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**Review Article**

# Development and strengthening of teachers' digital competence: Systematic review

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**ABSTRACT**

The systematic review permitted the characterization of training programs in digital teaching competence using an analysis of their structure, implementation, and results. A comprehensive search was conducted across five databases, namely Scopus, Web of Science, Redalyc, Science Direct, and LENS, to retrieve scientific articles published between 2017 and 2023. The search was conducted using the inclusion-exclusion criteria, and the articles were selected to answer five guiding questions. The review addressed five aspects: initiatives and practices, configuration, implementation, concrete results, and dimensions according to recurrent frames of reference. It was observed that there has been an improvement in digital competence and teacher motivation, with elements such as information literacy, communication, digital content creation, and information security. However, there is a lack of alignment with current needs. It is important to articulate with reference frameworks such as DigCompEdu. To prepare future teachers and train active ones, it is suggested that conceptual, procedural, and attitudinal aspects be considered.

**Keywords:** education, digital competence, teacher training program

## INTRODUCTION

In the context of the postmodern age, digital teaching competence (DTC) is a fundamental aspect of education in a world increasingly permeated by technology. This competence encompasses not only the ability to handle programs and devices but also a diverse set of digital skills that are indispensable for performance in both the educational field and in other social and work contexts (Carvalho et al., 2019; Cateriano-Chavez et al., 2021; Díaz-Arce & Loyola-Illescas, 2021; Salazar Gómez et al., 2018; Shuyushbayeva et al., 2020). The incorporation of appropriate digital technologies into the digital competence in education (CDD) confers a competitive advantage by differentiating the professional profile, which is manifested in the improvement of the teaching-learning process and the relationship between teachers and students (Manjarrez Yépez & Cordero, 2023; Ortega-Ruipérez et al., 2021; Romero-Hermoza, 2021; Vilchez Guizado, 2019). In addition, it is of paramount importance for teachers to be able to develop their ability to produce and share digital content, as it constitutes an integral element of their pedagogical practice (Cabero-Almenara & Palacios-Rodríguez, 2020; Gabarda Méndez et al., 2023; Valdivieso Guerrero & Gonzáles Galán, 2016).

The development of digital competencies in teachers requires the concurrent application of diverse and complex strategies. This is why training programs represent optimal settings for the acquisition of technological resources and the incorporation of digital tools in the classroom. The emphasis on CDD, understood as information and digital literacy and as an enhancer of virtual methodologies, results in the enrichment of the educational experience for both teachers and students (Cabero-Almenara et al., 2020a; Díaz et al., 2019; González et al., 2020; Jiménez Hernández et al., 2021; Juárez & Marqués, 2019; Navarrete Sánchez et al., 2022). The significance of CDD extends beyond its immediate impact on the academic realm. It is also instrumental in fostering the holistic development of individuals in contemporary society. By facilitating the transfer of knowledge, it prepares individuals to navigate the sociocultural and academic challenges of a digitized world (Agreda Montoro et al., 2016; Cabero-Almenara & Palacios-Rodríguez, 2020; Girón Escudero et al., 2019; González et al., 2020; Nóbile & Porlán, 2022; Padilla-Hernández et al., 2019).

The transversality is a property of the CDD. However, its current relevance necessitates the creation of specialized training programs. While digital competencies have been enhanced by incorporating new resources and tools originating in other disciplines, which have strengthened the teaching process, there are still gaps in their utilization (Carvalho et al., 2019; Díaz-Arce & Loyola-Illescas, 2021). In response to this need, similar programs, courses, or strategies aimed at strengthening the CDD have been developed, especially since the pandemic generated by the novel coronavirus (COVID-19) (Montenegro Díaz, 2020; Sandoval, 2020). Nevertheless, the structure and approach of these programs, courses, and strategies vary considerably. This was demonstrated by the findings of the systematic evaluation of their characteristics and results. It is proposed that the development and strengthening of the CDD is a multifaceted process. Consequently, to achieve a significant impact on teaching practice and, ultimately, on learning by students, it is necessary to combine technical and pedagogical training, institutional support, and continuous evaluation (Almenara & Díaz, 2014; Çebi & Reisoglu, 2020; Díaz Pinzón, 2017; ElSayary, 2023; Reisoglu, 2022).

