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RESEARCH ARTICLE

Factors influencing vocational education teachers' digital competencies: A systematic literature review

Mohd Nasir Ismail[1], Xiangyong Duan[1,2,*], Khalid Abdul Wahid[1]

[1] *Faculty of Information Science, Universiti Teknologi MARA Kelantan Branch, Malaysia*

[2] *Guiyang KangYang University, GuiZhou, China*

*** Corresponding author:** Xiangyong Duan, duanxy@gyhvu.edu.cn

ABSTRACT

Digital technologies in vocational education significantly impact teacher digital competencies so these digital competencies play a considerable impact on both teaching efficiency and data management. For the following systematic literature review to examine the role of factors in the digital competences of teachers in higher vocational college we aimed to review literatures published from 2018 to 2023. Professional development was particularly interesting to us. We searched Web of Science, Scopus, CNKI, and Google Scholar, yielding 20 empirical studies corresponding with our selection criteria. Professional training was perhaps the strongest factor - it significantly increased the confidence and the capability of teachers to work with digital tools. Other important factors include self-confidence, age, attitudes toward technology, digital awareness, years of teaching experience and access to adequate digital resources. An interesting trend emerged: Older teachers in general seemed to have lower digital competencies, although well-organized training schemes along with helpful digital environments, in particular in terms of support systems, were able to raise skill levels in all age groups. Although training is important, we found surprisingly limited empirical research specifically on vocational education. More research is required regarding the relationship between professional training and other influencers. Our results provide policymakers and educational institutions with practical recommendations towards improving digital integration among professionals and fostering the ongoing competence of vocational teachers.

Keywords: digital competence; vocational education; teachers; professional training

1. Introduction

The first topic of this systematic literature review is a simple purpose: to explore teachers' construction of digital competence and their causes of development. We formulated a systematic search to retrieve relevant literature using e.g., "educational technology," "professional development," "school support," "technical infrastructure," etc.Selection was conducted following a carefully conducted screening process comprised of identification, screening, eligibility evaluation, and quality testing. Multiple rounds of review were conducted that helped ensure that all stages were transparent, reproducible, and conducted comprehensively and that the methodology was coherent, cohesive, and comprehensive. We carefully ensure

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the quality of methodology when reviewing full text materials. Analysis of the data enabled careful investigation of important trends and patterns based upon previous research in the time after data were extracted and the theoretical underpinning as well as practical guidance for future studies. Previous studies, the need for teachers to keep pace with technological progress has been reiterated. Lucena et al.[1] looked at technology development implications on adults' lifestyles and concluded that teachers need to adapt.

As Starkey mentioned: The era of digital tools and internet resources was emerging and how fast that domain of education is advancing. Hanifah et al.[2,3] discovered the relationship between teachers using digital tools in the classroom and teachers' digital competence—real world experience is essential in order to help develop these skills. The objective of this review is to illustrate that insights which can help teachers' develop digital competence in vocational education institutions with concrete examples.

2. Methodology

2.1. Source referencing in the assembly of systematic literature review

All material was properly documented, so the academic trustworthiness of the systematic literature review is based on source referencing. The citation includes the author name, year in issue, the article title, the title of the journal or book the author of the article is using, volume and number of book or journal used (each is in APA citation form). This method simplifies the task for readers to easily find our studies and extend their own readings.

2.2. Formulation of research question

RQ1: What is digital competence? RQ2: What are the elements influencing vocational education teachers' digital competence? RQ3: What suitable theoretical models can be used to investigate influencing factors of vocational education teachers' digital competencies?

2.3. Systematic searching strategies

2.3.1. Identification stage

Our research topic can therefore be divided into three key search terms: "teacher"; "digital competence"; and "vocational college." We also looked for synonyms and terminology like each of the terms for broader searches. We leveraged Scopus, Web of Science (WoS), and China National Knowledge Infrastructure (CNKI) as the primary databases. Based on these keywords, search strategies were modified for each database according to the keywords. **Table 1** shows the details.

Table 1. Search strategies in the three databases.

Section	Scopus	Web of Science	CNKI
RQ1 RQ2 RQ3	TITLE-ABS-KEY (("Teacher*" OR "Educator*" OR "Instructor*" OR "professor*" OR "Lecturer*") AND ("Digital Competenc*" OR "Digital Proficienc*" OR "Digital Fluenc*" OR "Digital literac*" OR "Digital abiliti*" OR "Digital skill*") AND ("Vocational Education*" OR "Vocational College*"))	TS=(("Teacher*" OR "Educator*" OR "Instructor*" OR "professor*" OR "Lecturer*") AND ("Digital Competenc*" OR "Digital Proficienc*" OR "Digital Fluenc*" OR "Digital literac*" OR "Digital abiliti*" OR "Digital skill*") AND ("Vocational Education*" OR "Vocational College*"))	((TI='Teacher' OR TI='Educator' OR TI='Instructor' OR TI='Professor' OR TI='Lecturer') AND (TI='Digital Competency' OR TI='Digital Proficienc' OR TI='Digital Fluency' OR TI='Digital literacy'OR TI='Digital abilities'OR TI='Digital skill') AND(TI='Vocational Education' OR TI='Vocational College'))

2.3.2. Screening stage

We restricted our searches to those publications published in the previous 5 years to help narrow down the relevant research to prevent the same old studies from emerging. In particular, for CNKI, we only examined documents indexed in SCI, EI, PKU, CSSCI, CSCD, and AMI. We included Chinese literature and English literature. Our inclusion and exclusion criteria are summarized in **Table 2**.

