

MAPPING DIGITAL COMPETENCE IN EDUCATIONAL ENVIRONMENTS: A LITERATURE REVIEW AND IMPLICATIONS FOR LEARNING**Dudi Ruhyadi Muharam^{1*}, Suryadi², Andy Hadiyanto³**
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andy-hadiyanto@unj.ac.id³**ABSTRACT**

This study aims to map digital competence in educational environments by identifying the dominant competency frameworks, analyzing emerging trends and challenges, and formulating implications for learning development. Using a systematic literature review method, the study synthesizes findings from recent international research, focusing on teacher digital competence models, pedagogical integration of technology, and institutional support factors. The review reveals that digital competence in education is multidimensional, covering technical skills, pedagogical application, ethical awareness, critical evaluation, and professional engagement. The European Commission's digital capability pillars and Falloon's (2020) expanded TPACK framework demonstrate how teachers' digital competence now includes personal-ethical and personal-professional dimensions, especially relevant in AI-supported learning. Other studies identify recurring aspects such as technological knowledge, pedagogical competence, attitudes toward technology, cultural awareness, and student empowerment. The findings also indicate that infrastructure readiness, supportive policies, training availability, and teachers' self-efficacy significantly influence digital competence development. These findings imply that strengthening digital competence requires continuous, holistic professional development, alignment of institutional policies, and adequate technological infrastructure. Schools must integrate digital competence frameworks into teacher training to ensure effective, ethical, and innovative technology enhanced learning.

Keywords: *teacher digital competence, professional development, learning innovation***INTRODUCTION**

Technological advancements require individuals to have the understanding and skills to use technology effectively, both in their personal and professional lives (Caena & Redecker, 2019b). There are four main competencies expected of teachers: pedagogical competence, personal competence, professional competence, and social competence. One indicator of pedagogical competence is improving digital pedagogical skills. Teachers are not only expected to be able to create engaging learning media, but also to utilize the internet for learning materials and social media in the teaching and learning process. This aligns with 21st-century teacher competencies, which demand strong digital skills and literacy (Falloon, 2020a; Fernández-Batanero et al., 2022).

Teachers in the digital era are faced with rapid change. Teachers are required to possess digital competence with optimal mastery to keep pace with students' diverse characteristics. The goal is to make the teaching and learning process more effective and efficient because they can teach more creatively using technology. One indicator of pedagogical competence is improving digital pedagogical skills. Teachers must not only be able to create engaging learning media, but also be able to utilize the internet for learning materials and social media in learning. This aligns perfectly with 21st-century teacher competencies, namely strong digital skills and literacy (Sitompul, 2022). In other words, teacher competencies must be continually upgraded to keep pace with current developments.

Teachers' digital competency is strongly linked to their ability to use information and communication technology. According to Mishra & Koehler (2006), the use of suitable technology in learning is a cooperation of pedagogy (P), content (C), and technology (T), which results in intersections and areas of concentration that demonstrate that teachers may develop input from classroom learning. Teachers must be able to use technology to enhance classroom learning for pupils. Because using digital technology in the classroom can boost creativity, motivation, and student engagement (Tang et al., 2022). Seufert & Scheffler (2018) emphasize this by stating that the usage of digital technology can assist students learn employment skills such as communication skills, creativity, and the capacity to work in teams. In accordance with digital competence, teachers are no longer the sole source of learning, as students can study and master topics that teachers have not or have not mastered.

The International Report on Computer and Information Literacy documented that less than 50% of teachers use technology regularly in their teaching (Fraillon et al., 2019). Results from the OECD International Survey on Teaching and Learning revealed that teachers reported a high need for training in technology-related skills and that only 43% felt prepared to use technology in their teaching (Thomson & Hillman, 2019). The UNICEF Survey on Mapping the State of Digital Learning in Indonesia noted that as of 2020, 67% of teachers across Indonesia still lacked the knowledge, abilities, skills, and accessibility necessary to implement digital learning. Furthermore, UNICEF, in the same study, also reported that many teachers in Indonesia are still unable to integrate curriculum content and lesson plans oriented toward digitalization in education.

The survey, which involved 70 school teachers, showed that: (1) The intensity of digital device use showed that 53% of teachers used them in every lesson, 31% used them intermittently, and 16% never used them. (2) Computer application programs that are frequently used are through social media (68%) and video conferencing (59%), which are the most frequently used media for alternative learning communication. (3) As many as 44% of teachers are at a very capable level in mastering the use of computer application programs for learning (Syahid et al., 2022). Based on a survey conducted by the Center for Data on Technology and Information in Education and Culture (Pusdatin) in 2020, it showed that 60% of teachers were included in the category of being unable to use technology in learning, even the majority of this number were included in the category of technological stutters (Rahman et al., 2021). This finding certainly presents a complex problem that the heart of education, namely teachers, has low competence. It cannot be denied that low teacher ICT competence has a domino effect on teachers directly, even for the ongoing learning process (Ghavifekr et al., 2016; Simanjuntak, 2022).