In this context, the objective of the systematic review was to describe the programs, courses, or other teacher training activities in digital competence, with particular emphasis on their structure, activities developed, and results obtained. This overview aimed to understand their key dimensions and impact on educational practice. The information gathered is intended to identify successful experiences in incorporating digital competence into training processes that facilitate the development of the requisite skills to effectively navigate the technological challenges of the 21st century in the context of teaching and learning.

## MATERIALS AND METHODS

A literature review on various programs, modules, or courses designed to enhance CDD competencies yielded pertinent information, which was then organized and analyzed. To achieve this objective, scientific articles were retrieved from the Scopus, Web of Science, Redalyc, Science Direct, and LENS databases between 2017 and 2023. The optimized search algorithm was employed, resulting in the retrieval of over 500 documents.

The search terms included (“programa de formación docente” OR “ teacher training program “) AND (“competencia digital” OR “digital competence”)

An initial search was conducted, duplicates were removed, and the relevance of the documents was assessed according to the inclusion and exclusion criteria defined to address the research questions, as detailed in the results section.

The inclusion criteria were, as follows:

- Research on CDD training programs, courses, or activities published in indexed scientific journals.
- Studies on design, and implementation of teacher training programs, courses, diploma courses, etc., with CDD.
- Studies that evaluate programs, courses, diploma courses, or teacher training activities focused on the development of digital competence.
- Studies published in the time window from 2017 to 2023, to ensure the relevance and timeliness of the information collected, mainly in Spanish and English.