Table 2. Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Timeline	2018 to 2023	Before 2018
Publication type	Article journal, book, chapters in book. CNKI Source Type: SCI,EI,PKU,CSSCI,CSCD,AMI .	Conference proceeding, newspaper, review paper
Language	English, Chinese	

2.4. Eligibility assessment

We have imported the retrieved articles into EndNote and arranged them using the PRISMA flow structure. Deduplication tools for EndNote removed duplicate entries. We subsequently screened titles, abstracts, and keywords to eliminate studies that did not map to our research focus — preserving focused studies only on vocational education teachers and factors affecting digital competence. Articles were excluded if they were unable to be included in the respective time frames, journals, and language specified in Table 2. For the remaining articles, we downloaded full texts of the complete set of articles and carefully read them. We checked each of them against our research questions, and if and how inclusion criteria were met. We extracted important data to detect whether they were empirical studies: whether they used qualitative or quantitative approaches; whether they had clearly defined variables; whether the sound research design, sample size, and techniques used in their analysis were conducted. Articles with demonstrated methodological quality and meeting the inclusion criteria were included, as reflected in the flow chart of the PRISMA (**Figure 1**).

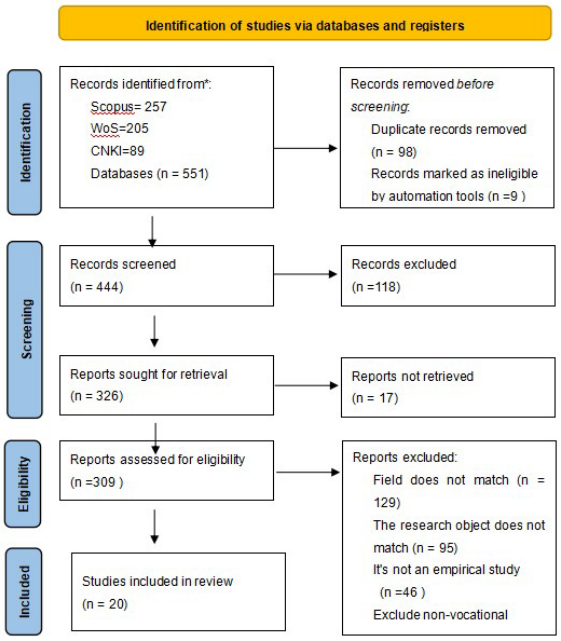

Figure 1. PRISMA flow diagram

2.5. Quality appraisal of articles

Quality assessment of included articles is also a consideration, as the aim is to synthesise robust evidence in a systematic review. Quality appraisal enables researchers to make the methodological rigour of the study and the findings trustworthiness. Majid and Vanstone highlight that a good quality assessment doesn't merely identify strengths and weaknesses, it also shows how these findings have an impact on policy and practice[4]. We used the methods used in previous reviews. Enghiad et al.[5] for example, implemented the Critical Appraisal Skills Programme (CASP) as a checklist tool to evaluate articles regarding precision, reliability, scope, impartiality, timeliness, and relevance. Standardized appraisal devices are needed for systematic reviews. Mendelsohn et al. [6]applied the Mixed Methods Appraisal Tool.

(MMAT) for the critical quality analysis and emphasizing that the methodological rigour that is so critical in synthesis of evidence actually is fundamental. Long et al.[7]discussed enhancing CASP for qualitative evidence synthesis, noting the practical hurdles that emerge within both reviews and data synthesis. Close scrutiny of article quality is crucial to ensure that our data synthesis results remain methodologically robust and reliable in the long term. This involves applying relevant methods of research evaluation to specific studies while also recognizing significant influences quality assessment has on the review process more generally. Not all articles are ruled out simply on account of quality assessment often this is because it provides the reader with insights into contextual and methodological limitations of the studied work, especially concerning gathering qualitative research[8]. The Mixed Methods Appraisal Tool (MMAT) [9] was used to assess the methodological quality of our selected articles. MMAT was developed to evaluate empirical studies, whether qualitative, quantitative, or mixed in nature. It provides a set of criteria to evaluate criteria including the clarity of research questions, adequacy of data collection methods, appropriate design of studies, and quality of findings. Based on our quality assessment, results showed 90% (18 articles) were of a quantitative nature and 10% (2 articles) were of a qualitative nature (**Figure 2**). We evaluated each article using MMAT criteria, which matched the methods used in the article. For quantitative literature, we examined sampling method and reliability/validity of measurement and quality of statistical analysis. In qualitative studies, we asked whether a qualitative approach to research was appropriate, examined how data were collected, and considered the coherence across data sources, collection, analysis, and interpretation.