The challenges of becoming a competent teacher in the digital age include intelligence, skills, and wisdom in mastering and utilizing technology (Tsvejkova &

Kiryukhin, 2019). Rapid technological developments provide opportunities for the emergence of various new sources of knowledge that were previously more limited. Knowledge content for the learning process is no longer solely the responsibility of teachers but can also be easily obtained from a wealth of online sources. To some extent, the knowledge content provided online is more engaging than the knowledge content teachers can provide through conventional methods. It is not impossible that in the future, the ability to provide knowledge content for learning processes online will no longer be able to match teachers who still use conventional methods (Ally, 2019). At this point, the need for teachers with digital competence becomes inevitable.

This research makes a significant contribution to the development of digital competency theory in education by presenting a comprehensive mapping of digital competency concepts, indicators, and frameworks from various recent studies. Therefore, this study aims to map digital competency in educational settings through a systematic analysis of the literature to identify competency frameworks used, analyze emerging trends and challenges, and formulate implications for learning development.

METHOD

The methodology of this study employs a Systematic Literature Review (SLR) approach to map digital competence within educational environments and analyze its implications for learning. The research begins with the formulation of research questions, focusing on: (1) how digital competence is defined and measured in educational contexts, (2) which models or frameworks are used to assess digital competence, and (3) how previous findings contribute to improving the quality of learning. The next stage is the literature search strategy, conducted through reputable international academic databases such as Scopus, Web of Science, ERIC, ScienceDirect, and Google Scholar. The search uses a combination of keywords including *digital competence*, *digital literacy*, *ICT skills*, *educational technology*, *teacher digital competence*, and *student digital competence*, along with Boolean operators (*AND*, *OR*) to broaden the search scope. The search is limited to articles published between 2015 and 2025, written in English or Indonesian, and appearing in indexed scientific journals to ensure relevance and credibility.

After collecting all potential articles, a screening process is conducted following the four stages of the PRISMA protocol: *identification*, *screening*, *eligibility*, and *inclusion*. During the *screening* stage, duplicate articles are removed and abstracts are reviewed to determine preliminary relevance. In the *eligibility* stage, full-text articles are read to confirm that the studies genuinely address digital competence within educational settings, whether at the teacher, student, or institutional level. Exclusion criteria include non-empirical articles (unless directly related), opinion pieces, conference proceedings without clear research data, and publications lacking sufficient methodological and results information. Only articles meeting all criteria are retained for further analysis.

Data analysis is carried out using a thematic content analysis approach, organizing information into major themes such as definitions of digital competence, theoretical frameworks (e.g., *DigComp*, *TPACK*, *ISTE Standards*), measurement approaches, enabling and inhibiting factors, and learning implications. Each article is coded using a matrix that includes research objectives, methodological approaches, participants, key

findings, and contributions to the literature. The coded data are then synthesized to identify patterns, global trends, research gaps, and areas requiring further investigation.

The final stage is the synthesis of the literature, aimed at producing a comprehensive mapping of digital competence in educational environments. The synthesis compares various digital competence frameworks, evaluates the extent to which digital competence is integrated into learning practices, and elaborates on its practical implications for instructional design, teacher professional development, assessment practices, and educational policy. This process results in a holistic overview that not only summarizes past research but also provides strategic recommendations to strengthen digital literacy and enhance learning quality in the era of digital transformation.

RESULTS AND DISCUSSION

According to the European Commission in the digital era, teachers must adhere to the pillars of digital capabilities which include aspects (1) Professional engagement, the use of information technology in this area is not only as a learning support but also as a professional liaison with students, parents and groups who have the same interests. (2) Digital devices, teachers can take advantage of the diversity of technology products that provide learning effectiveness and efficiency. (3) Learning and teaching, teaching and learning activities can be interpreted more broadly when viewed from the presence of technology, its presence can make teachers free to develop learning formats, bridge collective interactions or personal guidance to students more freely. (4) Assessment, the role of technology in learning assessment can be used as a maker or monitoring device and as a continuous teaching strategy. (5) Student empowerment, technology can be adjusted to the learning needs of the students themselves so that teachers can also provide learning freedom without reducing the existence of the teacher through the selection of learning tools or media, measuring learning outcomes, empowering students through technology and fostering digitalization skills in students (Rubach & Lazarides, 2021).