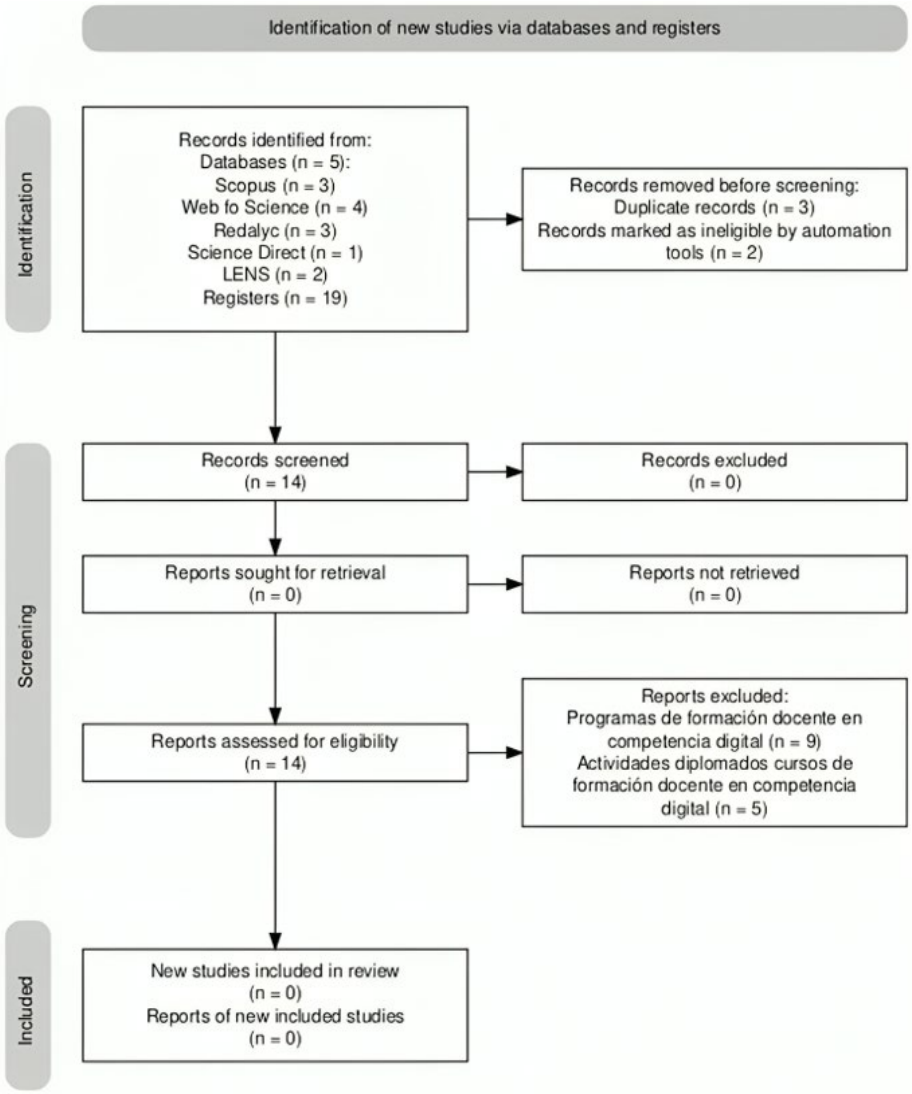


**Figure 1.** Flow chart with the selection process of the study sample [The flow chart was designed considering the interactive tool created by Haddaway et al. (2022), available at https://estech.shinyapps.io/prisma_flowdiagram/].

- Studies with information focused on practicing teachers and teachers in training.
- Studies on the design and implementation of teacher training programs, courses, and diplomas that include CDD.

The exclusion criteria were, as follows:

- Research that focuses on teacher training or teacher digital competence separately.
- Studies that did not conform to the methodological design of a teacher training program, course, or activity using CDD.
- Studies that were not published as scientific articles, i.e., gray literature was excluded (these, non-scientific articles, popularization papers, etc.).
- Research that did not provide sufficient information to draw meaningful or relevant conclusions for the review.

The title, abstract, keywords, methods, and results were subjected to a meticulous analysis. Each chosen document was meticulously read, its methodological quality evaluated, and the most important results were synthesized based on the criteria outlined in the PRISMA 2020 statement, as illustrated in **Figure 1** (Page et al., 2021).

**Table 1.** Characteristics of identified training practices, methodology, structure, and content in the studied documents

| Training practice/ methodology | Characteristics/contents | Organization or structure | References |
|---|---|---|---|
| MOOC | Creation of digital resources with peer review. Videos recorded by experts, interactive multimedia resources, video tutorials, forums, links to external resources, self-correcting quizzes, guided exercises, etc. | Digital identity, privacy management, risks for minors associated with Internet use, good practices for the use of social networks, rules of behavior on the network and licenses for the use of digital materials. | Gordillo et al. (2019) |
| Training program for leveling tutors through the virtual modality | Proficient in Office 365, cloud storage, online presentation creation, social media interaction, technical troubleshooting. | Methodology of PACIE (presencia, alcance, capacitación, interacción, e-learning) & duration: 40 hours) | Basantes-Andrade et al. (2020) |
| Mathematical and physical specialization through the use of digital resources | Digital technologies for homework, computer lab class, interactive activities using the computer. | Use of technological resources in the development of mathematics tasks both inside and outside the classroom. | Vilchez Guizado (2019) |
| Advanced courses for training in the use of e-books in professional activities | Creativity competitions, participation in entrepreneurship and innovation startup activities, and business pitching (pitch business). | In a modular environment, current problems of the role of information technologies in the teaching of professional courses are studied using innovative technologies for recycling textile waste and developing the creativity of future teachers. | Vorotnykova (2019) |
| Blended learning and instructor-mentoring | Digital citizenship; communication and collaboration; critical thinking, problem-solving and decision making; creativity and innovation; using technology as a tool. | 10-week training program with the objective of improving competency in skills, attitudes and knowledge. | ElSayary (2023) |
| Collaborative and applied digital competency training to create interactive e-books | Virtual classrooms and organization of collaborative groups, presentation of theoretical information, development and evaluation of resources, integration of contents and materials to the interactive e-book. | Design of a website to specify the contents of the CDD training, and to receive the applications. | Reisoglu (2022) |
| Implementation stages | Teaching orientation round tables, external practice days, and competitive examination orientation days, simulations, real presentations and exhibitions, Moodle and eLearning content creation tools, G-Suite and Microsoft Teams packages. | Three-stage approach: Orientation to the teaching profession, training in communication skills and training in digital teaching tools. | Trigueros Gordillo and Ceballos Hernández (2021) |

To address the research questions, data were extracted from each teacher training program on a range of characteristics, including design, variables associated with the CDD, methodologies, and results obtained after its application. This was done to provide an overview of the status of the training programs.