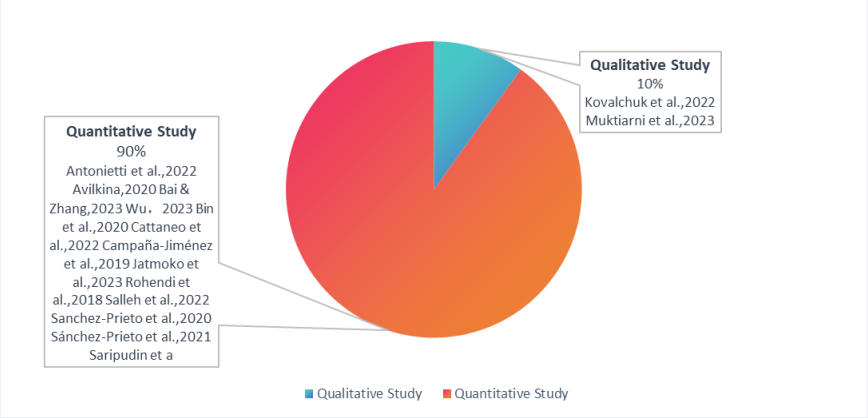

Figure 2. Distribution of articles by research methodology.

By using MMAT in a systematic method, we ensured that only studies that fulfilled least quality standards in research methods were incorporated into the synthesis. This critical examination also adds to our

findings and conclusions their credibility. It is consistent with systematic review best practice for transparency and methodological precision [35].

Table 3. Criteria of the mixed methods appraisal tool (MMAT, 2018).

Category of study designs	Methodological quality criteria	Responses Yes No Can't tell Comments
Screening questions	S1. Are there clear research questions?	
	S2. Do the collected data allow to address the research questions? Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.	
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?	
	1.2. Are the qualitative data collection methods adequate to address the research question?	
	1.3 Are the finding adequately derived from the data?	
	1.4. Is the interpretation of results sufficiently substantiated by data?	
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?	
2.Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?	
	4.2. Is the sample representative of the target population?	
	4.3. Are the measurements appropriate?	
	4.4. Is the risk of nonresponse bias low?	
	4.5. Is the statistical analysis appropriate to answer the research question?	

We assessed some papers using the Mixed Methods Appraisal Tool (MMAT) [9], using the two mandatory screening questions (S1 and S2) and suitable checklists for qualitative and quantitative studies. The MMAT evaluation criteria are displayed in **Table 3**. Considering that quality appraisal is one of the key components to systematic reviews, best-practice recommendations include a minimum of two independent reviewers in order to enhance reliability and minimize bias[9,10] . In the end, we adhered to the suggestion—each article was independently reviewed by two reviewers, who rated the quality as high, medium, or low. Both reviewers had to be satisfied that an original article met minimum quality standards before it could be included. Disagreements that may have emerged were discussed in the group and settled by consensus before making the selection of the inclusion and exclusion, which mitigated any potential conflict. This collaborative decision made our review more objective. A total of 18 articles were rated high quality and 2 medium based on the quality assessment. No articles were deemed low quality and none were excluded on the basis of appraisal findings. It included all 20 articles in a final analysis. Methodology and results of this appraisal are detailed in **Table 4**[11-30].

Table 4. Literature review registration form.

Authors	**Reviewer1**	**Reviewer2**
Kovalchuk et al.,2022	high quality	high quality
Muktiarni et al.,2023	high quality	high quality
Antonietti et al.,2022	high quality	high quality

Authors	Reviewer1	Reviewer2
Avilkina,2020	high quality	high quality
Bai & Zhang,2023	high quality	high quality
Wu，2023	medium quality	medium quality
Bin et al.,2020	high quality	high quality
Cattaneo et al.,2022	high quality	high quality
Campaña-Jiménez et al.,2019	high quality	high quality
Jatmoko et al.,2023	high quality	high quality
Rohendi et al.,2018	high quality	high quality
Salleh et al.,2022	high quality	high quality
Sanchez-Prieto et al.,2020	high quality	high quality
Sánchez-Prieto et al.,2021	high quality	high quality
Saripudin et al.,2021	high quality	high quality
Seufert et al.,2021	high quality	high quality
Koshkinbayeva et al.,2023	high quality	high quality
Villalba et al.,2018	high quality	high quality
Wen W& Han X,2018	medium quality	medium quality
Yang et al.,2023	high quality	high quality

Table 4. (*Continued*)

2.6. Data extraction and analysis

The focused reviews of selected documents according to our three research questions and critical data extraction and analysis were performed. Systematic literature reviews are essential for academic research; they create systematic methods for systematically gathering evidence and providing an evaluation of the related evidence. At these reviews we use systemic searching, critical evaluation and synthesis of necessary research to answer relevant questions. In the last few decades, systematic review approaches have developed in the name of transparency, reproducibility, and minimizing bias [31]. A systematic review process involves selection of eligible articles using known eligibility criteria and is geared towards ensuring reviews are based on a comprehensive and unbiased inclusion of the appropriate studies[32]. In research with empirical nature, systematic literature reviews have many important functions including: identifying knowledge gaps in general; synthesizing evidence from diverse studies; and creating pathways for subsequent research. First, we got definitions of digital competence from the literature. **Table 5** lists nine of the 20 documents that were given definitions. Then we determined factors impacting teachers' digital competencies. Eighteen studies specified specific influencing factors, summarized in **Table 6**. **Table 7** summarizes the theoretical models in eight documents that were directly cited in the literature review.

