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La competencia digital de los maestros en formación en Educación Infantil y Primaria: una revisión sistemática de la literatura

Pre-service teachers' digital competence in Early Childhood and Primary Education: a systematic review of the literature

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Resumen

La irrupción de las TIC en las aulas como práctica habitual obliga a los futuros maestros a formarse en el uso didáctico de las nuevas tecnologías, así como de adquirir competencias digitales que les permitan ponerlas en práctica. Por este motivo, es necesario investigar sobre la temática para alcanzar un mejor entendimiento de las competencias digitales con las que cuentan los futuros maestros. El objetivo de esta investigación es realizar una revisión sistemática en la que se analice el estado actual de la literatura sobre las competencias digitales de los futuros maestros, con el propósito de establecer futuras líneas de investigación y propuestas formativas. Se ha hecho uso de la metodología PRISMA y los resultados de la se han representado haciendo uso del diagrama de flujo de este diseño metodológico. Se han revisado los estudios hasta el año 2023 (N=18) publicados en las bases de datos SCOPUS, JCR y Proquest. Los resultados muestran el estado actual de la literatura sobre competencias digitales en futuros maestros. Se finaliza con una propuesta de líneas de investigación, así como con algunas medidas formativas a llevar a cabo con futuros docentes atendiendo a las necesidades detectadas de las investigaciones que componen la muestra.

Palabras clave: competencias digitales; revisión sistemática; TIC; futuros maestros.

Abstract

The integration of ICT in classrooms as a regular practice requires future teachers to be trained in the didactic use of new technologies and to acquire digital competences that enable them to implement these technologies effectively. Therefore, it is necessary to research this topic to achieve a better understanding of the digital competences that future teachers possess. The aim of this research is to conduct a systematic review that analyzes the current state of the literature on the digital competences of future teachers, with the goal of establishing future research lines and training proposals. The PRISMA methodology was employed, and the results were presented using the flowchart of this methodological design. Studies published up to the year 2023 (N=18) in the SCOPUS, JCR, and Proquest databases were reviewed. The results show the current state of the literature on digital competences in future teachers. The study concludes with a proposal for research lines, as well as some training measures to be implemented with future teachers, addressing the needs identified in the studies that comprise the sample.

Keywords: *digital competences; systematic review; ICT; preservice teachers.*

Introduction

Digital competence is an increasingly vital concept in the modern world, where the use of digital technology permeates almost every aspect of life. It encompasses a broad range of skills and knowledge necessary to effectively engage with digital environments (Haşlamam et al., 2024). Includes a variety of skills such as technical competence, meaningful use of digital technologies, critical evaluation, and motivation to engage with digital culture (Ilomäki et al., 2014). It is recognized as a key competence for lifelong learning and is essential for personal development, active citizenship, social inclusion, and employment (Napal-Fraile et al., 2018). The concept of digital competence is still evolving, with various terms used to describe it, such as digital literacy, media literacy, and information literacy, each with a different focus (Ilomäki et al., 2014; Sánchez-Caballé et al., 2020). For the purposes of this study, we will focus on the concept of digital competence (Alastor et al., 2023b).

Digital teacher competence refers to the knowledge, skills, and attitudes required by educators to effectively integrate digital technologies into their teaching practices (Guillén-Gámez & Mayorga-Fernández, 2020). This concept has gained prominence due to the increasing role of technology in education and the need for teachers to adapt to the digital society's demands (Alastor et al., 2024; Pinto-Santos et al., 2023). To operationalize this concept, researchers have developed various frameworks; the conceptual frameworks of digital teaching competence analyzed in Cabero-Almenara & Palacios-Rodríguez (2020) include DigCompEdu, the ISTE Standards for Educators, the UNESCO ICT Competency Framework for Teachers, the Spanish Common Framework, the British Digital Teaching Framework, the Colombian ICT Competencies and the Chilean ICT Competencies and Standards. Analyzing the frameworks used in other digital competence studies is important because it reveals how these frameworks influence research outcomes, measure different competences, and vary in validity. This analysis ensures standardization, identifies best practices, highlights research gaps, enhances relevance, adds credibility, and informs policy and curriculum development based on evidence-based models (Alastor et al., 2023c).

Is now considered a fundamental skill in education, essential for teaching and learning in modern classrooms, and is included in national curricula and teacher education programs (Krumsvik, 2014; Ottestad et al., 2014; Atiqah et al., 2024). Teachers' digital competence encompasses both technical and pedagogical skills, enabling them to enhance their teaching and support the development of their students' digital skills (Esteve-Mon et al., 2020b; Skantz-Åberg et al., 2022; Villalustre-Martínez, 2024).