## RESULTS

The literature on digital competence is voluminous, yet the information necessary to answer the guiding questions was extracted from 14 documents, as follows:

*What initiatives and practices have been implemented in the training field to promote and develop CDD?*

The initiatives and practices implemented in teacher training to promote digital competence have focused on the acquisition of knowledge and skills for the use of digital technologies in teaching practice. These strategies can be characterized by two main types of practices:

(1) the promotion of the design of digital teaching-learning resources and

(2) the use of applications (apps) or digital resources as support tools in the classroom.

**Table 1** presents a summary of the information retrieved, considering the structure of the training practices and the characteristics of the activities.

Many training strategies are present in both formal programs and short courses. However, in the latter, it is more common to focus on specific aspects of the CDD addressing specific needs. Among the most relevant practices are, as follows:

(1) Implementing innovative methodologies,

(2) motivating confidence in the integration of technology, and

(3) effectively integrating ICTs for the improvement of learning (ElSayary, 2023; Kubrushko et al., 2020).

*What is the configuration and organization of the courses and training programs designed and implemented, specifically about the CDD?*

The configuration and organization of teacher training courses in digital competence can be characterized according to their respective methodology and structure. ElSayary (2023) highlights the importance of differentiating programs focused on "upskilling," or the process of learning new skills that allow for the improvement of current job performance, from programs focused on "re-skilling," or the process of learning new skills to change careers. Nevertheless, the programs were primarily designed to enhance the efficiency of knowledge transfer (**Table 1**).

A variety of alternatives were observed for the design and implementation of teacher training programs to address each of the five areas of teacher competence according to INTEF (2017):

(1) information literacy,

(2) communication and collaboration,

(3) digital content creation,

(4) computer security, and

(5) problem solving (Díaz et al., 2019; Sánchez-Cruzado et al., 2021).

In the configuration of CDD training programs, elements such as the creation of virtual classrooms, collaborative work, the design of educational materials, and the use of various digital tools stand out as particularly noteworthy. Similarly, various methodologies have been employed in the implementation of educational programs, including exploratory methodologies, which are exemplified by training programs, and descriptive methodologies, which are exemplified by training programs (Gordillo et al., 2019; López-Belmonte et al., 2020; Reisoglu, 2022).

The didactics, planning, and management of technological resources are also fundamental components. These components incorporate theoretical and practical sessions and various classroom application activities, mainly through the remote or virtual modality (Gordillo et al., 2019; López-Belmonte et al., 2020). The structure is typically organized into modules, with course activities emphasizing the creation of digital educational resources and problem-solving. These activities commonly include a variety of digital resources and tools, such as videos, interactive material, simulators, or collaborative applications. Additionally, they often incorporate different didactic strategies to encourage participation and active learning. Finally, courses and programs whose structure allow for comparative assessment of competencies stand out (Basantes-Andrade et al., 2020; Trigueros Gordillo & Ceballos Hernández, 2021; Vilchez Guizado, 2019).

*What CDD implementation has been carried out in teacher training programs, courses, or activities?*

In this third aspect, the implementation of CDD in teacher training courses (**Table 2**) was evaluated through participant observation, in-depth interviews, and intersubjective reflection of the researcher and the researched people. Activities such as theoretical sessions, practices, and classroom application activities were evaluated (Munawaroh et al., 2022; Trigueros Gordillo & Ceballos Hernández, 2021).

To ascertain the implementation of CDD in each case, the methodological structure of the documents reviewed was identified, considering sampling units, registration and context, duration, evaluation by experts, and self-evaluation. These factors are presented in **Table 2**. It was found to be pertinent when applying a digital competence training strategy to observe the age of the teachers in training, as younger teachers had access to digital technologies for a longer period and started using them at an earlier age than older teachers.

