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Exploring the Interconnections: Digital Competence, Teacher Training and Remote Teaching

Meneroka Hubungkait: Kompetensi Digital, Latihan Guru dan Pengajaran Jarak Jauh

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ABSTRACT

This literature review examines the relationships between digital competence, teacher training, and remote teaching practices, addressing the critical gap between the increasing demand for digitally competent educators and current teacher proficiency levels. The importance of this research lies in the rapidly evolving educational landscape, where digital skills have become crucial for effective teaching, particularly in remote and hybrid learning environments. Using the PRISMA methodology, the study analyzes research from 2019 to 2023 in databases such as Scopus and ERIC. Key findings reveal: 1. A spectrum of digital competencies among teachers, ranging from novices to experts. 2. Significant positive impact of targeted training programs on teachers' digital expertise. 3. Persistent challenges in online education, including student engagement and digital accessibility issues. The review highlights the transformative impact of training programs in elevating teachers' digital skills and their ability to integrate technology in educational settings. It emphasizes the need for customized professional development to address evolving technological needs. These insights have important implications, suggesting the need for: 1. More comprehensive digital competence frameworks for educators. 2. Adaptive, personalized training programs. 3. Integration of digital competence development in teacher education. 4. Policy reforms ensuring equitable access to digital resources and training. This review serves as a foundation for future research and policy development, emphasizing the pivotal role of digital competence in modern education.

Keywords: digital competence; teacher training; remote teaching; digital literacy; educational technology; teacher professional development

ABSTRAK

Kajian literatur ini meneliti hubungan antara kecekapan digital, latihan guru, dan amalan pengajaran jarak jauh, menangani jurang kritikal antara permintaan yang meningkat untuk pendidik yang cekap digital dan tahap kemahiran semasa guru. Kepentingan penyelidikan ini terletak pada landskap pendidikan yang berkembang pesat, di mana kemahiran digital telah menjadi penting untuk pengajaran yang berkesan, terutamanya dalam persekitaran pembelajaran jarak jauh dan hibrid. Menggunakan metodologi PRISMA, kajian ini menganalisis penyelidikan dari 2019 hingga 2023 dalam pangkalan data seperti Scopus dan ERIC. Penemuan utama menunjukkan: 1. Spektrum kecekapan digital dalam kalangan guru, dari pemula hingga pakar. 2. Kesan positif yang signifikan dari program latihan bersasar terhadap kepakaran digital guru. 3. Cabaran berterusan dalam pendidikan dalam talian, termasuk isu penglibatan pelajar dan kebolehcapaian digital. Kajian ini menekankan kesan transformatif program latihan dalam meningkatkan kemahiran digital guru dan keupayaan mereka untuk mengintegrasikan teknologi dalam persekitaran pendidikan. Ia menekankan keperluan untuk pembangunan profesional yang disesuaikan untuk menangani keperluan teknologi yang berkembang. Penemuan ini mempunyai implikasi penting, mencadangkan keperluan untuk: 1. Rangka kerja kecekapan digital yang lebih komprehensif untuk pendidik. 2. Program latihan adaptif dan peribadi. 3. Integrasi pembangunan kecekapan digital dalam pendidikan guru. 4. Pembaharuan dasar yang memastikan akses saksama kepada sumber dan latihan digital. Kajian ini menjadi asas untuk penyelidikan dan pembangunan dasar masa depan, menekankan peranan penting kecekapan digital dalam pendidikan moden.

Kata kunci: kompetensi digital; latihan guru; pengajaran jarak jauh; literasi digital; teknologi pendidikan; pembangunan profesional guru

INTRODUCTION

In recent times, there has been an increasing emphasis on evaluating educators' digital proficiency, which encompasses the knowledge and adept utilization of digital tools to accommodate diverse learning requirements and optimize teaching and learning processes. However, a critical challenge persists: the lack of universally validated assessment tools that can accurately measure educators' digital competencies across diverse cultural and linguistic settings. While numerous frameworks and self-assessment instruments have been established, such as the DigCompEdu CheckIn, which has been effectively validated in various settings, including English in Morocco, German in Germany, and Spanish in Spain (Gallardo-Echenique et al., 2021), there remains a pressing need to extend this validation to other contexts. The current study aims to address this gap by validating the DigCompEdu CheckIn tool in [specific language/country context], contributing to the development of a more globally applicable instrument for assessing educators' digital proficiency. Validating these tools across diverse educational contexts is essential to guarantee their efficacy and applicability. It is imperative to validate these assessment frameworks in various pedagogical environments to ascertain their impact and pertinence. Building upon these validation efforts, the current study aims to validate the DigCompEdu CheckIn in a distinct context, specifically at a private university in Lima, Peru, to measure the digital competence of teachers based on their self-perception. This validation will serve the pressing need to gauge the digital competence of educators in this particular setting, empowering them to integrate digital technologies effectively into the educational process.

Other investigations have also recognized the significance of teachers' digital competence and its impact on education. For example, a research project undertaken by Ruiz-Cabezas et al.(2021) at the Catholic University of Santiago de Guayaquil in Ecuador investigated educators' understanding, proficiency, and outlook regarding digital competencies. The study aimed to bolster the professional growth of instructors and optimize the teaching and learning experiences, particularly for freshmen university students. As technology continues to evolve rapidly, Developing modern evaluation instruments that can pinpoint the digital proficiencies educators need to adjust and attain novel abilities is crucial. Such an up-to-date scale is indispensable for educators to effectively utilize emerging technologies in educational environments (Gümüş & Kukul, 2022). While these studies have made significant contributions, there is still a need to validate digital competence assessment tools in diverse educational contexts and develop updated scales that align with the demands of evolving technology.