There is a distinction between teachers' mastery of digital tools and the appropriation of these tools for educational purposes, with the latter being crucial for integrating technology into

pedagogy (Instefjord, 2015). While many teachers possess adequate technical digital skills, there is a disparity in their ability to use these skills pedagogically to improve teaching and learning processes (Napal-Fraile et al., 2018; Alastor et al., 2023a). Factors such as age, training, gender and school type can influence teachers' digital competence levels, particularly in areas like content creation, information literacy, and problem-solving (Garzón-Artacho et al., 2020; Fernández-Robles & Duarte-Hueros, 2023). In terms of gender, exits in digital competence, with women often perceiving themselves as less competent, especially in technological aspects (Esteve-Mon et al., 2020a).

There is a need for practical tools to measure digital competences to facilitate the design of training programs for professional development (Canina & Orero-Blat, 2021). Despite its importance, there is a recognized need for improved education and training to bridge the digital competence gap, including addressing gender disparities and developing reliable assessment tools. Pre-service and in-service teacher training programs are essential for developing teachers' digital competences, with a focus on relational and didactic aspects of ICT integration (Instefjord & Munthe, 2017).

Future teachers are tasked with the critical challenge of integrating digital competences into their professional skill set. This requires a comprehensive approach to training that includes both theoretical understanding and practical application, supported by educational programs that emphasize digital content creation, ethical considerations, and continuous adaptation to technological advancements (Martín-Párraga et al., 2024).

The key to success for future teachers lies in building their digital skills and turning difficulties into chances to learn and grow. Teacher training programs can achieve this by offering bite-sized online courses (Brevik et al., 2019). By reflecting on ethical issues and their own experiences with social media, student teachers can gain valuable insights into becoming responsible digital educators. The rapid pace of technology throws new challenges at teachers, like having to adapt their roles, take on more work, and deal with a lack of good digital learning materials (Helleve et al., 2020). To prepare future teachers for this digital world, their education should combine traditional classroom learning with more flexible approaches and a strong focus on using these skills in real-world teaching (Babushko et al., 2022).

Despite the growing importance of technology in education, there is a concerning lack of pre service teacher training in digital competences, potentially hindering student preparation for the digital future (Brianza et al., 2024). A systematic review is essential for investigating this issue as it allows for a comprehensive analysis of existing literature, identifies gaps and trends in pre-service teacher training in digital competences, and evaluates current training programs. This review provides evidence-based recommendations to improve teacher preparation, ensuring students are well-equipped for the digital future.

Therefore, the objective of this work is to carry out a systematic review of the existing research in the literature on digital competencies in future teachers in training. The specific objectives are as follows:

- To analyze the methodological design of published works on digital teaching competence.
- To identify the frameworks of reference used by researchers in the studies.
- To describe the research findings and the variables studied together with digital teaching competencies.
- To develop proposals for action to improve the digital competencies of future teachers based on the research.
- To identify suggestions for future research based on the limitations detected in the studies.

Methodology

The research methodology employed in this study is a systematic literature review. This methodology is distinguished by its systematic and scientifically rigorous approach, making it the most suitable method for conducting an in-depth analysis of a research topic. Specifically, the PRISMA (Preferred Reporting Items for Systematic Reviews and Metaanalyses) methodology was utilized for the execution of this review. This is carried out in four phases: identification, screening, eligibility and included (Barquero-Morales, 2022). Its main characteristic is its objectivity, as well as the fact that the different phases that lead to the sample selection process are graphically represented in the flow chart of the methodology (Sánchez-Serrano et al., 2022) used in this research (Figure 1).

Procedure

For the selection of the articles that make up the sample of this systematic literature review, all publications on the subject were considered, with no time restriction up to the year 2023. To carry out the process, the databases Scopus, Web of Science and Proquest were used because they include peer-reviewed publications with a high level of impact. Search keywords were used in English and Spanish from the UNESCO thesaurus and ERIC; "competencia digital", "competencias TIC", "alfabetización digital", "habilidades digitales", "maestros", "magisterio", "estudiantes de educación infantil", "estudiantes de educación primaria", "grado en educación infantil", "grado en educación primaria", "digital competence", "ICT competences", "Computer literacy", "Digital skills", "Digital literacy", "student teachers", "primary teacher education", "early childhood education degree", "primary education degree". Searches were carried out by combining the concepts referring to digital competences with those relating to teachers and their training using the Boolean operator "AND".