**Table 2.** Program characteristics, implementation, and results generated

| Program/course | Implementation | Results | References |
|---|---|---|---|
| Digital competence teacher training programs | Lack of alignment with current needs. | Limitation to use innovative methodologies. Improved techno-pedagogical skills. | López-Belmonte et al. (2020) & Morales et al. (2020) |
| Safe use of ICTs | Focus on safe and responsible use of ICTs. | Significant knowledge acquisition, development of digital competence and satisfaction with the training received. | Basantes-Andrade et al. (2020) |
| Improvement of digital competencies | Improvement in digital competence and technological skills. | Increased level of digital expertise, ability to use various ICT tools and improved communication, collaboration and digital content creation skills. | Kubrushko et al. (2020) & Reisoglu (2022) |
| Curricular adaptation with technology | Improved communication with students, adaptation to individual needs, summative and formative evaluations with digital technologies. | Development of skills to plan participatory activities. | Vorotnykova (2019) |
| Professional development in technology | Positive growth in technological knowledge and skills. | Improvement in the application of digital technologies in professional activity. | ElSayary (2023) |
| Technology integration in education | Increased digital competence, technology integration and improved quality of learning. | Increased interest and motivation to continue developing digital skills. | Boronenko et al. (2022) |
| Future teacher training | Improvement in digital skills, adaptation to online and semi face-to-face environments. | Positive assessment of training in digital and communication tools. | Trigueros Gordillo and Ceballos Hernández (2021) & Pascual et al. (2019) |
| Impact on teaching and learning | Improved teacher performance, increased motivation and confidence, positive impact on student learning. | Increased use of ICTs, greater student participation and improved academic results. | Vilchez Guizado (2019) |
| Self-design of digital materials | Development of a didactic proposal that allows them to teach the selected contents through didactic instruments and self-built digital material. | Digital materials as teaching tools can have a positive impact on learning, increasing motivation, engagement and concentration. | Delgado Álvarez and Egido Vicente (2023) & Gordillo et al. (2019) |

This undoubtedly influences the manner and confidence with which they incorporate these skills into their profession (Betancur-Chicué et al., 2023; Vilchez Guizado, 2019).

*What are the tangible outcomes of the teacher training programs implementation courses, and activities, with a particular focus on the utilization and advancement of the CDD?*

The tangible outcomes of CDD training programs indicate a heightened integration of technology in the classroom, an enhanced quality of student learning, and a surge in teachers' motivation to sustain their digital skill development (**Table 2**). Other significant outcomes include an improvement in techno-pedagogical skills, despite a lack of alignment with current needs. Additionally, the focus on the safe use of ICT has led to the acquisition of meaningful knowledge, as noted by Basantes-Andrade et al. (2020). The enhancement of digital competencies has been considerable, with a heightened level of digital expertise and proficiency in utilizing a multitude of technological tools, as evidenced by Kubrushko et al. (2020) and Reisoglu (2022). Technology integration in teaching has contributed to an increase in digital competence and the quality of learning, as evidenced by greater interest and motivation for the development of digital skills (Boronenko et al., 2022).

In conclusion, the efficacy of training programs and integrated learning during the implementation of CDD was demonstrated by the following outcomes:

(1) the construction of digital didactic instruments that facilitate meaningful learning,

(2) the development of primary digital competencies that promote transversality, and

(3) collaboration among participants, which demonstrates an enhanced capacity for reflection and critical analysis of information (Delgado Álvarez & Egido Vicente, 2023).

These findings demonstrate the positive impact of teacher digital competence training on various aspects of educational practice. In terms of tangible outcomes, the integration of technology in the classroom was observed, resulting in enhanced student learning outcomes and a positive impact on the domains of information, information literacy, communication, and collaboration. However, the remaining skills and competencies exhibited a lack of development (López-Belmonte et al., 2020).

*What are the specific aspects and dimensions of the CDD, according to the frames of reference, that are most prevalent during the stages of characterization, design, and implementation in teacher training programs, courses, or activities?*

The specific dimensions of the most recurrent reference frameworks are presented in **Table 2**. It can be observed that DigCompEdu (Redecker, 2017) and INTEF (2017) are similar, share an interdependent origin, and according to Cabero-Almenara et al. (2020b) are suitable references to consider in the design of training spaces such as massive open online courses (MOOC). The technological pedagogical content knowledge (TPACK) model is well-suited for integrating ICT efficiently in the classroom and for fostering the adaptation of technologies and the creation of new ones at the service of the teaching-learning process (Delgado Álvarez & Egido Vicente, 2023). It is noteworthy that Claro et al. (2024) have concluded that there are currently no unified standards for digital competencies. They have also highlighted the necessity for greater consensus and specification regarding the operationalization of digital competencies for in-service teachers, as well as the improvement of measurement instruments. This is a situation that is like that found in other areas of educator training, and it is an inevitable consequence of globalization since it has made it possible to learn about and compare strategies in the international educational context.