This literature review aims to:

1. Investigate the present landscape of scholarly inquiry concerning the digital proficiency of teachers and its evaluation.
2. Identify gaps and limitations in existing studies and assessment tools.
3. Provide recommendations for prospective studies and the creation of modernized instruments for assessing digital proficiency.

In line with these research efforts, this comprehensive examination of scholarly works seeks to consolidate and critically assess the current body of knowledge concerning educators' digital proficiency, highlighting the importance of validating assessment tools in different educational contexts and the necessity of developing updated scales to meet the demands of evolving technology. By exploring the insights from the aforementioned studies and other relevant sources,

this literature review aims to advance the comprehension and improvement of educators' digital capabilities within the constantly evolving educational terrain. Through addressing these objectives, the review strives to contribute to the ongoing development of effective digital competence assessment in education.

MATERIAL AND METHOD

IDENTIFICATION

To select suitable articles for this review, a three-phase systematic approach was employed. To begin, key terms were pinpointed, and relevant synonyms were gathered from thesauri, dictionaries, encyclopedias, and previous studies. The selection of keywords focused on terms directly related to digital competence in teaching, including "digital literacy" and "teacher training". These terms were chosen based on their frequency in preliminary literature searches and relevance to the research objectives. Upon establishing the salient keywords, search queries were constructed for both the Scopus and ERIC databases (see Table 1). The search strings were initially developed based on the identified keywords and were iteratively refined to ensure comprehensive coverage while maintaining specificity to the research topic. Boolean operators were used to combine terms and database-specific syntax was applied as needed. This preliminary stage of the systematic review methodology produced a cumulative total of 716 articles from the two databases collectively.

TABLE 1. Search strings from the Scopus and ERIC databases The search string

Scopus	TITLE-ABS-KEY (digital AND teacher AND competency) AND PUBYEAR > 2018 AND PUBYEAR < 2024 AND (LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Digital Competence") OR LIMIT-TO (EXACTKEYWORD , "Teacher Training") OR LIMIT-TO (EXACTKEYWORD , "Digital Literacy"))
ERIC	(digital AND teacher AND competency) AND PUBYEAR > 2018 AND PUBYEAR < 2024 AND (LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Digital Competence") OR LIMIT-TO (EXACTKEYWORD , "Teacher Training") OR LIMIT-TO (EXACTKEYWORD , "Digital Literacy"))

SCREENING

During the screening stage, duplicate articles were initially eliminated. The first phase removed 98 papers, while the subsequent phase involved screening 89 articles based on a set of inclusion and exclusion criteria determined by the researchers. These criteria were carefully selected to ensure the relevance and quality of the included studies while maintaining a focus on recent developments in digital competence within the Malaysian context.

To be incorporated in the review, studies had to fulfill the following requirements: (1) published between 2019 and 2023 to capture the most recent developments in the rapidly evolving field of digital competence, (2) composed in English to ensure accessibility and comparability of

findings, (3) focused on digital competence within the realm of teacher preparation or education to align directly with the research objectives, and (4) categorized as empirical research papers to ensure the inclusion of primary data and robust methodologies.

Conversely, the exclusion criteria encompassed: (1) systematic reviews, meta-analyses, meta-syntheses, book series, books, chapters, and conference proceedings to avoid redundancy and focus on original research, and (2) research conducted outside the geographical boundaries of Malaysia to maintain a specific focus on the Malaysian educational context and its unique challenges.

The screening process was conducted independently by two researchers using a standardized form based on the inclusion and exclusion criteria. Any disagreements were resolved through discussion with a third researcher. Each article was carefully examined, first by title and abstract, and then by full text if necessary, to determine its eligibility. Applying these specific parameters resulted in the exclusion of 59 publications from the review.

ELIGIBILITY

In the third phase, referred to as eligibility, 89 articles were readied for assessment. During this stage, the titles and key content of all articles were meticulously examined to ascertain their adherence to the inclusion criteria and alignment with the objectives of the current research. The assessment process involved a detailed evaluation of each article's methodology, findings, and relevance to digital competence in teacher education within the Malaysian context.

The eligibility assessment was conducted using a standardized evaluation form that included the following criteria:

1. Relevance to research questions: The article's primary focus should address aspects of digital competence in teacher education.
2. Methodological rigor: The study should employ sound research methods appropriate to its design.
3. Contribution to the field: The article should offer new insights or substantive findings related to digital competence.
4. Applicability to the Malaysian context: The findings should be relevant or adaptable to the Malaysian educational landscape.

The inclusion criteria at this stage were: (1) empirical research articles and (2) directly relevant to the research questions and objectives of the current study. Two papers were excluded as they did not constitute original research articles grounded in empirical data.

To ensure consistency in the eligibility assessment, two researchers independently evaluated each article using the standardized form. Any discrepancies in assessment were resolved through discussion, and a third researcher was consulted when necessary. This process helped maintain the reliability and validity of the article selection.

