to face the dynamics of the job market influenced by technological advances Akram et al., (2021) . Teachers in vocational institutions need to master and continuously improve digital competencies to support teaching effectiveness, in line with the dynamics of today's industry and technology Goulart et al., (2022).

Recent research also emphasizes that digital training must be contextually designed and tailored to specific areas of expertise to be effective. Zhao, Chen, and Wang (2023) stated that general digital training often fails to address the practical needs of vocational teachers, while programs tailored to local contexts and specific areas tend to result in more meaningful technology integration. Similarly, Nguyen and Pham (2022) highlight the importance of institutional policies in supporting the sustainable development of digital competencies. Without structured institutional support and long-term planning, efforts to improve teachers' digital skills risk becoming fragmented and lacking systemic impact.

Digital competence for teachers includes confident and critical mastery of information and communication technology (ICT), not just basic literacy, but also to support professional performance in teaching, communicating, and learning Sergeeva et al., (2023) . Mastery of digital pedagogy is a must, including the integration of digital devices in curriculum delivery, student performance assessment via digital platforms, development of engaging content, and adaptation to the latest technologies such as virtual simulations, artificial intelligence-based learning platforms, and online collaborative tools. Especially in vocational education that emphasizes hands-on learning and practice, this competence plays a vital role in uniting the digital and technical realms Lee and Meng, (2021).

The recognition of the importance of enhancing teachers' digital capacity has been widespread in many countries, both by governments and educational institutions. Global frameworks such as DigCompEdu (European Commission) and the ICT Competence Framework for Teachers (UNESCO) have provided standards and guidelines to assess and improve these competencies. However, studies have shown that there are still significant gaps in teachers' digital readiness, influenced by factors such as access to infrastructure, age, previous technology experience, institutional support,

and professional development opportunities. This results in a marked disparity in digital competencies among vocational teachers Antonietti et al., (2022).

The application of digital technologies in vocational education presents unique challenges and opportunities. Unlike general education, vocational education requires the use of specialized equipment, hands-on practice, and work simulations that require physical interaction and real-world experience Ghosh and Ravichandran, (2024). As a result, vocational educators are required to fulfill a dual responsibility, namely mastering conventional teaching methods rooted in practical training and at the same time transforming these methods into digital or blended formats without compromising their effectiveness Anisimova and Efremova, (2022) .

The COVID-19 pandemic accelerated the adoption of digital learning in vocational education. The sudden shift to distance and hybrid learning environments required teachers to quickly adapt their teaching strategies using online platforms and digital tools. While some educators were able to respond effectively by integrating innovative technologies, many others faced obstacles. These obstacles included limited access to adequate infrastructure, inadequate digital literacy, and lack of professional development related to online teaching. These gaps highlight the urgent need to improve digital competencies among vocational teachers to ensure continuity and quality of teaching in both normal and crisis conditions. Timotheou et al., (2023) . Given the increasing role of digital technologies in education and the labour market, a comprehensive understanding of teachers' digital competence in vocational education is essential. Much research has explored this topic, but findings are fragmented across disciplines, countries and research approaches. This systematic literature review aims to synthesise existing knowledge to identify applicable trends, gaps and recommendations that can inform policy and practice.

Method

This study used a Systematic Literature Review (SLR) approach to collect and synthesize evidence on teachers' digital competence in vocational education. The scope of the study included publications published between 2019 and 2025. The literature search was conducted on electronic databases, namely Google Scholar, and was complemented by a manual search of bibliographies and related conference proceedings Pablos et al., (2022). The search strategy used a combination of keywords and Boolean operators to cover all relevant studies. Key terms used included “digital competence”, “vocational education”, “vocational teacher”, “ICT in VET”, and “technology in vocational training”. Each term was matched to the specific syntax of each database.

The literature screening followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. PRISMA is an international guideline designed to improve transparency and reporting quality in systematic literature reviews. PRISMA helps researchers systematically and reproducibly identify, screen, evaluate for eligibility, and include articles. The initial stage involved reviewing titles and abstracts based on pre-defined inclusion criteria of a teacher population in vocational institutions and discussing at least one dimension of digital competence. Studies that only addressed general education, student populations, or hardware aspects without a pedagogical focus were excluded. Next, full-text articles from the screening results were evaluated for eligibility. Reasons for exclusion such as lack of empirical data, not in English or Indonesian, or lack of methodological details were recorded in detail O'Dea et al., (2021).

Data extraction was performed on selected articles using a standard format. Information extracted included year of publication, country context, study design, sample size, dimensions of digital competence studied, and main findings. To assess the quality of each study, a nine-point checklist adapted from international SLR guidelines was used. Criteria included clarity of purpose, appropriateness of sample description, validity of data collection instruments, and transparency of analysis procedures and PRISMA flowchart explain in Figure 1.