DigCompEdu contemplates six progressive levels of performance starting from teachers with little experience or contact with technology: awaken (A1), explore (A2), integrate (B1), expertise (B2), lead (C1), and innovate (C2). These levels have a similar structure in the INTEF (2017) framework, although the latter has five areas unlike the first (**Table 2**)

Other frameworks found in the literature include:

- The UNESCO competency framework serves as a guide for initial and ongoing teacher training, considering the use of ICTs within the education system. It is committed to educational change, transformation, and leadership. The framework addresses six key areas:

  (1) understanding ICTs in education,

  (2) curriculum and evaluation,

  (3) pedagogy,

  (4) application of digital competencies,

  (5) organization and administration, and

  (6) teacher professional learning.

  The framework proposes three levels of technology mastery:

  (1) knowledge acquisition,

  (2) knowledge deepening, and

  (3) knowledge creation (López-Belmonte et al., 2020).

- The national educational technology standards for teachers (NEST-T) delineate the competencies required for learning, teaching, and leadership in the digital age. The objective is to utilize technology to facilitate the creation of impactful, sustainable, scalable, and equitable learning experiences for students. The NEST-T framework proposes seven progressive levels for digital teacher expertise, as follows:

  (1) learner,

  (2) leader,

  (3) citizen,

(4) collaborator,

(5) designer,

(6) facilitator, and

(7) analyst (Kubrushko et al., 2020).

- The teaching emphasis on the development of students' digital information and communication skills (TEDDICS) program is designed to enhance students' abilities to navigate digital information and communication in the classroom. TEDDICS posits that teaching competencies encompass knowledge, skills, and attitudes that enable educators to design, organize, guide, and evaluate activities that facilitate problem-solving in digital environments for students (Claro et al., 2024).
- The digital teaching professional framework (DTPF) is a competency framework designed for teachers and tutors that emphasizes the fusion of effective pedagogy with the use of technology to increase learning. One differentiating factor is that it is accompanied by free online modules, which are available at no cost and provide digital accreditation. These modules allow teachers in training to identify their needs and thus improve their educational practices. The framework is structured into seven areas, each with three performance levels: exploration, adaptation, and leadership. The first area, pedagogical planning, encompasses the following subcategories:

  (1) pedagogical planning,

  (2) pedagogical approach,

  (3) student employability,

  (4) specific teaching,

  (5) assessment,

  (6) accessibility and inclusion, and

  (7) self-development (Cabero-Almenara et al., 2020).
- The competencies for the professional development of Colombian teachers, as proposed by the Ministry of National Education, aims to enhance innovation using ICTs. This is achieved through the implementation of a reference framework comprising five competencies, which are to be developed:

  (1) technological,

  (2) communicative,

  (3) pedagogical,

  (4) management, and

  (5) research.

Each of the competencies is divided into three levels of performance, namely Explorers, Integrators, and Innovators (Cabero-Almenara et al., 2020a).

## DISCUSSION

The results of this review confirm the wide variety of approaches and methodologies in the implementation of CDD in training programs. Through the identification of fourteen studies, training initiatives were synthesized around strategies, course configuration, implementation of digital competencies, and frameworks used. These practices, according to Kubrushko et al. (2020) and ElSayary (2023), tend to focus on the design of digital resources and the use of support tools in the classroom, highlighting the implementation of innovative methodologies and reliance on technology integration as key aspects for the adoption of digital competencies. However, a bias towards the development of practical skills in the use of tools is also observed in these programs, neglecting broader dimensions such as problem solving and the ability to adapt to changing digital environments, which are crucial elements for a meaningful integration of technology in teaching.

The configuration of courses and training programs is related to a segmentation between "upskilling" and "reskilling" initiatives (ElSayary, 2023), part of an approach that allows adjusting competencies to the demands

of the current educational context. Díaz et al. (2019) and Sánchez-Cruzado et al. (2021) emphasize that this modular organization facilitates adaptability and allows for a more in-depth evaluation of each participant's progress in specific areas such as digital content creation and problem solving. Regarding the implementation of the CDD, studies made by Trigueros Gordillo and Ceballos Hernández (2021), and Munawaroh et al. (2022), highlight the importance of articulating knowledge, pedagogy and technology to optimize educational practice, promoting an adaptive methodology adjusted to the characteristics and previous experiences of teachers.