The concept of teachers' professional digital competence still appears to be ambiguous and elusive. Falloon (2020) expanded the TPACK framework to include personal-ethic and personal-professional competencies, addressing ethical, safe, and productive functioning in diverse, digital environments for a new TDC framework. The two new sets of personal-competencies are very important to the use of AI and metaverse in education. Skantz-Åberg et al. (2022) could distinguish seven recurring aspects of teachers' professional digital competence; 1) technological competence, 2) content knowledge, 3) attitudes to technology use, 4) pedagogical competence, 5) cultural awareness, 6) critical approach and 7) professional engagement, with the technological and pedagogical competences as the most prominent.

In addition to technical skills, teachers must be able to effectively integrate digital resources into their teaching practices. Designing interactive and engaging learning experiences using technology can improve student comprehension and involvement (Diachuk, 2024; Falloon, 2020b). They must also control the social dynamics of digital interactions to ensure that technology promotes rather than inhibits social learning (Rustandi et al., 2024). Professional training and institutional resources are frequently used to help people improve these skills (Bandura, 2023; Caena & Redecker, 2019a).

Access to technology infrastructure and supportive education policies are crucial for the development of TDC. Schools that give enough resources and training opportunities allow instructors to improve their digital competence more effectively (Rustandi et al., 2024; Zhou et al., 2023). Teachers' self-efficacy, work happiness, and

attitudes towards technology all have a substantial impact on their digital competence. Those with better self-efficacy and positive views toward technology have higher levels of digital competence (Zhou et al., 2023). Teachers in schools with a rich informational environment are more likely to be digitally competent.

Ferrari (2012) divides digital competence into three levels (see Figure 1). Level I encompasses the basic skills, competencies, and approaches considered fundamental to digital competence. Level II refers to the application of digital competence in a specific professional context or domain, where digital competence is applied to practice. Level III is about innovation and creativity, and the ability to stimulate significant change in a professional domain or knowledge.

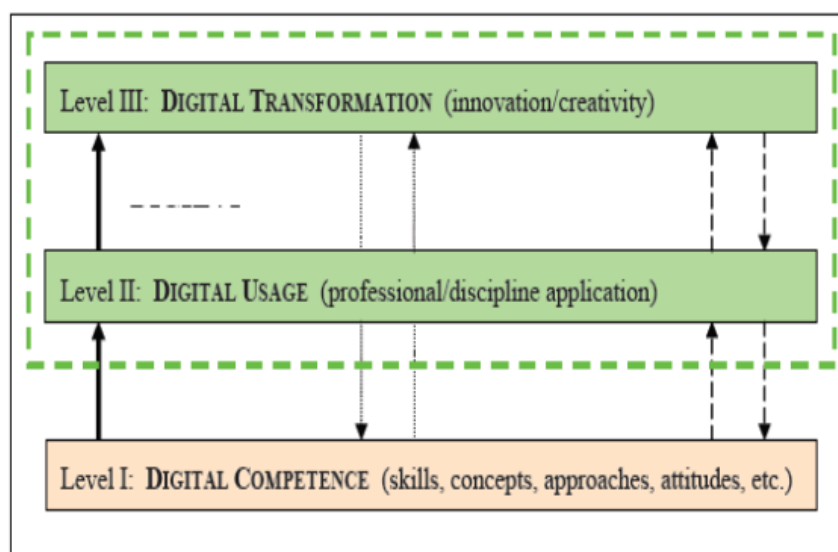


Figure 1. Level of digital competence

This three-step hierarchical approach (know → use → create) is based on the hypothesis that knowledge is a prerequisite for use and that transformation is the highest cognitive outcome achievable. This reflects a theoretical understanding of learning rather than reflecting how learning with and about technology actually occurs. When we observe how users adopt technology, we see a different sequence of events: first, we all tend to use the new tool, and then we may want to learn something about it (Ferrari, 2012). In general, digital competence builds on multiple learning domains (knowledge, attitudes, and skills) and extends across multiple competency areas.

In the educational context, Lund et al (2014) commented on the unique challenges teachers face in developing a holistic view of digital competence in their students. Teachers are required not only to educate students about the use of emerging digital resources in professional practice, but also to equip students with the skills to use technology productively to support their own learning.