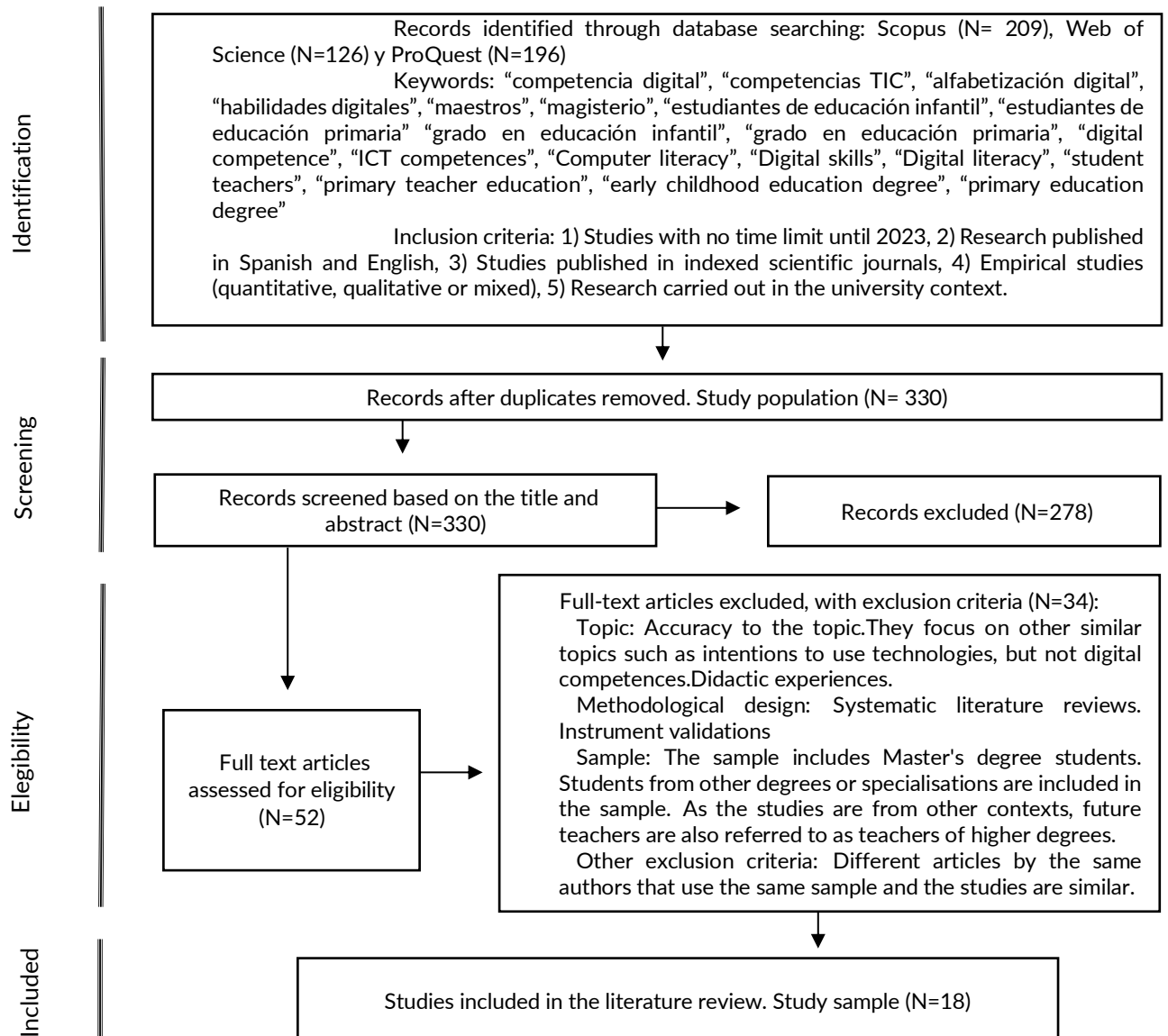
The terms were selected considering the objectives of the study. The search for these terms was conducted in the title, abstract, and keywords. The inclusion criteria that determined the search were as follows: 1) Studies with no time limit until 2023, 2) Research published in Spanish and English, 3) Studies published in indexed scientific journals, 4) Empirical studies (quantitative, qualitative or mixed), 5) Research carried out in the university context. The exclusion criteria followed for the elimination of articles until the final sample was completed are the following: 1) other systematic literature reviews on the topic, 2) teaching experiences, 3) studies on the topic carried out in non-university contexts, 4) research on future teachers of secondary education or other stages other than primary or early childhood education, 6) validation of instruments, 7) articles in languages not included in the inclusion criteria, 8) Accuracy to the topic.

Referring to the procedure, the phases of the PRISMA methodology have been conducted (Figure 1). The first phase carried out is identification, where keyword searches are performed in the title, abstract, and keywords across the three databases, and duplicate entries are removed. As a result, a total population of N=330 studies were obtained. This initial population was analyzed based on the title and abstract in phase 2 (screening) and, following the exclusion criteria, 278 articles were eliminated, resulting in a total of N=52. Next, the third phase, called eligibility, was carried out, in which the full texts were reviewed and those that did not meet the inclusion criteria were eliminated, resulting in a final sample of 18 studies. The texts that make up the sample have been analyzed in depth and the results of this study have been extracted from them.