Ultimately, 30 articles were selected for inclusion in the final analysis (See Table 2).

TABLE 2. The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2019 – 2023	< 2019
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Subject Area	Science social	Besides Science social

DATA ABSTRACTION AND ANALYSIS

An integrative analysis was employed to examine and consolidate the various research methodologies (qualitative, quantitative, and mixed methods) utilized in the selected studies. The development of appropriate topics and sub-topics was the primary focus of expert research.

The theme development process followed a rigorous, multi-stage approach. Initially, the authors independently conducted a thorough review of all 30 papers, employing an open coding technique to identify and annotate relevant statements and information pertinent to the research questions. Subsequently, these codes were systematically grouped into broader categories through an iterative process of refinement and consolidation. From these categories, overarching themes were derived, resulting in the identification of three central themes: best practices for online teaching and learning, challenges and opportunities associated with online education, and the integration of technology and pedagogy. To ensure the validity and comprehensiveness of these themes, the authors engaged in a collaborative review and refinement process. This final step involved critical discussions and adjustments to guarantee that the themes accurately represented the data corpus and effectively addressed the study's objectives. This methodical approach to thematic analysis enhanced the reliability and depth of the findings, providing a robust foundation for subsequent interpretation and discussion.

The authors then delved deeper into each theme, incorporating related themes, concepts, and ideas to provide a comprehensive understanding of the subject matter. Working within the study's framework, the lead author worked in conjunction with co-authors to identify overarching themes that emerged from the research findings. Throughout the data analysis process, the authors meticulously maintained a record of their analyses, insights, questions, and other reflections pertinent to the interpretation of the data.

To ensure the validity and reliability of the identified themes, a rigorous expert validation process was implemented. Two independent experts, one specializing in education and the other in language, were carefully selected to conduct a thorough examination of the themes. These experts assessed each theme and sub-theme for clarity, importance, and adequacy, thereby establishing domain validity. The authors meticulously reviewed the feedback and suggestions provided by the experts, incorporating necessary modifications to enhance the overall validity and reliability of the thematic structure. To address any remaining concerns and achieve a final consensus on the themes, a collaborative meeting was convened with the experts. This comprehensive validation process not only strengthened the credibility of the findings but also ensured that the themes accurately reflected the complexities of the subject matter under investigation.

The data collection process encountered several challenges that warrant acknowledgment. A notable limitation was the inaccessibility of full-text versions for five papers, potentially impacting the comprehensiveness of the analysis. The study's focus on English-language publications, while pragmatic, may have inadvertently excluded pertinent research from non-English speaking countries, potentially introducing a language bias. Additionally, the selected date

range (2019-2023), chosen to capture recent developments, might have omitted seminal works published prior to this period, potentially affecting the historical context of the findings. Despite rigorous efforts to maintain objectivity, the initial screening process may have been subtly influenced by the researchers' perspectives, introducing an element of subjectivity. These constraints, while not invalidating the study's findings, underscore the importance of interpreting the results within the context of these methodological limitations and highlight potential areas for future research to address these gaps.

This cooperative methodology ensured the precision and trustworthiness of the themes being explored.

