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Systematic Review

Digital Teaching Competence: A Systematic Review

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Abstract: This systematic literature review aimed to discover how the concept of digital teaching competence (DTC) has been developed, how its dimensions have been defined, and how educational development models and models that evaluate teachers' digital teaching competence have been constructed. Concurrently, this review aimed to draw conclusions on the implementation processes of digital teaching competence in order to uncover its strengths and limitations, and to propose future lines of research to develop it further in initial teacher training programmes. A systematic literature review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology was proposed in order to achieve these aims. We chose the time frame of 2015 to the end of 2021 in an attempt to cover the appearance of the first scientific articles dealing with the subject, up until the present day. Thus, the inclusion criteria covered scientific research articles from the Web of Science (WoS) and Scopus databases, in English or Spanish, that focused on samples of teachers in primary education, secondary education, baccalaureates, and initial teacher training. The database searches, which will be detailed in depth later, initially provided a corpus of 127 articles, which was reduced to 26 articles after screening for duplicity and applying the inclusion criteria.

Keywords: digital teaching competence; systematic review; teacher training; integration; information and communication technologies

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1. Introduction

The process of digitalisation has been observed in every context in which modern human beings have developed (social, labour, political, communicative, economic, and educational contexts, among others). Due to this, it is worth asking how, in this process of transformation, new needs and demands of citizens have emerged in accordance with new circumstances where technology plays a core role, and where digital literacy is indispensable in order for citizens to fully develop in society. The idea that citizens need to be digitally competent arose in this context, leading the European Commission [1] to recommend a competence system that involves the establishment of eight key competences for lifelong learning. Digital competence poses a learning commitment for citizens, marking a turning point towards the acquisition of learning that encompasses a set of skills and knowledge that people should master in order to develop optimally in digital society [2].

Digital teaching competence (DTC), which refers to the skills, abilities, and knowledge that teachers must acquire in order to carry out their educational work, originated from the concept of digital competence. It has been developed in several countries around a common framework established by the European Commission [3], but its implementation is based on various development and evaluation models. Such a variety of models, paradigms, dimensions, and levels justifies the need for a literature review that will help researchers discover which models of DTC currently exist in the countries where it has been implemented, and how these models adjust to the particular circumstances and characteristics of

each territory. The analysis of the subject's scientific contributions will help us to discover which models are mainly used, as well as the particularities of this competence's adhesion to the training processes of practicing teachers or trainee teachers. Furthermore, it will reveal which models have been the most successful, which have expanded to other places, which instruments have been used, which methodologies are the most widespread, and how this competence has been evaluated. Additionally, based on the experiences reflected in scientific texts, we will discover the main aspects of the models that are applied to specific situations, and how the teachers perform these competences in their careers once they have acquired them.

In order to focus on the study of digital teaching competence, we selected a set of scientific articles to carry out this review. In order to achieve our aim of discovering how digital teaching competence is being implemented, how it is experienced, and what its results are, we needed to bring the studies of the selected articles together to obtain a panoramic view of the ways in which trainee teachers are learning about the educational technologies available to them and their role in the various learning scenarios. As such, the results obtained in this study provide a global vision that acts as a starting point for compiling the trajectory of digital teaching competence, as it was necessary to discover the extent to which political measures have influenced its implementation, in order to understand the models' typology, and to understand the training of both active and pre-service teachers. The compilation of experiences, articles and reports, among others, shows that the implementation of this competence has been eminently practical, as teachers have perceived both how useful it is and how vital it is that they adapt to the demands of the knowledge of society.

The literature reveals that there have been other systematic reviews concerning the subject, but they focus on specific aspects. Jiménez-Hernández et al. [4] focus on the models' typology, and point out that, despite there being several models, they seek to standardize the learning of competences, which has already offered brief positive insights into technology training for teachers. Other research studies, such as that of Lores Gómez et al. [5], allude to the training gap between the training demanded by teachers with respect to digital teaching competence and what they actually obtain in their training.

Others, such as the review by Romero-Hermoza [6], give an overview of this competence, with a focus on the theories and foundations of digital competences.

Evidently, it is necessary to study the current situation of digital teaching competence such that future teachers can start working, having overcome theoretical debates, discovered the existence of different models, and encountered practical experiences where the implementation of digital teaching competence has had a subsequent influence.