Following the methodological procedure of the PRISMA methodology, we present the flow chart (Liberati et al., 2009) in which all the phases of the review are represented, and which is shown in figure 1. The final sample resulting from the systematic review is 18 studies.

Figure 1.

Flowchart of the PRISMA methodology with the phases followed in the systematic review. Based on Liberati et al. 2009



Sample

The population resulting from the systematic review consists of 330 articles. After conducting the phases of the PRISMA methodology, as previously explained, the research has a sample of 18 studies that meet the initially determined inclusion criteria. The excluded articles were omitted for reasons related to the topic, methodological design, sample, and other exclusion criteria specified in the flow diagram (Figure 1) and, therefore, were not selected to be part of the sample.

Results

The following are the results obtained from the systematic review, addressing the research objectives.

1. Characteristics of studies on digital competencies in future teachers.

Regarding the first research objective, Table 1 presents the main characteristics of the studies that make up the sample, followed by an analysis of these characteristics.

Table 1.
Characteristics of the studies that make up the sample of the systematic review (N=18).

Authors and years	Country	Methodological design	Sample (pre service teachers)
Ahmad et al. (2016)	Malaysia	Quantitative, ad hoc questionnaire (44 items).	N= 104 primary education
Alnasib (2023)	Saudi Arabia	Quantitative design. Questionnaire based on DigComp framework (closed-ended (37) and open-ended questions (5).	N= 140 early childhood and primary education (art education)
Castiñeira-Rodríguez (2022)	Spain	Quantitative, Ad hoc questionnaire (39 items).	N=115 early childhood and primary education
Esteve-Mon (2016)	Spain	Quantitative, ad hoc questionnaire based on NETS-T from ISTE (2008) (40 items).	N= 140 early childhood, primary education and pedagogy
Fernández de la Iglesia et al. (2020)	Spain	Quantitative design. Ad hoc questionnaire. Scales: attitudes towards ICT use, ICT use skills, frequency of use (57 items).	N= 526 early childhood and primary education
Gabarda Méndez et al. (2017)	Spain	Quantitative, Ad hoc questionnaire based on the Common Framework of Digital Teaching Competence (21 items).	N= 104 early childhood and primary education
Girón-Escudero et al. (2019)	Spain	Quantitative, Ad hoc questionnaire based on the Common Framework of Digital Teaching Competence (37 items).	N= 117 early childhood and primary education
Grande de Prado et al. (2021)	Spain	Quantitative, questionnaire based on COTASEBA (Casero & Llorente, 2006) and DigComp (INTEF, 2017).	N= 329 primary education
Gudmundsdottir et al. (2020)	Spain and Norway	Quantitative, questionnaire adapted from International Computer and Information Literacy Study (ICILS) questionnaire (Fraillon et al., 2013).	N=1244 early childhood and primary education
Gutiérrez-Martín et al. (2010)	Spain	Quantitative, questionnaire: Perception of ICT Knowledge (PCTIC), Perception of ICT Knowledge applied to Education (PCTIC-E), Computer Anxiety and Dislike Scales, and Attitudes towards the use of ICT in the classroom.	N=863 early childhood and primary education (music and physical education)
Liesa Orús et al. (2016)	Spain	Quantitative, ad hoc questionnaire (30 items).	N= 960 early childhood and primary education
Marimon-Martí et al. (2023)	Spain and Andorra	Quantitative, questionnaire based on the COMDID rubric (Lázaro & Gisbert, 2015) (22 items).	N=1558 early childhood and primary education

Authors and years	Country	Methodological design	Sample (pre service teachers)
Martínez Pérez et al. (2022)	Spain	Quantitative, questionnaire. Digital Competence Questionnaire "DigCompEdu" (Cabero-Almenara & Palacios-Rodríguez, 2020) (7 items or dimensions) and the Content Questionnaire: Digital Resources and Digital Pedagogy (20 items).	N= 313 primary education
Masoumi (2021)	Sweden	Qualitative, Focus group. Seven key questions and semi-structured interviews.	N= 25 early childhood
Mercader & Gairín (2021)	Spain	Quantitative, questionnaire. COMDID instrument (Lázaro-Cantabrana et al, 2019).	N= 301 early childhood and primary education
Moreno Rodríguez et al. (2018)	Spain	Quantitative, ad hoc designed questionnaire based on DigComp (21 items).	N=104 early childhood and primary education
Nuzzaci (2017)	Italy	Quantitative, questionnaire. Attitudes Towards ICT (101 items). Perception of the level of technological competence. (20 items).	N= 289 primary education
Pegalajar Palomino (2018)	Spain	Quantitative, ad hoc questionnaire (35 items).	N=231 early childhood and primary education