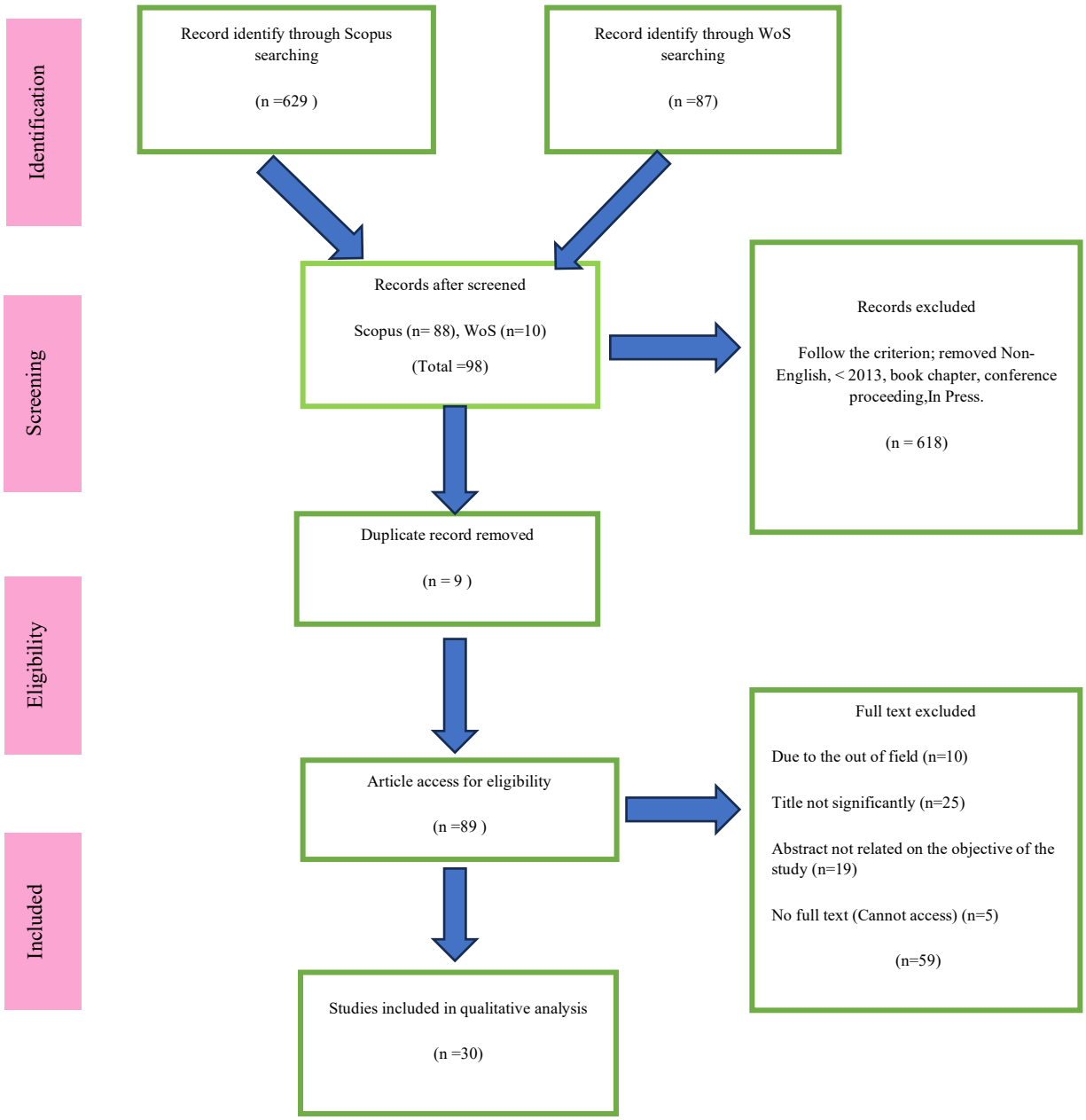

FIGURE 1. Flow diagram of the proposed searching study (Moher D, Liberati A, Tetzlaff J, 2009)

RESULTS AND FINDINGS

Study	Context	Assessment Tool	Key Findings	Implications
Gallardo-Echenique et al. (2021)	Higher Education	DigCompEdu CheckIn	Digital skills regrouped into 3 factors: Student Competencies, Educators' Professional Competencies, Educators' Pedagogical Competencies	Need for a streamlined yet interconnected framework for digital competence
Karunaweera & Wah (2021)	K-12 Education	DigCompEdu	<50% of English teachers demonstrated competency in one area	Urgent need for targeted teacher training
Gutiérrez & Artime (2021)	Higher Education	Custom assessment	University teachers possessed skills for using mobile devices to select digital resources	Potential for leveraging mobile technology in higher education
Rodríguez-Medina et al. (2020)	K-12 Education	Self-assessment	Older teachers (50-59) estimated higher ICT knowledge than younger colleagues	Age may not be a reliable predictor of digital competence
Demeshkant (2020)	Higher Education	Custom assessment	PhD students' digital competence varied by field of study	Need for discipline-specific approaches to digital competence development
Cañete Estigarribia et al. (2022)	Teacher Education	Custom assessment	Positive relationship between ICT training and digital competence	Importance of continuous training for digital competence development
Basantes-Andrade et al. (2020)	Teacher Education	PACIE methodology	Online course improved digital proficiencies of aspiring virtual tutors	Effectiveness of targeted online training for digital competence
Vilppola et al. (2022)	Vocational Education	Qualitative analysis	Work-based VET cultivated ICT proficiencies	Importance of practical, hands-on experience in developing digital competence
ElSayary (2020)	K-12 Education	Custom assessment	Upskilling program enhanced teachers' digital competence and attitudes	Effectiveness of upskilling programs for in-service teachers
Nabhan (2021)	Teacher Education	Custom assessment	Pre-service teachers focused on basic digital skills, less on critical thinking	Need for broader conception of digital literacy in teacher preparation
Tomczyk et al. (2023)	Teacher Education	Cross-country comparison	Pre-service teachers proficient in basic tools, less in advanced software	Need for exposure to diverse digital tools in teacher preparation
Retelj (2022)	K-12 Education	Digital profile analysis	Most teachers had a 'digital hybrid' profile	Need for tailored approaches for different digital profiles
Frolova et al. (2021)	Higher Education	Student adaptation analysis	25% of students struggled with online learning	Need for support systems in transition to online learning
Samane-Cutipa et al. (2022)	K-12 Education	Digital literacy assessment	Limited digital literacy due to technological and economic gaps	Need for policies addressing digital divide
Martín-Gutiérrez et al. (2022)	Higher Education	Adaptation model analysis	Developed progressive models for post-pandemic learning	Importance of structured approaches to digital adaptation
Reisoğlu (2021)	K-12 Education	Pre-post training assessment	Positive impact of training on technology integration	Effectiveness of targeted training for technology integration
Cabero-Almenara et al. (2020)	Higher Education	Institutional analysis	Need for greater institutional support for digital competence	Importance of systemic approach to digital competence development

The findings from various studies on digital competence and teacher training can be grouped into three main thematic areas: assessment of digital competence, factors influencing digital competence, and the impact of training programs.