2. Method

In this study, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, http://www.prisma-statement.org/ accessed on 4 May 2021) (identifier registration number: DOI 10.17605/OSF.IO/P5KTG) method was implemented, building on the original Quality of Reporting of Meta-Analyses (QUOROM) guide for systematic reviews and meta-analyses. A systematic review consists of the compilation of a body of research according to previous inclusion criteria, with the aim of answering specific research questions [7]. According to Liberati et al. [8], the PRISMA statement consists of a 27-item checklist and a four-phase flow chart (Supplementary Materials). The checklist includes elements that are considered essential for reporting a transparent systematic review. The systematic review process applied in this study consisted of different phases [9]:

- Phase 1: Research questions (RQ). The questions were organized into three main areas: (a) the conceptual framework, to analyse the relationships between the keywords identified in the literature (RQ.1); (b) study characteristics, to identify the subjects, geographical location, educational levels included in the research, Q levels of the JCR and SJR journals, and research methodologies used (RQ.2–5); and (c) the strategic

dimension (RQ.6–9), to prioritize answering four major questions that lead to progress in the field of digital teaching competence.

- Phase 2: Inclusion criteria and sources of information. Articles published in scientific journals between January 2015 and November 2021 were included. Empirical studies with quantitative and/or qualitative and/or mixed methods were included. An inclusion criterion was that the samples should have been selected from among active teachers in primary and secondary education. Samples from trainee teachers were also included. The exclusion criteria applied were limited to the rejection of articles that were not open access, theoretical studies, studies related to non-formal and informal contexts, and studies related to university professors.
- Phase 3: Search strategies. The Web of Science (WoS) and Scopus databases were used for the article selection. In each of the databases, we used keywords to find articles that include in their title, abstract, or keywords the concepts "teacher digital competence", "digital teaching competence" and "competencia digital docente", in English or Spanish. Table 1 shows the search strings used in each database, the search date, and the number of articles obtained.

Table 1. Search table.

Database	Search String	Search Date	N
Scopus	TITLE-ABS-KEY ("teacher digital competence") AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011)) AND (LIMIT-TO (LANGUAGE, "Spanish") OR LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (PUBSTAGE, "final"))	16 November 2021	39
	TITLE-ABS-KEY ("digital teaching competence") AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE, "ar")) AND LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011)) AND (LIMIT-TO (LANGUAGE, "Spanish") OR LIMIT-TO (LANGUAGE, "English"))		30
	TITLE-ABS-KEY ("competencia digital docente") AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011)) AND (LIMIT-TO (LANGUAGE, "Spanish") OR LIMIT-TO (LANGUAGE, "English"))		18
WoS	TOPIC: ("teacher digital competence") Timeframe: 2016-2021. Index: SSCI DOCUMENT TYPE: AR. LANGUAGES: Spanish or English	4 November 2021	11
	TOPIC: ("digital teaching competence ") Time frame: 2016-2021. Index: SSCI DOCUMENT TYPE: AR. LANGUAGES: Spanish or English		29

- Phase 4: Study selection process. The initial search resulted in 127 articles, of which 38 were duplicates. We analysed the remaining 89 articles on the basis of the title and abstract, according to the inclusion–exclusion criteria. Once we agreed on the results, 49 articles were excluded because they did not meet the inclusion criteria. We independently analysed the remaining 40 articles in full, which resulted in 26 articles following the second selection process (see Figure 1).

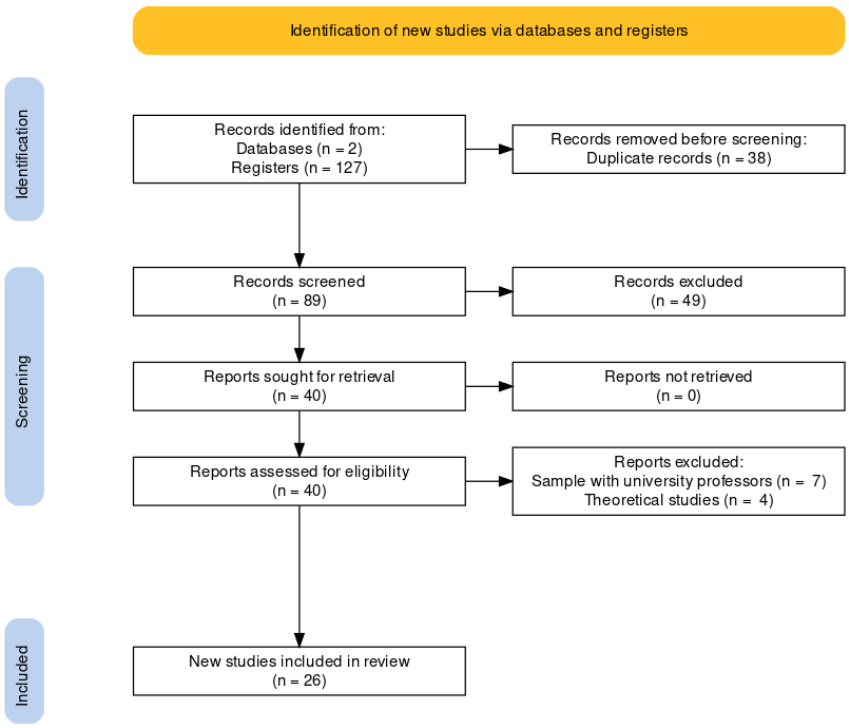

Figure 1. Study selection process flowchart.