The digital competency framework for teachers developed by Falloon (2020) describes competencies aligned with TPACK, specifically focusing on the skills and abilities required to integrate digital resources to support learning. The green horizontal line depicts the core elements of TPACK, with the dark blue vertical side pillars indicating their integrated nature in shaping the abilities and skills required to use digital

technologies for subject-based learning. Technical competencies refer to a strong knowledge of the 'mechanics' of how various digital technologies operate, such as mobile devices, applications, network services, and so on. Technological competencies focus more on a theoretical understanding of the role and potential of digital technologies in teaching and learning, as well as knowledge of the rationale underlying their inclusion in educational environments. In short, these competencies emphasize an understanding of how (technical) and why (technological) digital technologies are used in the classroom.

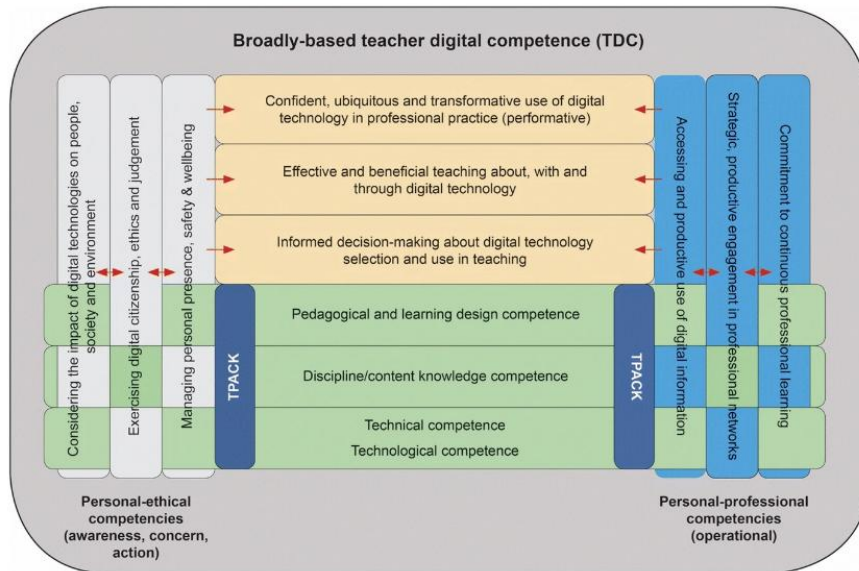


Figure 2. The teacher digital competence (TDC) Fframework

Falloon (2020) explains that digital literacy and digital competence are journeys that mark the development and transformation of an individual's skills and understanding of digital technology. Beginning with digital literacy, individuals acquire basic knowledge about using digital devices and applications, as well as the ability to search for information online. However, with time and experience, they advance their skills to more advanced digital skills, which involve the ability to communicate and collaborate effectively, and address challenges that arise in digital environments. The culmination of this journey is digital competence, where individuals not only possess strong technical skills but also possess a deep understanding of the use of digital technology in various contexts. Digital competence involves the ability to intelligently evaluate, select, and integrate digital tools and resources, and think critically about the ethical and social implications of digital technology.

From another perspective, digital competencies have been used in various areas to describe the abilities required in a digitalized knowledge society (Hatlevik & Christophersen, 2013). Ilomäki et al (2016) asserted digital competence related skills and competences; the most often used terms were digital literacy, new literacies, multiliteracy and media literacy, each with somewhat different focus. Digital competence is defined as consisting of (1) technical competence, (2) the ability to use digital technologies in a meaningful way for working, studying and in everyday life, (3) the ability to evaluate digital technologies critically, and (4) motivation to participate and commit in the digital culture.

CONCLUSION

Research findings reveal five key pillars of teacher digital competence: professional engagement, use of digital devices, teaching and learning skills, technology integration in assessment, and student empowerment. However, these competencies are often ambiguously understood, necessitating the need for a more comprehensive framework such as the TDC Framework to accommodate personal, ethical, and professional competencies in addressing the development of AI and the metaverse in education. Digital competence is inseparable from contextual factors such as infrastructure access, policy support, professional training, and teachers' self-efficacy and attitudes toward technology. Teachers who receive institutional support and have a positive view of technology tend to demonstrate higher levels of digital competence. Furthermore, the journey toward digital competence is a gradual process, from digital literacy to digital skills to mature digital competence, which demands critical thinking, creativity, and ethical awareness. Therefore, educational institutions are advised to provide comprehensive digital training programs, emphasizing not only technical skills but also digital literacy, ethics, technology-based pedagogy, and readiness for AI developments and new digital environments. Improving teachers' self-efficacy and positive attitudes toward technology needs to be pursued through mentoring programs, communities of practice, and supportive work environments.

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