ASSESSMENT OF DIGITAL COMPETENCE

The assessment of digital competence among educators has been a focal point of several recent studies, employing diverse tools and frameworks to evaluate these skills. A comprehensive study utilizing the DigCompEdu CheckIn instrument, with a substantial sample of 1,218 educators, proposed a streamlined framework that regrouped digital skills into three primary factors: Student Competencies, Educators' Professional Competencies, and Educators' Pedagogical Competencies. This restructuring maintained the intricate interconnections among overarching competencies (Gallardo-Echenique et al., 2021). In contrast, a smaller-scale study focusing on 40 English language teachers from the public education system revealed that less than half of the participants demonstrated proficiency in a single area of the DigCompEdu framework (Karunaweera & Wah, 2021). Additionally, research conducted on university teachers indicated a specific competency in leveraging mobile devices for digital resource selection (Gutiérrez & Artime, 2021). Collectively, these findings suggest that while educators possess varying levels of digital competence, there remains substantial room for improvement across multiple domains. The heterogeneity in assessment methodologies presents challenges in direct cross-study comparisons; nevertheless, the overarching trend underscores a pressing need for enhanced digital skills among educators. This synthesis highlights the complexity of digital competence assessment and emphasizes the importance of continued research and targeted professional development initiatives in this rapidly evolving field.

FACTORS INFLUENCING DIGITAL COMPETENCE

Recent research has illuminated several key factors influencing educators' digital competence, presenting a nuanced picture that challenges conventional assumptions. A study by Rodríguez-Medina et al. (2020) revealed an intriguing age-related pattern, where older teachers (aged 50-59) self-reported above-average ICT knowledge compared to their younger counterparts, contradicting the prevalent notion of younger educators being inherently more digitally adept. The field of study also emerged as a significant determinant, with Demeshkant (2020) demonstrating that PhD students' digital competence varied considerably based on their academic discipline and specialization. Furthermore, Cañete Estigarribia et al. (2022) established a positive correlation between ICT training and the frequency of ICT use, suggesting that targeted professional development contributes substantially to the enhancement of digital competence. These findings collectively underscore the complexity of factors shaping educators' digital skills, moving beyond simplistic age-based assumptions. The research highlights the critical importance of considering a multifaceted approach when assessing and fostering digital competence among educators, emphasizing the roles of specialized training, practical experience, and disciplinary context. This more comprehensive understanding can inform the development of more effective and tailored strategies for enhancing digital competence across the diverse landscape of educational professionals.

Recent research has provided compelling evidence for the efficacy of diverse training programs in enhancing educators' digital competence. A comprehensive study by Basantes-Andrade et al. (2020) demonstrated the success of an online course utilizing the PACIE methodology in improving digital proficiencies among 208 aspiring virtual tutors, underscoring the critical importance of equipping online educators with essential digital skills. In a different context, Vilppola et al. (2022) explored the impact of work-based vocational education and training (VET) on educators' ICT proficiencies, revealing that such programs foster skill development by providing immediate opportunities for application and experimentation with innovative ICT concepts and tools. Complementing these findings, ElSayary (2020) reported on an upskilling training program that not only enhanced teachers' digital competence but also cultivated a positive attitude towards technology use in educational settings. Collectively, these studies consistently affirm the positive impact of targeted training interventions on educators' digital competence. However, the diversity in program formats—ranging from online courses to work-based training and specialized upskilling initiatives—suggests that multiple approaches can yield beneficial outcomes, contingent upon the specific context and needs of the educators involved. This variability in effective training modalities highlights the importance of tailored, context-sensitive approaches to professional development in the realm of digital competence, offering valuable insights for educational policymakers and administrators seeking to design and implement effective training strategies.

DIGITAL COMPETENCE AND TEACHER PREPARATION

The findings related to digital competence and teacher preparation can be grouped into two main areas: current state of digital competence among pre-service teachers and strategies for improving digital competence in teacher preparation programs.

CURRENT STATE OF DIGITAL COMPETENCE AMONG PRE-SERVICE TEACHERS

Recent studies have shed light on the current state of digital competence among pre-service teachers, revealing a complex landscape of skills and gaps. Nabhan (2021) found that aspiring educators' conceptualization of digital literacy primarily centered on fundamental competencies in utilizing online resources and technological tools, with a notable lack of emphasis on critical thinking and digital culture aspects. This finding is complemented by a cross-cultural study conducted by Tomczyk et al. (2023) in Italy and Poland, which observed that pre-service teachers most frequently employed word processors and presentation creation tools, while demonstrating limited proficiency in more specialized applications such as web page creation, visual material development, and video editing software. In the context of developing countries, Retelj (2022) identified a prevalent digital hybrid profile among participating teachers, characterized by the adoption of digital tools alongside traditional methodologies. Collectively, these findings suggest that while pre-service teachers possess basic digital skills, significant competency gaps persist, particularly in advanced domains such as critical digital literacy, digital culture engagement, and the utilization of specialized software. The observed variations across different national contexts underscore the necessity for tailored, context-specific approaches to digital competence development within teacher preparation programs. This nuanced understanding of pre-service

teachers' digital competencies highlights the importance of comprehensive and adaptive strategies in teacher education to address the evolving demands of digital literacy in contemporary educational landscapes.