My position on this finding is that, although training programs are making progress in practical training, they require a broader approach that encompasses transversal competencies and greater adaptability to changes. I would propose that a CDD training model should not only train teachers in the use of tools, but also develop skills of adaptability, critical analysis and technological self-management, preparing them for continuous digital changes and for contextualized integration of technology in the classroom.

On the other hand, frames of reference such as DigCompEdu and TPACK, (Cabero-Almenara et al., 2020b), stand out for their applicability and adaptability in varied training stages, facilitating the adoption of strategies in different educational contexts. Claro et al. (2024) suggest that the lack of international consensus on these frameworks and the need for standardization could be addressed through globalization, which would facilitate a convergence in criteria and measurements.

It is hypothesized that integrating technology adaptability and self-management into CDD programs will increase teachers' ability to use technology consciously and effectively, improving the relevance and sustainability of digital practices in education. The idea of expanding the focus on CDD training to include adaptive and critical analysis skills is supported by studies such as those carried out by Gordillo et al. (2019), who argues that training focused solely on tools and applications limits teachers' ability to adapt to new technologies. Furthermore, Cabero-Almenara et al. (2020b) support this position and highlights that the DigCompEdu model, with its progressive levels, is essential to advance beyond technical skills and achieve a reflective and strategic mastery of technology in teaching.

In contrast, the training promoted by Kubrushko et al. (2020), although it is useful for technical and digital safety empowerment, it could be interpreted as limited because it does not fully encompass the adaptive skills needed in changing educational environments. In relation to this point, ElSayary (2023) provides a valuable perspective by differentiating between "upskilling" and "reskilling". ElSayary (2023) suggests CDD training tailored to the levels and teachers' needs. Based on this perspective, an emphasis on adaptability could also support the approach proposed by Betancur-Chicué et al. (2023), who recognize previous experience and digital technologies as key factors in the effectiveness of teacher training programs (**Table 3**).

## CONCLUSIONS

1. Despite the implementation of various initiatives, a discrepancy persists in the achievement of the optimal level of digital competence by teachers, which constrains their capacity to adopt innovative methodologies. Nevertheless, a positive correlation is observed between technological skills and the implementation of pedagogical models such as MOOCs, blended learning, or webinars.
2. A discrepancy between the content of training programs and the current demand of digital competence is evident, indicating the necessity for continuous review and adaptation of these programs. Nevertheless, encouraging outcomes are observed as practices to promote the design of digital media and tools for teaching-learning support in the classroom, present in programs and short courses as innovative and relevant practices motivating the integration of technology for the improvement of learning.
3. Regarding the organization of courses and programs, the interest in learning new skills that enhance teaching practice stands out, in addition to alternatives for the structured design and implementation of common CDD frameworks as INTEF (2017), which focuses on competencies such as literacy and problem solving.
4. On the other hand, in didactics, planning, and management of technological resources, the theoretical-practical sessions are regularly involved, mostly in the remote modality. It is organized in modules that

**Table 3.** Frameworks of reference for DTC and general digital dimensions and performance levels as proposed by Boronenko et al. (2022) (Claro et al., 2024)