Table 5. Definition of digital competencies.

Authors	Definition of digital competencies (9)
Bai & Zhang,2023	Digital competency is defined as the ability of an individual or organization to use digital technologies and tools effectively and confidently to achieve desired results. It covers a range of skills, knowledge and attitudes that enable individuals to navigate, evaluate, create and communicate using digital technologies.
Antonietti, C., Cattaneo, A., & Amenduni, F. (2022)	Digital competency is defined as an individual's ability to use digital technologies and resources effectively and confidently in a variety of contexts, including education. It covers not only technical skills but also pedagogical understanding, attitudes, strategies and awareness to enable individuals to utilize technology to achieve their goals. Digital competency involves the safe,

Authors	Definition of digital competencies (9)
	critical and creative use of technology to enhance teaching and learning objectives.
Bin et al.,2020	The term "digital competency" refers to a complex concept that emerged in the late 1990s as "digital literacy". It has since developed into a concept with historical connotations and hierarchical structures, product-agnostic, horizontal and multi-dimensional. Digital competence encompasses technical, ethical and cognitive dimensions and consists of four components: 1. Technical skills and practices for using digital technologies, 2. Ability to use and apply digital technologies in meaningful ways, 3. Understanding digital technology phenomena capabilities, and 4. Motivation to participate in and integrate into digital culture.
Jatmoko et al.,2022	The document provides no detailed and specific definition of "digital capabilities." It also includes the statement that best approaches to digital literacy practice are those that effectively and critically work with and use digital technologies and information. It entails skills like operating support tools, social media literacy, online fact-checking and the handling of personal data security.
Sánchez-Prieto et al.,2021	Digital competency is described as one's capacity to use digital technologies properly, and responsibly, to obtain, analyze, create, and share information. It incorporates various skills, knowledge, and attitudes that allow people to participate fully in a digital society. Digital capabilities include digital literacy, information literacy, digital communication, digital problem solving and digital security.
Sanchez-Prieto, J. et al.,2021	'Digital competence' means the creative, critical and safe use of information and communication technologies (ICT) in pursuit of a variety of goals related to work, employability, learning, leisure, inclusion and social participation. It encompasses the skills required to use digital tools efficiently, browse and evaluate digital content, collaborate and communicate, create and edit digital content, ensure the security and protection of personal data, use digital media to solve problems, and manage digital identities.
Saripudin, S et al.,2021	Digital competency is the way individuals are able to navigate their way through virtual spaces through digital tools effectively and confidently. Digital competencies encompass the awareness, knowledge and attitudes needed to understand and utilize digital resources and tools across contexts, including education.
Shagataeva et al.,2023	The document does not clearly provide a definition of "digital capabilities". However, it mentions developing a framework for teachers' digital competencies that includes content knowledge, pedagogical content knowledge, pedagogical knowledge, tool skills and knowledge of handling digital media. These capabilities can be viewed as components of digital competencies.
Yang et al.,2023	This refers to a person's readiness and ability to use various digital technologies effectively. It includes technical skills, communication skills and information management skills in a digital environment.

Table 5. (*Continued*)

Table 6. Factors influencing teachers' digital competencies in the literatures.

Authors	Influencing factors(19)
Antonietti et al.,2022	1.Digital tool availability, 2.quality of digital infrastructure, 3.beliefs, 4.attitudes, 5.motivation, 6. self-efficacy.
Avilkina,2020	1.Age, 2.subject taught, 3.continuing education.

Authors	Influencing factors(19)
Bai & Zhang,2023	1.National standards, 2.training, 3.tasks and responsibilities, 4.social forces, 5.needs, 6.digital teaching resources, 7.mastery of tools and equipment, 8.evaluation standards, 9.industry and corporate participation.
Bin et al.,2020	1.Self-efficacy, 2.intention to use, 3.perceived ease of use, 4.usefulness.
Cattaneo et al.,2022	5.Attitudes toward technology, 6.frequency of use of digital tools. 1.workload, 2.curriculum support, 3.teacher background, 4.personal characteristics, 5.school factors.
Campaña-Jiménez et al.,2019	1.Availability of assistance and support, 2.availability of technical resources, 3.perceived usefulness.
Jatmoko et al.,2023	1.Infrastructure readiness, 2.online learning implementation.
Kovalchuk et al.,2022	1.Lagging digital provision in educational institutions, 2.complex social changes, 3.globalization processes, 4.generation gap between students and teachers, 5.gap between digital skills of teachers and students.
Muktiarni et al.,2023	1.age, 2.training, 3.educational experience.
Rohendi et al.,2018	1.Attitude, 2.self-efficacy, 3.interest level, 4.willingness, training.
Salleh et al.,2022	1.school environment, 2.mentoring role.
Sanchez-Prieto et al.,2020	1.Age, 2.training, 3.original identity.
Sánchez-Prieto et al.,2021	1.Teacher training, 2.school location, 3.teaching type, 4.age, 5.gender, 6.teaching experience, 7.educational stage or level of study, 8.teacher's professional background, 9.teacher's attitude, assessment of ICT, 10.interests, 11.preference for technology, 12.need for digital training Perception, 13.constructive approach to the teaching-learning process, 14.culture of collaboration, 15.population size of the teaching area, 16.academic qualifications, 17.category of teachers.
Saripudin et al.,2021	1.Age, 2.working experience, 3.gender, 4.attitude towards digital technology, 5.frequency of using digital technology, 6.and ways to acquire digital technology.
Seufert et al.,2021	1.Teaching content knowledge, 2.tool skills, 3.emotional motivation, 4.attitude, 5.professional learning and development.
Shagataeva et al.,2023	1.workload,2.resource availability, 3.infrastructure and equipment availability.
Villalba et al.,2018	1.Innovative practices, 2.attitudes, 3.teachers' IT skills, 4.training, 5.school infrastructure.
Wen W& Han X,2018	1.Perceived usefulness, 2.attitude towards use, 3.convenience of use, 4.behavioral intention to use, 5.promotion conditions.
Yang et al.,2023	1.Attitudes, 2.intentions, 3.ICT literacy, 4.availability of infrastructure, 5.presence of digital educational resources, 6.training.