As can be seen, the sample is predominantly comprised of research conducted in the Spanish context (N=13), although two of these are comparative studies that include participants from other countries (Gudmundsdottir et al., 2020; Marimon-Martí et al., 2023). The remaining studies (N=5) are international, conducted in Saudi Arabia, Sweden, Italy, and Malaysia. Regarding the publication years, although there was no time restriction in the searches, the publications are from the last eight years, starting from 2016, with one exception from 2010. This indicates that the training in digital competencies for future teachers is a relatively recent area of research that has been growing in recent years.

Regarding the methodological design, all studies are quantitative except for the one conducted in Sweden, where Masoumi (2021) employs a qualitative methodological design using focus groups for data collection. The instruments used for data collection are questionnaires in all the studies, with a predominance of ad hoc questionnaires designed based on digital competency frameworks.

Examples include the questionnaires from the studies by Alnasib (2023), Grande de Prado et al. (2021), Martínez-Pérez et al. (2022), and Moreno-Rodríguez et al. (2018), which reference DigComp; Esteve-Mon (2016), which is based on ISTE's NETS-T (2008); Gabarda-Méndez et al. (2017) and Girón-Escudero et al. (2019), which follow the criteria of the Common Framework for Digital Teaching Competence; and the studies by Marimon-Martí et al. (2023) and Mercader & Gairín (2021), which use the COMDID rubric (Lázaro & Gisbert, 2015).

Lastly, regarding the samples, we can affirm that, as established in the search criteria, the participants are future teachers of early childhood and primary education who are in university training at the time of the research. However, some studies, such as those by Grande de Prado et al. (2021), Gutiérrez-Martín et al. (2010), Martínez-Pérez et al. (2022), Nuzzaci (2017), and Ahmad et al. (2016), include only primary education students. In the case of Masoumi (2021), it is the only study that includes only early childhood education students, without considering primary education students. Exceptionally, there is the publication by Esteve-Mon (2016), which also includes pedagogy students. This study has been included in the review because these students may serve as teachers in the future if they so choose.

Reference Frameworks on Digital Competencies

Regarding the second research objective, it can be stated that different frameworks serve as references for analyzing the digital competencies of future teachers. The authors of the studies in the sample use these frameworks to justify their research and design their data collection instruments. In some cases, the authors use multiple models to support their research and design their instruments. After analyzing the research, we can affirm that there are two main frames of reference in the design of the research analyzed: DigComp and DigCompEdu.

In the case of DigComp (Mattar et al., 2022), it is used by Alnasib (2023) in his study, which aims to understand the digital competence of future teachers based on their perspectives. The studies conducted by Grande de Prado et al. (2021) and Pérez et al. (2022) use the Digital Teaching Competences Framework (DigCompEdu) to analyze digital competencies in the context of future teachers. Moreno-Rodríguez et al. (2018) also choose the Common Framework of Digital Teaching Competence (INTEF, 2014), which is based on the DigComp project, for their research.

Gabarda-Méndez et al. (2017) also refer to the Common Framework of Digital Teaching Competence (DigComp) for designing their instrument, although they mention other theoretical models in their theoretical framework, such as the NETS Standards for Teachers by the International Society for Technology in Education (ISTE, 2008). This is also the case for Girón-Escudero et al. (2019), who, in the theoretical foundation of their article, mention various reference frameworks for digital teaching competencies and their evolution over time: UNESCO ICT Competency Framework for Teachers (ICT-CFT), the National Educational Technology Standards (NETS) (ISTE, 2008), the Qualified Teacher Status (QTS), the European Pedagogical ICT License, Chile's Enlaces Network, the INSA Curriculum of Colombia, and the Australian model. However, for designing their instrument, they again use the Common Framework of Digital Teaching Competence (INTEF, 2017).

Another framework that is also mentioned as a reference point is the NETS Standards for Teachers from the International Society for Technology in Education (ISTE, 2008) used by Esteve-Mon (2016) in his study. And there is also the case of the COMDID model by Lázaro & Gisbert (2015) which is taken as a reference for the design of the data collection instruments in the research of Marimón-Martí et al. (2023) and Mercader & Gairín (2021).