The questions of the present review are compiled in Table 2 in order to specify the key areas, reflected in the selected articles, that the research questions seek to address.

Table 2. DTC areas, questions, and initial coding criteria.

Areas	DTC Research Questions (RQ)	Initial Coding
Conceptual framework	RQ.1. What conceptual network for the terms "teacher digital competence", "digital teaching competence" and "competencia digital docente" is extracted from the literature?	Co-occurrence map by keywords. Automatic coding and selection of nodes and sub-nodes.
Study characteristics	RQ.2. How are the articles distributed according to the type of journal and its position in the database (Q)?	Quartile of the journal and year of publication of the article.
	RQ.3. What is the geographic distribution of the study sample?	Country where the research is conducted.
	RQ.4. What research methodologies are used in the selected studies and, if applicable, what size are their samples?	Theoretical studies, quantitative, qualitative, or mixed research studies.
Strategic dimension	RQ.5. What are the dimensions that define DTC and how has it evolved? How is the concept defined?	
	RQ.6. What models of DTC assessment exist at the international level (political vision)? What typologies exist? Theoretical and/or practical?	
	RQ.7. How are such DTC models being implemented? What are the levels?	
	RQ.8. What DTC models exist for initial teacher training?	

3. Results

The results obtained from the study analysis are listed below, organized in such a way as to provide answers to each of the research questions.

RQ.1. *What conceptual network for the terms "teacher digital competence", "digital teaching competence" and "competencia digital docente" is extracted from the literature?*

This visual presentation (Figure 2) provides an analysis of the key concepts identified by viewing the clusters generated by the co-occurrence of the selected articles' keywords. One cluster identifies the concept of "digital competence" and its relationship with "teacher", "teacher education" or "expert proficiency", while another cluster includes the concepts of "teacher training", "educational technology" and "teacher digital technology". Different terminologies that refer to the same concept were observed in this co-occurrence of words, which helps us understand how different research scenarios and socio-cultural constructions coexist and—through social labelling—how they enrich the search.

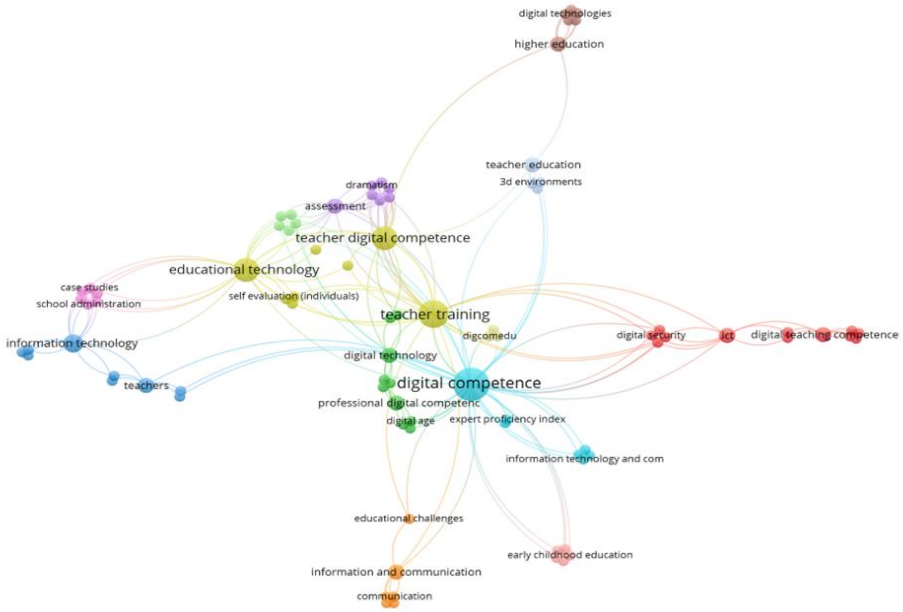

Figure 2. Co-occurrence of the keywords in the set of articles (frequency = 1).