Table 6. (*Continued*)

Table 7. Research theoretical models in literatures.

Authors	theoretical models
Antonietti et al.,2022	Technology Acceptance Model, TAM
Bin et al.,2020	Technology Acceptance and Gratification, TAG
Cattaneo et al.,2022	Technological Pedagogical Content Knowledge, TPACK
Jatmoko et al.,2023	Ex post facto research method
Salleh et al.,2022	Technological Pedagogical Content Knowledge, TPACK
Saripudin et al.,2021	Triadic Reciprocal Determinism.
Wen W& Han X,2018	Technology Acceptance Model, TAM
Yang et al.,2023	Unified Theory of Acceptance and Use of Technology, UTAUT

3. Findings

The 20 selected articles came from nine countries: China, Malaysia, Russia, Spain, Ukraine, Indonesia, Switzerland, Hungary, and Kazakhstan. In relation to the definitions of digital competencies of the teachers (Table 5) we found the teachers' skills, knowledge, and attitudes in digital spaces were reported differently, but also remain consistently high. Combined, these definitions portray a framework for digital competency that embodies technological competency, educational technology and digital and information literacy integration, and the practical application of digital competencies across diverse cultures and social environments. These competencies are crucial for effective teaching in current education domains. When examining factors that influence teachers' digital competencies, 19 articles identified 77 influencing factors (Table 6). Nine of these contributors were present in two or more studies.

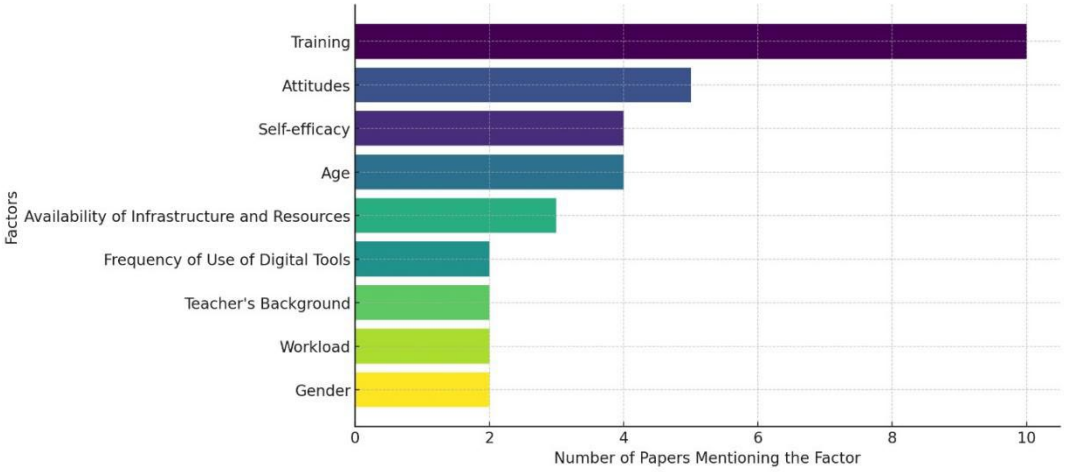

Figure 3. Key factors influencing teachers' digital competency.

Training (11 articles)

Self-Efficacy (4 articles)

Attitudes (5 articles)

Age (4 articles)

Frequency of Use of Digital Tools (2 articles)

Availability of Infrastructure and Resources (3 articles)

Teacher's Background (2 articles)

Workload (2 articles)

Gender (2 articles)

We then classified them under three headings:

Individual perspective: beliefs and attitudes; self-efficacy and emotional motivation; personal background and experience; professional development and learning; frequency of digital tool use; and ICT literacy.

Environmental Factors: educational support and digital environmental resources, online learning, and the impact of globalization.

Organizational Factors: education and teaching standards; training and professional development; industry trends; and the social environment.

Eight articles employed theoretical models covering various aspects of technology acceptance, educational practices, and behavioral analysis, which demonstrates considerable diversity overall.