Finally, there are authors who reference other less popular frameworks in the literature on the topic, such as Gudmundsdottir et al. (2020), who use the Pedagogical, Ethical, Attitudinal and Technical Dimensions of Digital Competence in Teacher Education (PEAT Model) by Dicte (2019) (Dicte, 2019 as cited in Gudmundsdottir et al., 2020). Masoumi (2021), for their qualitative research, utilizes the Technological-Pedagogical-Content-Knowledge (TPACK) framework by Mishra and Koehler (2006) (cited in Masoumi, 2021), which considers the content, pedagogy, and technology as domains of teaching forms for educators. Nuzzaci (2017) uses the Technology Acceptance Model (TAM) by Davis (1989) (cited by Nuzzaci, 2017) for developing their instrument, focusing more on perceptions and attitudes toward technologies, which is further removed from those commonly used in the literature to measure teachers' digital competencies.

On the other hand, the sample also includes articles whose authors reference multiple frameworks of digital competencies, both in their theoretical justification and for the development of the study's questionnaire. An example is Castiñeira-Rodríguez (2022), who utilizes DigComp (Punie & Brecko, 2014), DigCompEdu (Redecker, 2017), the Common Framework of Digital Teaching Competence (INTEF, 2017), and the UNESCO General Framework (Butcher, 2019). Another example is Fernández de la Iglesia et al. (2020), who also refer to the use of both DigCompEdu and the Common Framework of Digital Teaching Competence (INTEF, 2017).

Less commonly, we find three studies that do not mention any theoretical framework of reference. In the case of Gutiérrez-Martin et al. (2010), the authors rely on previously designed scales that align with the objectives of their research. In the studies conducted by Liesa-Orús et al. (2016) and Pegalajar-Palomino (2018), the authors design their instruments without using a theoretical framework of reference or previous instruments.

Findings and variables studied together with digital competences in teaching

The third objective of the review is to describe the results of the studies in the sample and to report on the variables studied together with the digital competences of teachers. We can affirm that the analyzed studies generally focus on measuring perceptions of digital competence levels among future teachers, with the sample including only one study that assesses actual digital competence capabilities. This is seen in the research conducted by Ahmad et al. (2016), who find that future teachers possess high levels of ICT skills even in their early years of training.

Referring to the results of the other studies, it can be stated that in the majority of the studies comprising the sample, there is unanimity among the authors in asserting the existence of a perceived intermediate to high level of digital competencies. In general, future teachers are perceived as competent (Alnasib, 2023; Esteve-Mon et al., 2016; Fernández De la Iglesia et al., 2020; Gabarda-Méndez et al., 2017; Grande de Prado et al., 2021; Marimon-Martí et al., 2023; Martínez Pérez et al., 2022; Mercader & Gairín, 2021).

However, the studies agree in affirming that this perceived level of competence is relative to basic skills, with didactic competencies using ICT relegated to a lower level (Esteve-Mon et al., 2016; Gabarda-Méndez et al., 2017; Gutiérrez-Martín et al., 2010; Mercader & Gairín, 2021), such as content creation or instructional material design (Castiñeira-Rodríguez et al., 2022; Fernández De la Iglesia et al., 2020). These findings are also supported by research conducted by Marimon-Martí et al. (2023), who also find in their study that students are not adequately prepared in areas such as pedagogical design and the use of ICT in learning processes. Girón-Escudero et al. (2019) study self-perception of digital competencies in the areas of "digital content creation" and "problem-solving" and state that "the digital competencies of future teachers, 'digital natives,' are not as extensive as one might expect" (p. 203). Similarly, Liesa-Orús et al. (2016) conclude that participants have low levels of digital competencies in the use of specific tools despite being digital natives.

Students demonstrate the highest competency in daily ICT tools like email, web browsers, and social networks, not used in educational contexts. Masoumi (2021) and Gutiérrez-Martín et al. (2010) also find that students are proficient with everyday ICT but need more training in pedagogical digital competencies, such as educational applications and curriculum integration. Nuzzaci (2017) highlights that this pedagogical use of ICT is a major concern for students' future careers. Overall, research consistently shows that students and future teachers lack the skills to implement and apply digital competencies in educational settings.

As indicated from the beginning, most of the research in the sample has been dedicated to measuring self-perception in levels of digital competence. However, one aspect to take into account in this research is that, as some authors point out (Ex: Gabarda-Méndez et al., 2017; Grande de Prado et al., 2021; Gudmundsdottir et al., 2020; Marimon-Martí et al., 2023; Moreno-Rodríguez et al., 2018), studying self-perception could have a bias, since perceived digital competence may be greater than real digital competence. For this reason, it would be necessary to discriminate in the research between self-perceptions and the real skill level of future teachers when they put their digital skills into practice.

On the other hand, some of the studies comprising the sample focus on examining the level of digital competencies alongside other variables. Gender is one of the most studied variables among the research (Esteve-Mon et al., 2016; Fernández De la Iglesia et al., 2020; Grande de Prado et al., 2021), although there is no consensus in the results. While Fernández De la Iglesia et al. (2020) and Grande de Prado et al. (2021) find significant differences by gender, with men perceiving themselves as more competent in ICT use, Marimon-Martí et al. (2023) find that women are equally or more competent. Another example is age, with younger students perceived to have a higher level of competency (Esteve-Mon et al., 2016).