STRATEGIES FOR IMPROVING DIGITAL COMPETENCE IN TEACHER PREPARATION

Recent research has identified several key strategies for enhancing digital competence within teacher preparation programs, emphasizing the need for adaptive and continuous approaches. Cañete Estigarribia et al. (2022) underscored the critical importance of ongoing training to bolster the digital competence of future educators, recognizing the rapidly evolving nature of digital technologies in education. Building on this, Retelj (2022) highlighted the significance of customized technology professional development, advocating for differentiated approaches that address the distinct needs of digital native and digital immigrant teachers. This nuanced perspective acknowledges the varied technological backgrounds and comfort levels among pre-service teachers. Complementing these findings, Falloon (2020) proposed an interdisciplinary framework aimed at optimizing pedagogical approaches and enhancing learners' academic performance, suggesting a holistic integration of digital competence development within broader educational contexts. Collectively, these studies emphasize the necessity for ongoing, tailored strategies in fostering digital competence among pre-service teachers. The recognition of diverse teacher profiles and the call for customized approaches challenge the efficacy of uniform training methods, suggesting that teacher preparation programs should adopt flexible, context-sensitive strategies to effectively equip future educators with the digital skills required in contemporary classrooms. This research synthesis underscores the complexity of digital competence development and highlights the need for innovative, adaptive approaches in teacher education to meet the evolving demands of digital literacy in education.

DIGITAL COMPETENCE IN THE CONTEXT OF PANDEMIC AND REMOTE TEACHING

The findings related to digital competence in the context of the pandemic and remote teaching can be grouped into three main areas: challenges faced, adaptations made, and implications for future practice.

CHALLENGES FACED

The abrupt transition to remote teaching necessitated by the global pandemic has illuminated a complex array of challenges in educational contexts. A comprehensive study by Frolova et al. (2021) revealed that approximately one-quarter of students encountered significant difficulties in adapting to online learning modalities. The same research identified critical risks associated with online learning, including the absence of direct communication channels and the emergence of learning activity imitation without adequate instructor oversight. These findings were further corroborated by Samane-Cutipa et al. (2022), who reported limited digital literacy levels among both students and educators, primarily attributed to technological, economic, and coverage disparities. Collectively, these studies underscore the multifaceted nature of the obstacles encountered during the shift to remote instruction. The identified challenges extend beyond mere technological proficiency, encompassing pedagogical adaptations and raising critical questions about equity and access in digital learning environments. This nuanced understanding of the

difficulties faced during pandemic-induced remote teaching highlights the need for comprehensive strategies that address not only the development of digital skills but also the adaptation of pedagogical approaches and the mitigation of socio-economic barriers to ensure equitable access to quality education in digital contexts. These insights provide valuable directions for educational policymakers and institutions in developing resilient and inclusive remote learning systems for future crises or long-term implementation.

ADAPTATIONS MADE

The global pandemic precipitated a series of adaptive responses within educational systems, demonstrating remarkable resilience and innovation. Martín-Gutiérrez et al. (2022) delineated progressive models for post-pandemic learning adaptation, comprising three distinct levels: an initial adaptation model, a moderate adaptation model, and an advanced adaptation model. This tiered approach offered a structured framework for educational institutions to navigate the evolving landscape. Complementing this, Martín-Cuadrado et al. (2021) implemented a comprehensive three-stage process for virtual/online educational services, encompassing diagnosis, design, and training phases, aimed at bolstering both instructional and digital competencies. Further insights were provided by Bacus et al. (2022), who documented significant adjustments in teachers' pedagogical practices, underscoring the pivotal role of professional development in addressing the emergent challenges and opportunities in the post-pandemic educational milieu. Collectively, these adaptations reflect a paradigm shift towards more systematic and flexible approaches to online and hybrid learning modalities. The development of progressive models and structured processes for virtual education signifies a strategic response to the exigencies of remote teaching, potentially heralding long-term transformations in educational methodologies. This body of research not only illuminates the immediate adaptations made during the crisis but also provides valuable insights for the future development of resilient, adaptive educational systems capable of navigating unforeseen challenges while maintaining educational quality and accessibility.

IMPLICATIONS FOR FUTURE PRACTICE

The pandemic-induced shift to remote learning has precipitated a reevaluation of educational practices, yielding significant implications for future pedagogical approaches. Samane-Cutipa et al. (2022) emphasized the pressing need for educational policies that prioritize the integration of digital competence within school curricula, underscoring the urgency of systemic reform. Complementing this perspective, Reisoğlu (2021) highlighted the critical importance of seamlessly integrating digital technologies to enhance teaching methodologies, assessment practices, and student engagement, suggesting a holistic approach to digital integration in education. Further insights were provided by Cabero-Almenara, Gutiérrez-Castillo, et al. (2020), who advocated for increased institutional support and comprehensive training in digital teaching competencies for university faculty, recognizing the pivotal role of higher education institutions in driving digital transformation. Collectively, these studies point towards a paradigm shift in educational practice, advocating for more comprehensive and integrated approaches to digital competence development. The implications extend beyond mere technological adoption, calling for systemic changes at policy, curricular, and institutional levels to foster the development of digital competencies among both educators and students. This research synthesis underscores the necessity for a multifaceted approach to educational reform, encompassing policy formulation,

curriculum redesign, and institutional capacity building to effectively prepare educational systems for an increasingly digital future. These insights provide valuable guidance for policymakers, educational administrators, and practitioners in shaping resilient, digitally-enhanced educational ecosystems capable of meeting the evolving demands of 21st-century learning.