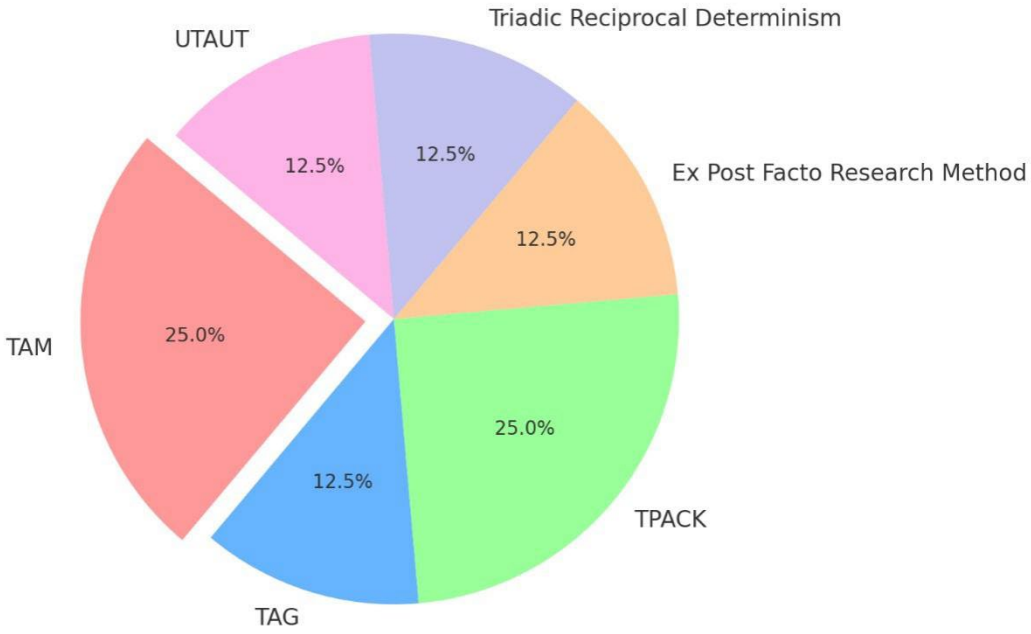

Figure 4. Theoretical models used in the research articles.

Technology Acceptance Model (TAM): Antonietti et al.[13] and Han and Sa used TAM to understand how users adopt and use technology, focusing their acceptance and usage based on the perceived ease of use and usefulness[14]. Technology Acceptance and Gratification (TAG) Framework: Bin et al.[17], which incorporates the notion that the ease and usefulness of technology use may be determined by the use satisfaction and the user satisfaction using the same. The Technological Pedagogical Content Knowledge (TPACK) Framework: Cattaneo et al. [18] and Salleh et al.[22] employed TPACK as a framework to examine the ways that educators successfully embed technology, pedagogy, and content knowledge. Ex Post Facto Research Methodology: Jatmoko et al.[20]used this technique for testing associations between variables under conditions devoid of experimental control. Saripudin et al.[25] utilize Triadic Reciprocal Determinism approach where behavior, personal factors and environmental influencers interact. Shie et al.[33] used UTAUT that combines technology acceptance theories but with a special emphasis on expected performance, effort expectancy, social influence and facilitating conditions.

4. Discussion

Our research uncovered 9 factors which influence teachers' digital competencies: training, self-efficacy, attitudes, age, frequency of digital tool use, infrastructure and resource availability, teacher background, workload, and gender. These factors can affect how teachers are able to successfully incorporate digital technology into their teaching. We elaborate on each of these factors below.

4.1. Training

Training of participants is found to be the most important factor impacting on teachers' digital competencies and it was mentioned in 11 of the 20 articles reviewed. Digital skills require robust teacher

training programs. Hays and Singer contend training should not be limited to the acquisition of primary technical competencies, but to incorporate pedagogical applications, assessment approach and online course development[34]. Personalized and differentiated training plans could address the varying experience levels and proficiency levels of teachers. It is also well established that continued professional development fosters long-term career development as opposed to a single, one-time solution[35,36]. As such, universities have established a systematic support system covering training projects, digital teaching credit courses, collaboration projects, and mentor teaching plans. These align with learning management systems to continuously guide teachers' development of digital capabilities. It is absolutely critical to check the effectiveness of the training consistently and give feedback regularly[25]. Thus the above all approach is needed, because for improving teachers' digital competencies, a comprehensive training approach with personalized content, continuous development and good evaluation is essential.

4.2. Self-confidence

Self-efficacy is very important when it comes to determining the extent to which digital technology integration from teachers into their teaching takes place. Several studies emphasize the vital importance of teachers' faith in using digital tools effectively. Drijvers et al.[37] discovered that teachers who grow confident in the use of digital technology get to plan more confidently and gain better strategy implementation skills for specific educational objectives. Kotzebue et al. [38] studied how various digital skill elements interact with one another and impact teachers' self-efficacy. Kholifah et al. [39]found out that teachers with high level of self-efficacy usually had higher morale and better performance. Overall, this suggests that enhancing teachers' self-confidence is the best way to promote digital competency development and the capability of effective school technology use.