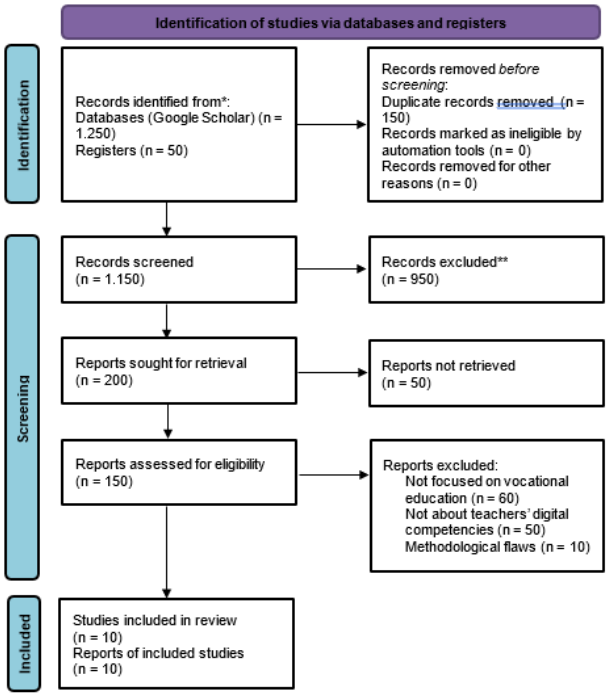

Fig 1: PRISMA *Flowchart*

Result and Discussion

Result

The results of this study reveal that vocational teachers' digital competence is an increasingly crucial aspect in facing the demands of the Industry 4.0 era. Of the 1.300 documents identified, only 10 articles met the inclusion criteria and were analyzed in-depth using the PRISMA approach. These articles came from various countries and institutional settings, reflecting the diversity of approaches and challenges faced in developing vocational teachers' digital competence.

The findings from these articles indicate that vocational teachers' digital competence encompasses three main dimensions: digital pedagogy, mastery of educational technology, and the ability to create digital-based learning content. Digital pedagogy refers to teachers' ability to integrate digital tools into the learning process, including the use of online learning platforms, virtual simulations, and technology-based collaborative tools. Mastery of educational technology encompasses technical skills in operating learning software and applications, while the ability to create digital content emphasizes teachers' creativity in designing interactive teaching materials that are relevant to industry needs.

A study by Antonietti et al. showed that teachers' perceptions of their digital competence were significantly related to their level of technology acceptance in learning. Teachers who felt digitally competent tended to be more open to the use of technology and had a higher intention to integrate it into their teaching practices. This finding is supported by the findings of Cattaneo et al., which involved more than 1,600 teachers in Switzerland. The study found that personal factors such as attitudes toward technology and frequency of digital device use had a greater influence on digital competence than contextual factors such as curriculum support or institutional policies.

Although many teachers had positive perceptions of their digital competence, the reality on the ground revealed a gap between perception and actual capabilities. A study by Khademi-Vidra and Bakos in Hungary found that although teachers felt quite confident, there was still an urgent need for subject-based thematic training and the development of adequate digital infrastructure. Vocational teachers in agriculture, for example, needed specific training on the use of digital tools relevant to modern agricultural practices.

In Indonesia, a study by Astuti et al. identified five levels of digital maturity: awareness, literacy, capability, creativity, and critical thinking. Unfortunately, the majority of teachers and students still perform poorly in all these categories. This indicates that the training provided has not been effective enough in improving overall digital competence. Furthermore, Mutohhari et al. found that

teachers and students experience difficulties implementing 21st-century skills, particularly in digital communication and problem-solving. Differences in the levels of difficulty between teachers and students were also highlighted, indicating the need for a more adaptive and needs-based training approach.

A study from Ukraine by Kovalchuk et al., highlighted the structural challenges faced by vocational institutions in the digital transformation process. Limited infrastructure, lack of institutional readiness, and limited digital resources are key barriers to developing teachers' digital competence. In the context of crises such as the COVID-19 pandemic and geopolitical conflicts, these challenges are further compounded, as teachers are required to adapt to online learning without adequate support.

Roll and Ifenthaler developed a multidisciplinary digital competence model encompassing aspects of information literacy, virtual collaboration, and digital security. This study emphasizes that vocational teachers require not only technical skills but also the ability to work in a complex and dynamic digital environment. This model suggests that attitudes toward digitalization influence self-efficacy, although they do not always have a direct impact on learning outcomes.

Fernández-Batanero et al., (2022) in their systematic review, found that digital training for teachers remains very limited and poorly structured. The majority of the studies they analyzed indicated that teachers lack confidence in using technology, and available training is often irrelevant to practical needs in the field. Lindfors et al. also highlight the importance of institutional support and continuous professional development policies to systematically support teachers' digital competence.

The results of this study indicate that vocational teachers' digital competence is a crucial element in facing the challenges of education in the Industry 4.0 era. However, developing this competence cannot be done in a piecemeal or individual manner. A holistic approach is needed that includes needs-based training, infrastructure strengthening, policy support, and collaboration between educational institutions, industry, and the government. Only in this way can vocational teachers be truly prepared to educate a generation that is competent and adaptable to the ever-evolving technological changes. Table 1 explains the relevant articles that support these findings and provide a deeper understanding of the importance of digital competence development among vocational teachers in the modern educational environment.