FIGURES AND TABLES

The paper includes three figures and one table, each providing valuable insights into different aspects of digital competence:

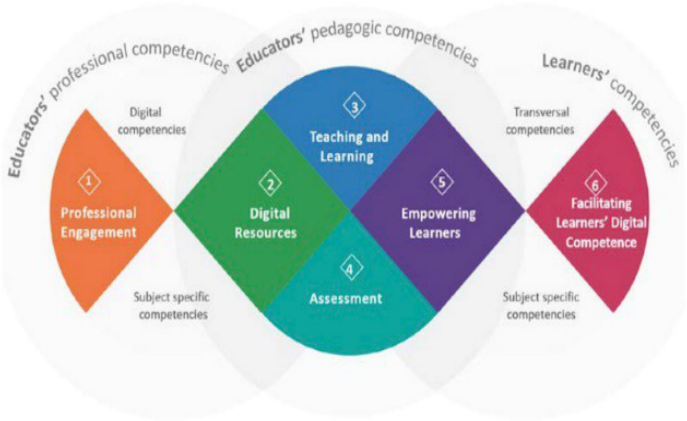

FIGURE 2. DigCompEdu in a nutshell

This figure visually represents the European Framework for the Digital Competence of Educators (2017). It illustrates the convergence of professional, pedagogical, and technological knowledge and skills essential for educators in the digital era. The figure emphasizes the interconnectedness of educators' pedagogical, professional, and digital competencies, highlighting the need for a holistic approach to digital competence development.

TABLE 3. Stages of educator's digital competence

Stage	Description
Newcomer (A1)	Has the opportunity to start improving their digital technology skills.
Explorer (A2)	Recognizes the potential of digital technologies and is motivated to explore them to enhance pedagogical and professional practice.
Integrator (B1)	Utilizes digital technologies in various contexts and should be motivated to expand their range of practices.
Expert (B2)	Confidently, creatively, and purposefully employs a variety of digital technologies; selects digital technologies for specific situations, is inquisitive and receptive to new ideas. Should persistently critically develop their digital strategies.
Leader (C1)	Consistently reflects on and further enhances their practices, exchanges innovative ideas with peers, and assists other lecturers in harnessing the potential of digital technologies to improve teaching and learning. Should engage in more experimentation.
Pioneer (C2)	Explores highly innovative and complex digital technologies and develops original pedagogical approaches. They spearhead innovation and serve as a role model for other lecturers.

This table outlines six stages of digital competence development for educators, ranging from Newcomer (A1) to Pioneer (C2). Each stage is described in terms of the educator's abilities and attitudes towards digital technologies. This progression model provides a useful framework for assessing and developing educators' digital competence.

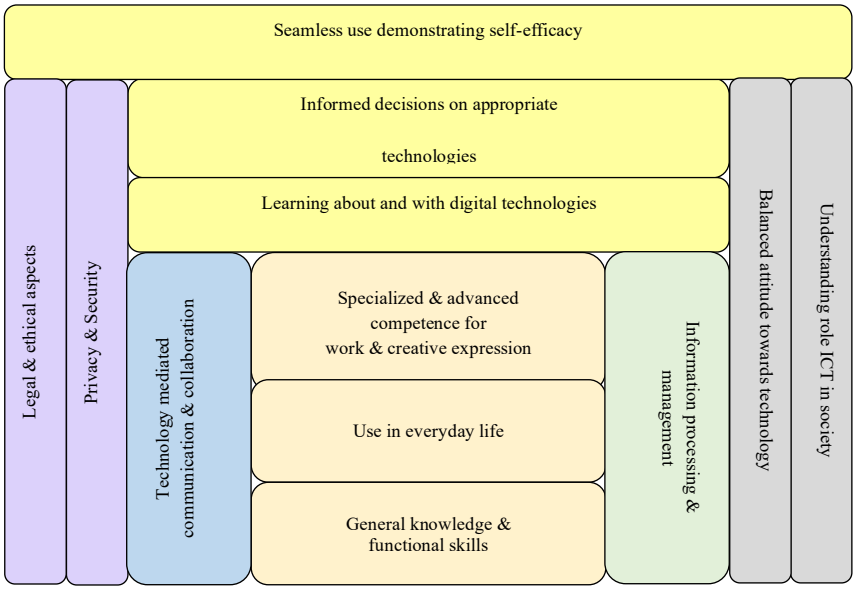

FIGURE 3. Janssen et al.'s (2013) elements of digital competence model

This figure presents a holistic model of digital competence, comprising three core elements: functional, integrative, and specialized uses of digital technology. The model emphasizes the importance of viewing digital competence as a pluralistic concept, adaptable to various contexts.

These visual representations provide valuable frameworks for understanding, assessing, and developing digital competence among educators. They can serve as useful tools for designing training programs and policies aimed at enhancing digital competence in educational settings.

IMPLICATIONS AND RECOMMENDATIONS

The findings presented in this paper yield several crucial implications and recommendations for enhancing digital competence in educational contexts. Foremost among these is the need for more comprehensive and standardized assessment tools that can effectively capture the multifaceted nature of digital competence. While the DigCompEdu framework provides a solid foundation, further refinement and contextual adaptation may be necessary to ensure accurate evaluation across diverse educational settings. The observed diversity in educators' digital competence levels and influencing factors underscores the importance of tailored training programs, potentially incorporating differentiated paths for digital natives, immigrants, and hybrids. Furthermore, the integration of digital competence into teacher preparation curricula and professional development programs should extend beyond basic ICT skills, encompassing critical thinking, digital culture, and the pedagogical applications of technology.