| Framework | Description | Dimensions | Performance level | References |
|---|---|---|---|---|
| INTEF's (2017) common framework for teaching digital competence–2017 | It is a reference for the diagnosis and improvement of teachers' digital skills, it structures 21 competencies grouped into five categories. | Information literacy | Search and filter data, information and digital content on a topic in an academic discipline; find up-to-date information on school supplies or digital content development services; evaluating digital content by comparing data from different information sources; & acquire information to learn or work through electronic resources | Basantes-Andrade et al. (2020), Gordillo et al. (2019), López-Belmonte et al. (2020), & Pascual et al. (2019) |
| | | Communication and collaboration | Organizing the exchange of information in a digital environment (e.g., using a social network, messenger, etc.); install a communication application on the computer or mobile device; schedule and deliver an online lesson using videoconferencing systems; & create your own social networking page and manage your account | |
| | | Digital content creation | Create a video, audio or photographic image and post it online; write a blog post or a post on social networks, & make a selection of useful educational resources | |
| | | Computer security | To make security adjustments for a personal digital device & to restrict student access to digital resources according to the situation (ban digital content, fake news, etc.) | |
| | | Troubleshooting | Select digital technologies according to learning needs & evaluate the quality of digital resources used in the classes according to educational objectives | |
| Digital competency framework for educators (DigCompEdu) –2017 | Provides a reference for teachers across different educational levels (early childhood, higher education, adult, general and vocational education, special education, and non-formal education) | Professional commitment | Use cloud storage to save and share files | Gordillo et al. (2019) & Reisoglu (2022) |
| | | Digital resources | Evaluate and adjust the use of digital resources according to educational needs | |
| | | Teaching and learning | Create an online learning environment and use digital platforms to share information | |
| | | Assessment | Evaluate and adjust the use of digital resources according to educational needs | |
| | | Student empowerment | Facilitate students' autonomous use of digital technologies | |
| | | Facilitating digital competence for students | Support students' development of digital competence through the use of varied tools and platforms | |
| TPACK–2006 | It highlights what a teacher should teach in the digital era. It offers a model to apply in teaching practice and provides evaluation tools for trainers. | Contents | Search and analyze digital information related to the discipline. | Delgado Álvarez and Egido Vicente (2023) |
| | | Technology | Install and update software or applications on digital devices & customize security settings on devices | |
| | | Pedagogy | Design teaching experiences integrating appropriate digital technologies with pedagogical objectives | |

include varied activities that promote the creation of resources and problem-solving tasks through interactive resources, simulations, videos or collaborative applications that encourage participation.

5. The participant observation and the structured interviews are among the most addressed implementations, followed by the evaluation through an observation of the activities carried out in the theoretical-practical sessions (Munawaroh et al, 2022).

6. The most common results focus on the technological integration in the classroom, in an attempt to improve the quality of learning and increase motivation, strengthening the self-construction of digital tools for meaningful learning as well as the development of the CDD to strengthen transversality, a critical and reflective capacity regarding teaching practice.
7. The common frameworks that stand out in the design and implementation of courses and/or teacher training programs in digital competence are: INTEF (2017), DigCompEdu (Redecker, 2017), and TPACK. Still, a greater consensus would be more convenient in order to consider several approaches that point towards the same competences, particularly those that have to do with the use of digital resources and the continuous improvement of teaching through their use and implementation.
8. The replacement of expository sessions with autonomous work sessions, research, design, and construction tasks yielded satisfactory results among the students. This type of didactic proposal facilitates the initiation of students into research techniques and the systematic search for information. It also encourages them to analyze critically and select those media that best suit their interests, for example, using disruptive technologies such as artificial intelligence, and virtual and augmented reality, among others.
9. The results of the information, communication, and content creation dimensions are becoming increasingly important, particularly in the context of low levels of knowledge in the use of tools for image and sound editing and a lack of knowledge about the regulations and the use of responsible authorship, knowledge, and respect for licenses and online security. These factors hinder the rigorous production of materials on the part of teachers in training.
10. The increase in computer usage demonstrates the necessity for individuals to possess the ability to utilize specialized programs for the ordering and classification of information. Additionally, digital competence is also related to the management of large amounts of information. Consequently, there is a lack of knowledge regarding the effective handling of such data.
11. There is a need for curricular adaptation to comprehensively and transversally include the development of digital competence in initial teacher training programs, aligning with globally well-weighted reference frameworks such as DigCompEdu and other similar models. The curriculum should address the conceptual, procedural, and attitudinal aspects of digital competence to ensure a holistic approach to preparing future teachers to face the challenges of the digital era in the educational environment.

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**Ethics declaration:** This study focuses on a systematic review and theoretical analysis of existing literature on training programs for teachers' digital competence. Since the research does not involve direct interaction with individuals, the collection of personal data, or experimental procedures, obtaining approval from an ethics committee was not required. The study is based entirely on publicly available research and theoretical sources, so informed consent from participants does not apply. To ensure the research process was conducted responsibly, we followed the PRISMA 2020 guidelines. This allowed us to maintain transparency, rigor, and reproducibility throughout the study. Additionally, all sources and studies included in the review have been appropriately cited and referenced to respect authorship and intellectual property. Lastly, as no sensitive or confidential personal data was handled, there was no need for measures related to anonymization or data protection. Given the nature of this study, formal ethical approval was not necessary.

**Declaration of interest:** The authors declare no competing interest.

**Data availability:** Data generated or analyzed during this study are available from the authors on request.

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