Table 1. 10 relevant articles

No.	*Title*	*Writer*	*Year*	*Method*	*Country*	*Key Challenges Identified*	*Results*
1	Can teachers' digital competence influence technology acceptance in vocational education?	Antonietti et al. (2022)	Year 2022	Quantitative – Structural Equation Modeling (SEM)	Italia	Training needs that support technology adoption	This study shows that the Technology Acceptance Model (TAM) is relevant in vocational education. Teachers' digital competence positively influences perceived ease of use, usefulness, and intention to use technology in learning. The findings highlight the importance of digital competence training to support technology integration in vocational education.
|	|	|	|	|	|	|	|
10	Conditions for Professional Digital Competence: The Teacher Educators' View	Lindfors and friends (2021)	Year 2021	Qualitative (Semi-structured Interview)	Swedia	Need for supportive CPD policies; lack of access to ongoing training	This study highlights the need to improve teacher education and professional development policies to support digital competence.

Discussion

The discussion in this study reveals that vocational teachers' digital competence is not simply a collection of technical skills, but rather a multidimensional construct influenced by social, institutional, and psychological contexts. A systematic review of ten articles shows that while there is global agreement on the importance of technology mastery in vocational education, approaches to developing this competence vary widely—even contradicting each country's geographic setting, methodology, and policies.

One common thread that emerges is the recognition that ongoing training and institutional support are key foundations in shaping teachers' digital competence. Studies by Antonietti et al. and Cattaneo et al. show that teachers' perceptions of their digital competence correlate with their level of acceptance of technology in learning. Teachers who feel competent tend to be more open to digital innovation. However, Khademi-Vidra and Bakos' study reveals an interesting paradox: although teachers in Hungary have positive perceptions of their digital competence, they still experience difficulties in accessing thematic training and adequate infrastructure. This suggests that self-confidence does not always reflect actual readiness, and that relevant training is far more important than mere perception.

Another contradiction arises in the assessment of digital maturity levels. A study by Astuti et al. Research in Indonesia shows that teachers and students still have low levels of digital awareness, literacy, capability, creativity, and critical thinking. This finding contrasts with studies in Switzerland and Sweden, where teachers demonstrated higher levels of competency, although they still face challenges in terms of relevant training and professional development policies. This difference not only reflects technological disparities between countries but also suggests that approaches to improving digital competency must be contextual and cannot be standardized.

This synthesis also revealed that available training for vocational teachers is often generic and non-contextualized. A study by Fernández-Batanero et al. showed that digital teacher training is not tailored to the specific needs of vocational fields. Agriculture, engineering, or communication teachers, for example, require different approaches to technology use. However, the training provided tends to be uniform and not practice-based. Meanwhile, Lindfors et al. emphasize the importance of professional development policies that support continuous digital learning. Both studies highlight that effective training must be tailored to teachers' areas of expertise, local contexts, and the real-world challenges they face.

What is not apparent in each paper, but becomes clear through this synthesis, is that the digitalization of vocational education is not just about equipment and training, but about the readiness of the entire system. When read separately, these challenges appear as localized issues. However, when examined together, it becomes clear that these challenges are recurrent and mutually reinforcing, forming a larger pattern of failure. This synthesis also shows that no single solution is sufficient. Training, policy, infrastructure, and organizational culture change must work together within a single transformation framework.

Roll & Ifenthaler study expands the scope of digital competencies by proposing a multidisciplinary model that encompasses information literacy, virtual collaboration, and digital security. This model challenges traditional approaches that emphasize only technical skills. However, their findings also indicate that teachers' self-efficacy towards digitalization does not always have a direct impact on learning outcomes. This raises an important question: has digital training so far focused too much on technical aspects, neglecting the affective and social dimensions of digital learning?

In the context of crises such as the COVID-19 pandemic and geopolitical conflicts, the study by Kovalchuk et al. highlights the additional challenges faced by vocational institutions, particularly in terms of digital readiness and access to resources. Teachers were forced to adapt to online learning suddenly, without adequate preparation. This reinforces the argument that digital competence is not just about skills, but also about the resilience of the education system in the face of disruption.

Conceptually, this discussion leads to one important conclusion: the digital competence of vocational teachers cannot be separated from the educational ecosystem in which they operate. Efforts to improve competence must be carried out systematically, involving policymakers, educational institutions, and industry. Evaluation of digital competence must also consider aspects of perception, self-efficacy, and tangible outcomes in learning practices. Digital transformation in vocational education is not a short-term project, but rather an ongoing process that requires cross-sector commitment.

Conclusion

Digital competence has become a critical aspect in the advancement of vocational education worldwide. In the context of today's educational demands, the integration of digital technologies in teaching is no longer optional but essential. Teachers, as the main drivers of vocational learning, must not only have digital skills but also be supported through structured training, infrastructure

readiness, and policy strengthening. The challenges faced, ranging from limited access and low maturity levels to difficulties in implementing 21st century skills, highlight the urgent need for collaborative efforts between institutions, policymakers, and educators. By strengthening digital competence through continuous professional development and contextual learning strategies, vocational education can better prepare students for the modern workforce, ultimately contributing to national development and global competitiveness.

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