Educational institutions play a pivotal role in this transformation, necessitating robust support for digital competence development among both educators and students. This support

should transcend mere technology access, fostering a culture that values and promotes digital innovation in teaching and learning. At the policy level, there is a pressing need for comprehensive educational strategies that address digital competence development across all educational tiers, with particular attention to equity and access issues highlighted by the pandemic. Given the rapidly evolving nature of digital technologies and their educational applications, ongoing research is crucial to understand the changing landscape of digital competence and identify effective development strategies. Finally, future initiatives should adopt a holistic approach to digital competence development, considering not only technological skills but also pedagogical, ethical, and social aspects of technology use in education. This multifaceted approach will be instrumental in preparing educators and students to navigate the complexities of an increasingly digital educational landscape, ultimately fostering more resilient, adaptive, and effective learning environments for the 21st century.

Future research directions in the realm of digital competence in education present several promising avenues for exploration. Longitudinal studies tracking the development of digital competence over extended periods could provide invaluable insights into the progression and sustainability of these skills among educators and students. Cross-cultural comparative analyses would enhance our understanding of how digital competence manifests and evolves across diverse educational contexts, potentially revealing culturally-specific challenges and best practices. Action research projects, focused on testing and refining strategies for developing digital competence in various educational settings, could yield practical, evidence-based approaches for implementation. Moreover, studies investigating the relationship between educators' digital competence and student learning outcomes would contribute to a more nuanced understanding of the impact of digital skills on educational efficacy. These proposed research directions collectively aim to address critical gaps in our current knowledge, offering the potential to inform policy, practice, and pedagogical approaches. By pursuing these lines of inquiry, the research community can contribute significantly to the development of a more digitally competent education system, better equipped to navigate the complexities and harness the opportunities of 21st-century learning landscapes. Such a comprehensive research agenda would not only advance theoretical understanding but also provide actionable insights for educational stakeholders, ultimately fostering more resilient, adaptive, and effective educational ecosystems in an increasingly digital world.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the theme of digital competence and teacher training holds immense significance in the modern education landscape. The studies conducted on this subject offer valuable insights into the challenges and opportunities involved in developing teachers' digital skills and integrating technology effectively in the classroom. The research highlights the importance of the DigCompEdu CheckIn tool as a reliable and valid instrument for assessing teachers' digital competence across different disciplines (Gallardo-Echenique et al., 2021). Work-based VET teacher training emerges as a promising approach to enhancing ICT competencies in educators (Vilppola et al., 2022). Additionally, integrating mobile devices and innovative digital resources has shown positive outcomes in university teaching, fostering better communication and engagement (Gutiérrez & Artime, 2021).

The generational differences in digital competences among teachers underscore the need for tailored training programs that consider individual needs and preferences (Montenegro-Rueda

& Fernández-Cerero, 2023). Providing suitable online and face-to-face training can empower teachers to effectively utilize digital tools in their teaching practices (ElSayary, 2020). Moreover, addressing the digital divide is crucial in promoting inclusive and accessible digital education for all students (Samane-Cutipa et al., 2022). By prioritizing the development of teachers' digital competences, policymakers and educational institutions can create a dynamic and engaging learning environment that harnesses technology's full potential to empower students and drive educational excellence (Diz-Otero et al., 2023).

Future research should focus on several key areas to address remaining gaps and questions. First, there is a need for longitudinal studies that examine the long-term impact of digital competence training on teachers' practices and student outcomes. Second, researchers should investigate the effectiveness of different training modalities (e.g., online, face-to-face, blended) in developing teachers' digital skills. Third, exploring the role of contextual factors, such as school culture and infrastructure, in facilitating or hindering the implementation of digital technologies in education would provide valuable insights.

In terms of practical steps, policymakers and educational institutions should prioritize the following actions to enhance teachers' digital competence:

1. Develop comprehensive digital competence frameworks aligned with national and international standards to guide teacher training and assessment.
2. Allocate sufficient resources for professional development programs that focus on digital skills, pedagogical strategies, and technology integration.
3. Establish communities of practice and mentorship programs to facilitate knowledge sharing and support among teachers at different stages of their digital competence development.
4. Invest in technological infrastructure and support systems to ensure that teachers have access to the necessary tools and resources to effectively integrate digital technologies in their teaching.
5. Regularly assess teachers' digital competence using validated instruments and provide targeted support based on individual needs and strengths.

In conclusion, the findings from these studies underscore the significance of digital competence in teacher training and its impact on enhancing teaching practices and student learning outcomes. Equipping teachers with the necessary digital skills is essential to create a dynamic and inclusive learning environment in the digital age (Howard & Tondeur, 2023). Policymakers and educational institutions must prioritize the development of teachers' digital competences and provide comprehensive training programs that support their professional growth (Reisoğlu, 2021). By doing so, we can prepare educators to effectively navigate the digital landscape and foster a future-ready generation of learners (Mahapatra, 2020).

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