Marimon-Martí et al. (2023) and Mercader & Gairín (2021) analyze students' degree programs, finding higher digital competence among those in double degree and primary education programs, respectively. Mercader & Gairín (2021) also find that students who take university entrance exams perceive higher digital competence. Other variables studied include cybersecurity, privacy, digital

content evaluation (Gudmundsdottir et al., 2020), T-MOOCs for training (Martínez-Pérez et al., 2022), and digital competence in inclusive education (Pegalajar-Palomino, 2018).

Action proposals for improving future teachers' digital competences

The reviewed research generally presents intervention proposals to enhance future teachers' digital competences. Addressing the fourth research objective, a synthesis of these proposals shows they target institutional, departmental, curriculum, and degree program levels. A common theme, as asserted by Fernández de la Iglesia et al. (2020), is enhancing future educators' digital competence, focusing on both technical use and effective integration for learning. In the first group, we find proposals for training in digital competences that can be developed within faculties or universities themselves, which would be more feasibly implemented in the short or medium term. In this regard, authors such as Castiñeira-Rodríguez et al. (2022) and Gudmundsdottir et al. (2020) propose offering training courses or seminars on ICT, with the latter specifically suggesting topics like responsible use (privacy or cybersecurity). Additionally, Martínez Pérez et al. (2022) discuss the inclusion of T-MOOCs as training proposals in digital teaching competences.

Ahmad et al. (2016) also proposes conducting complementary training courses, improving ICT-focused training with a focus on material design, and suggests the idea of facilitating ICT facilities in training centers so that students have continuous access and can develop their digital competences. Finally, at this level, Masoumi (2021) suggests the need to support students, especially in their early years of practical experience in educational contexts, proposing the presence of professionals to supervise the work of future teachers in this area.

Measures requiring broader, program-level changes cannot be implemented quickly. Most authors agree on revising curricula to enhance digital competence (Moreno-Rodríguez et al., 2018) and making necessary reforms (Esteve-Mon et al., 2016; Marimon-Martí et al., 2023). Alnasib (2023) and Martínez-Pérez et al. (2022) suggest evaluating existing training programs for improvements. Some propose modifications to subjects and content, such as designing courses specifically on digital competences, linking practicum to ICT use, or integrating models like TPACK (Girón-Escudero et al., 2019). Liesa-Orús et al. (2016) advocate for embedding ICT-related content across subjects. Gutiérrez-Martín et al. (2010) and Castiñeira-Rodríguez et al. (2022) recommend integrating digital competence throughout the curriculum. Gabarda-Méndez et al. (2017) stress the need for practical ICT application in teacher education, bridging policy and practice.

Prospective research in digital teaching competences

Finally, addressing the fifth objective, the studies comprising the sample present areas for improvement in terms of research, aiming to address the shortcomings of current studies.

- Alternative methodological designs: mixed-methods studies including qualitative instruments (Alsanib, 2023; Castiñeira-Rodríguez et al., 2022; Grande de Prado et al., 2021; Mercader & Gairín, 2021; Pegalajar-Palomino, 2018), using digital competence rubrics as data collection instruments (Esteve-Mon et al., 2016), or conducting longitudinal studies collecting data at the beginning and end of the degree program (Mercader & Gairín, 2021).
- Changes in the sample: studies at various universities (Alnasib, 2023; Grande de Prado et al., 2021) at national or international levels (Esteve-Mon et al., 2016), or larger samples with more students from other majors or faculties to generalize results (Castiñeira-Rodríguez et al., 2022; Girón-Escudero et al., 2019; Martínez-Pérez et al., 2022; Pegalajar-Palomino, 2018). There is also a suggestion to expand to other educational groups such as future Secondary Education teachers (Gabarda-Méndez et al., 2017).
- Study of new variables related to digital teaching competencies: identifying which variables may influence the competency level of future teachers (Ahmad et al., 2016), teacher training specializations as a study variable (Alnasib, 2023), or investigating variables such as age, gender, and parental education (Castiñeira-Rodríguez et al., 2022).
- Other related study topics: research on ICT in the study plans of degrees prior to

university access (E.S.O and high school) (Castiñeira-Rodríguez et al., 2022), the responsible use of ICT (privacy, cybersecurity, bullying, etc.) (Gudmundsdottir et al., 2020), the application of T-MOOCs in training in digital skills (Martínez-Pérez et al., 2022), carrying out studies that measure the differences between perceived digital competence and real digital competence (Marimon-Martí et al., 2023; Mercader & Gairín, 2021) or research on digital competence and including educational practices (Pegalajar-Palomino, 2018).