4.3. Attitudes

The perception of digital technology by teachers has great implications on training of digital competencies. Positive attitudes significantly increase the probability of a technology integration to teaching being effective. Guðmundsdóttir and Hatlevik demonstrated that early positive experiences have impact on new teachers' attitudes toward digital technology and build professional resilience[40]. Baturay et al. [41] had also shown a significant positive correlation between computer skills, computer-aided learning beliefs and pre-service teachers' readiness to adopt technology. Drijvers et al.[37] further concluded that teachers' positive attitudes are positively associated with high self-efficacy beliefs regarding the use of digital technology in teaching. Therefore these measures indicate that developing favorable attitudes on digital science and technology will help to enhance teachers' digital literacy.

4.4. Age

Age is also perceived to be a significant predictor of teachers' digital competency. Teacher ability and confidence in using digital technology during teaching has been described with the help of research. Peters et al.[42]suggests that senior educators rated their digital proficiency higher than younger colleagues, which indicates that age may affect confidence and skill in using digital tools for teaching. Tuncay also examined teachers' online education skills deficiency and observed age-based variance, identifying age as an additional potential variable to digital skills[43]. Knowing how age affects digital competencies is crucial for planning appropriate PD practices in schools for teachers of different ages. When supporting teachers in improving their digital skills and integrating technology in the classroom, colleges need to take age into account.

4.5. Frequency of use of digital tools

Teachers' use of digital resources to a great extent has a major influence on their digital competencies. And regular use will enhance proficiency, confidence, the use of technology in education and comfort with

it—all aspects of using technology. Pettersson mentioned the challenges in the educational field about the use of ICT tools and methods of instruction and found that the organizational structures and resistance to change could impact on the frequency with which teachers use digital tools[44]. Štemberger and Čotar Konrad focused on self-report of using the different digital tools for their own learning, and found an overall

positive effect of the more frequently you use different digital tools on the overall digital skills[45]. DiasTrindade et al.[46] used a self-evaluation approach to assess the digital proficiency of Portuguese teachers, indicating the influence of regular digital tools use on wider digital skills through self-assessments. Promoting common use via conducive policies and professional development can result in significantly higher digital competencies within teachers.

4.6. Availability of infrastructure and resources

Availability of infrastructure services and resources strongly influences the degree to which teachers understand and adapt to digital competencies. To some degree, physical presence of teachers' digital capabilities is critical to achieving digital competency. Teachers should have access to digital tools and good digital frameworks to become better equipped to use technology effectively. To Guðmundsdóttir and Hatlevik[40], professional digital expertise is needed as digital tools enter the classroom on an everyday level of teaching. Pettersson emphasized that a comprehension of organizational underpinnings and digital leadership is important in schools. Sari et al.[47] stated that infrastructure availability influences digital literacy in basic education, which is regarded as an important factor for adapting digital tools in education. On the other hand, Soekamto et al.[48] recognized lack of accessibility to digital resources and poor infrastructure as significant hindrances, especially within rural areas. It is also important to tackle these barriers in order to help teachers acquire digital skills and integrate technology effectively.

4.7. Teacher's background

The background of the educator such as experience in education, and previous experience with technology and cultural background influence their digital competences. Tailored training is needed to suit each background and different needs of each ethnic community. For all types of people—educators and trainers in particular—needs to know them. For example, those lack experience with technology need foundational training while experts can benefit from advanced opportunities. Acknowledging and recognising the diversity of teachers' backgrounds can inform more effective and effective training, and help enable digital competency development across the teaching force.

4.8. Workload

Teacher's work burdens are at the center of their learning and digital competence. Administrative work, lesson planning, grading activities, extracurricular activities, etc., and teachers don't feel able to carve out either the time or energy to access digital tools or their continuing professional development. A study by Hasanah et al.[49] stated that if teachers are expected to work over one hour each week, their workload has a significant impact on their efforts not only to develop digital literacy – it is also linked with these abilities. The demands of educators' work align with the current landscape; it is crucial to manage this workload so educators can progress and respond to the constantly changing digital world [50]. By giving teachers the resources and time they need to focus on building their digital skills, we can help them manage and live up to today's demands.

4.9. Gender

The gender of teachers may have an effect on their digital competencies, and some empirical studies have investigated possible differences in technology penetration and ability. Teo et al.[51] focused on gender

differences in the view of pre-service teachers toward technology integration and concluded that differences by gender may impact the attitude toward technology and acceptance, which in turn may affect their digital competence and expertise. Çebi and Reisoğlu examine the digital ability of Turkish pre-service teachers and potential gender differences[52]. Sánchez et al.[53] measured self-reported teacher digital competence among university students and observed gender-specific differences. How gender may influence digital competence is also important in forming effective professional training programs for teachers' different requirements as well as for developing digital technology content and skills. Ensuring that technology integration is equitable may also support further improvements to these digital skills so as to help remedy gender biases. Leadership and Regulation: Effective leadership is a crucial element in developing digital competences, however, over control and deregulation can have dangerous consequences. Ahmed et al.[54] highlighted extreme leadership that significantly undermines work effectiveness of knowledge workers in higher education. These overzealous controls — monitoring, constant demands, demands that are too high and too punitive of a response on mistakes made — undercut teacher autonomy and self-efficacy as well as instill anxiety of technology usage and resistance. Schools require strong leadership styles aimed at turning improvements in digital capacity into psychologically safe environments. Statistical techniques, along with the correlation analysis, should be undertaken to examine in future studies associations concerning influence by digital literacy. It may be a good thing to calculate key variables related to skills, tool acquisition, motivation and age. It's definitely useful to compare teachers who have more institutional digital tool support to those who lack them so there might be differences in average literacy levels. Such quantitative analysis would shed light on how resource inequality affects career development and enable evidence-based decision making, rational resource allocation and customized support for diverse groups of teachers. Teachers' digital skills are very much influenced by personal, environmental and organizational factors. Education is a more important factor for training and may also influence other components, such as self-efficacy, attitudes, and variances depending on age. However, it is even more important to work on overcoming infrastructural, workload and gender-difference barriers that prevent learners from learning to navigate digital technology in education, and obtaining the knowledge needed to make it work the right way. If institutional and inter-school policies could be designed to consider and respond to these elements, teachers' digital skills would be improved, with the possibility that results should be obtained.