Discussion

The systematic review shows that digital competences in prospective teachers is a relatively recent field of study that is increasing in the scientific literature especially in the last decade. The research results underline the relevance of digital competence in the educational context and for teaching and learning processes (Krumsvik, 2014; Ottestad et al., 2014).

The analysis of the research studies shows that digital competence is a prominent topic in Spain, conducted across various universities. However, there is a notable lack of comparative studies between countries, which would enrich the findings. Authors prefer quantitative experimental designs due to large sample access, but some (Castiñeira-Rodríguez et al., 2022; Girón-Escudero et al., 2019; Martínez-Pérez et al., 2022; Pegalajar-Palomino, 2018) acknowledge the challenge of generalizing results to other contexts. They suggest that future research should employ mixed-methods studies.

A common aspect among the analyzed works is that the majority of them make use of theoretical frameworks and definitions of the concept of digital competence that serve as a theoretical basis for the research and for the design of data collection instruments. In line with the classification by Cabero-Almenara & Palacios-Rodríguez (2020), the most popular frameworks among the studies are DigComp (Punie & Brecko, 2014) and DigCompEdu (Redecker, 2017). While it is true that in most cases authors choose to focus on only some of their domains.

The studies reveal that teacher digital competencies include both technical and pedagogical aspects, consistent with Esteve-Mon et al. (2020b) and Skantz-Åberg et al. (2022). While future teachers generally perceive their technical digital competencies as moderate to high, their skills in content design and the didactic use of ICT are lacking. Napal-Fraile et al. (2018) and Alastor et al. (2023a) note that, although students possess basic ICT skills, they lack knowledge for pedagogical application. Therefore, following Liesa-Orús et al. (2016), the literature calls for training education students in the pedagogical integration of digital tools. In terms of the study variables, the research reveals that the gender variable is one of the most studied variables along with digital competences, however, there is no unanimity in terms of the results. The results of the research, as established by Esteve-Mon et al., (2020) show gender disparities in terms of self-perceived digital competence, however, it is not always the case that there is a lower level perceived in women in all the research. Age, degree and entrance path are variables that also appear in the studies that make up the sample, however, they do so in isolation in some studies.

The research results offer proposals to improve digital competences. Despite being digital natives, students need educational support, as noted by Sánchez-Caballé et al. (2020) and Fernández-Robles & Duarte-Hueros (2023). Therefore, teacher training programs are essential, as highlighted by Instefjord & Munthe (2017) and Escolano-Pérez & Martín-Bozas (2023). Short- and medium-term measures suggested include training courses or seminars on digital competences and T-MOOC courses, similar to those mentioned by Brevik et al. (2019). However, most authors advocate for curriculum changes, subject modifications, and transversal ICT content integration, which are more complex and require policy measures and medium-term goals.

Future research should address current study limitations by using qualitative data collection methods to provide detailed insights into future teachers' perceptions. Increasing sample sizes and conducting comparative studies with other faculties or universities are also crucial. Additionally, as noted by Marimon-Martí et al. (2023) and Mercader & Gairín (2021), studies should measure actual digital competence and compare it with perceived competence. This is important because

many studies in the sample rely on self-perception, which may not accurately reflect the real digital competences that future teachers need in the classroom.

Limitations and Future Lines of Research

The limitations of the study are inherent to the methodology used for conducting systematic reviews, such as the exclusion of studies from the sample due to selected inclusion criteria or the databases in which the searches were conducted.

Regarding the research prospects, considering the characteristics and limitations of the studies included in the sample, there is a recognized need for conducting further studies such as the following: investigations with larger samples of students or from different universities, employing qualitative or mixed-methods designs, and focusing on measuring actual levels of digital competencies rather than perceived ones.

Conclusion

This research conducts a systematic literature review on the digital competencies of students preparing to become future teachers. The results reveal that there are five theoretical frameworks mentioned as foundations for developing research and designing data collection instruments, with DigComp being the most commonly used by researchers. Referring to the characteristics of the studies, those conducted in the Spanish context predominate in the last eight years, employing quantitative methodological designs with questionnaires as data collection instruments. The research findings indicate that, generally, the level of digital competence self-perceived by future educators varies between medium and high levels in technical areas of general use.

However, there are deficiencies in the didactic and pedagogical use of ICT and its application in learning. The literature offers two groups of action proposals for improving digital competencies: those that can be implemented at the faculty or university level and those involving curriculum modifications. Finally, there is a certain consensus among authors in proposing methodological changes, expanding samples, and including new study variables.

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Conflicto de intereses

Los autores declaran no tener ningún conflicto de intereses.

Contribuciones de los autores

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