5. Recommendations

We searched and categorized literature for the factors affecting vocational education teachers' digital competencies. Our results revealed nine main factors: Training, Self-Efficacy, Attitudes, Age, Frequency of Digital Tool Use, Infrastructure and Resource Availability, Teacher Background, Workload, and Gender. An important observation of our findings is that previous studies have not adequately addressed the effects of teacher incentives or fully considered the speed of digital technology development. Training programs should account for teachers' ongoing professional development. There is a present gap in the research, which requires further investigation. Future studies can be aimed at exploring the potential role that incentives and sustainable development plans can play as mediating factors in the improvement of teachers' digital competencies in vocational education.

6. Conclusion

We examined and mapped variables that constitute teachers' digital knowledge in vocational education. Based on an exploration of available literature and research findings, we synthesized a number of key insights to support vocational education practice and policy:

As a Mediating Force of Influencing Forces: Training is a mediator of other effects, but it does not explain one or all factors depending on the infrastructure and resources. Specifically:

Knowledge Required: The knowledge and skills provided in this process of training may contribute, if not be fully realized, to teacher self-efficacy growth. Attitudes:

Teachers can also develop more positive attitudes toward digital technology through training, making them more proactive about new technologies. Age:

Teachers of varying age groups experience varying effects through training so that it can be adjusted. Use of Digital Tools:

Teachers' usage of digital tools can increase through training. Teachers come from different backgrounds and might require some further training for certain needs. Educating educators to best utilize technology to manage workloads. Gender: Gender differences likely will have to be taken into account at the trainee level to prepare teachers to work in equitable ways. Education has also to be systematic since it not only develops teachers digital skills but also enhances their confidence in employing digital technologies. Consequently, education quality is raised, general quality and student-centered quality are achieved. The use of AI has shown promising benefits on teacher preparedness for the online and offline learning environment, as demonstrated in the results obtained by the Ghana National Education Service. The moderating effects of teacher attitudes and age: Our findings suggest that attitudes and age determine teachers' digital competence. Positive attitudes and acceptance of the digital technologies make adoption more efficient. (True, younger teachers generally switch to new technology at a faster pace, but support will aid teachers, of all ages, to develop digital skills.) Infrastructure Resource Availability: The availability of adequate digital infrastructure and educational resources is essential to enhancing teachers' digital competences. Schools and educational institutions need to develop and maintain digital infrastructure and supply teachers with a variety of digital tools, equipment, and resources that enable them to teach effectively through technology. Policy Support: The government policies and the academic authorities help foster teachers' digital skills. Educational policies must also advocate and facilitate the participation of teachers in digital education training and the provision of related information.

Research questions: Since all the factors taken into consideration for our study were not identified; future studies regarding digital education are still needed. Research in the future can be divided into the following areas:

Social-Cultural Dimension: How socio-cultural circumstances impact teachers' online competences. Impact of Student Expectations and Feedback on Teachers' Use of Digital Technology:

Learning and Technology in the World of Educational Technology: Impact of Rapid Scale-up of Digital Tools on Teachers' Competence[55]. Motivation and optimization of leadership: How incentives act in concert with management to support systems; The removal of barriers to teachers promoting the development of digital skills caused by poor leadership. Teachers' ongoing professional development: What works now for teachers are long-term, professional development programmes that are responsive to the ongoing needs of teachers and help them build on their digital skills over time. And Now What Is Next for Future Studies? This provides a way of recognizing the systemic inadequacies in vocational education with respect to these perspectives. What we need are not just skill-building interventions: only understanding organizational mechanics, motivational drivers, and other psychological variables will develop evidence-based intervention programs that tailor evidence-informed interventions and target treatment for individual treatment beyond skill set building. Longer term studies of sustainable models should be pursued, which can underpin sustainable approaches which will help to make sure that digital skills-based programs that can help

sustain for the long term will help with successful efforts at preserving digital literacies in a fast moving technology transformation-driven environment to sustain technological transformation as an effective technology transformation-oriented world that is driving growth among employees to bring about change in vocational education. This study would motivate the development of vocational education instructors for digital skills. Lastly, practical relevance of this analysis also has potential for policy-makers, managers and organizations in learning about teachers' professional development and enhancing teachers themselves consequently the quality of education infrastructure and student learning. We trust the research provides practical guidance for future practice and practice development in digital education.

Conflict of interest

There is no conflict of interest.

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