RQ.2 *How are the articles distributed according to the type of journal and its position in the database (Q)?*

The following graph (Figure 3) shows that 73% of the selected articles are found in Q2 and Q3 journals in the WoS and Scopus databases, being indexed to a greater extent in the WoS database (58%). It is important to note that most articles in Q1 and Q3 journals belong to the Scopus database, while articles in Q2 and Q4 are mostly indexed in the WoS database. In total, 25 articles with an assigned quartile (Q) were counted, of which 50% belong to the WoS database, 46% belong to the Scopus database, and 4% correspond to articles that are currently indexed in the WoS database without a quartile assignment.

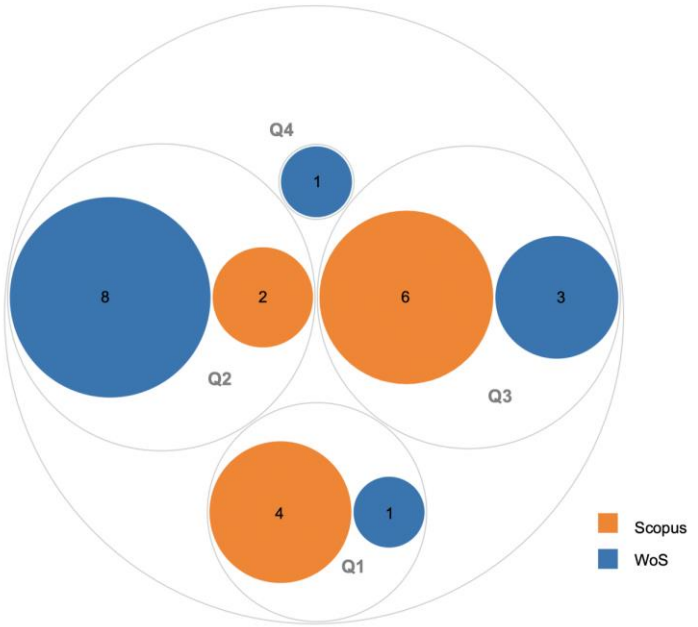

Figure 3. Graph of the quartile of the journals included in the review.

RQ.3. *What is the geographic distribution of the study sample?*

Of the studies identified in this review period, 18 (70%) of them are research studies with samples collected in Spain. Two of the articles combine samples collected in Spain and France, and Spain and Latin American countries; one study was conducted in Portugal; one was collected in Sweden, Norway and New Zealand; one was collected with a Swedish and Norwegian sample; and, finally, one study worked with a Chilean and Uruguayan sample. Therefore, it can be concluded that most of the studies selected in the last six years were carried out with Spanish samples. There are collaborations between Spain and Latin American countries, and some studies from Northern Europe—mainly Sweden and Norway—and New Zealand.

RQ.4. *What research methodologies are used in the selected studies and, if applicable, what size are their samples?*

The studies included in the review mainly used a quantitative methodology in which data collection was carried out using a questionnaire. Ad hoc methodologies were constructed to validate digital competence content in general terms. A very small number of studies used qualitative methodologies in which group discussion—as a technique for collecting information—and Delphi-based expert judgement predominate. One study that used 3D simulation as a methodology to assess digital competence performance was identified. The vast majority of the questionnaires were based on the construction of Likert-type scales, in which the teacher and/or the student in their initial training stage expressed their self-perception of their digital competence.

RQ.5. *What are the dimensions that define DTC and how has it evolved? How is the concept defined?*

Mostly, the articles reviewed that refer to studies conducted in Spain or other Spanish-speaking countries [10–14] assume the Common Framework of Digital Competence for Teachers prepared by the National Institute of Educational Technologies and Teacher Training [15] as a reference (Table 3). This document establishes the composition of DTC, structured into five competence areas and 21 competences that make up these areas. In addition, six progressive competence levels of performance are established.

Table 3. Competence areas and competences.

Competence Areas	Competences
Area 1. Information and data literacy	Competence 1.1. Browsing, searching and filtering data, information and digital content Competence 1.2. Evaluating data, information and digital content Competence 1.3. Managing and retrieval of data, information and digital content
Area 2. Communication and collaboration	Competence 2.1. Interacting through digital technologies Competence 2.2. Sharing information and digital content Competence 2.3. Citizen participation online Competence 2.4. Collaborating through digital technologies Competence 2.5. Netiquette Competence 2.6. Managing digital identity
Area 3. Digital content creation	Competence 3.1. Developing digital content Competence 3.2. Integrating and reelaborating digital content Competence 3.3. Copyright and licenses Competence 3.4. Programming
Area 4. Safety	Competence 4.1. Protecting devices Competence 4.2. Protecting personal data and privacy Competence 4.3. Protecting health Competence 4.4. Protecting the environment
Area 5. Problem-solving	Competence 5.1. Solving technical problems Competence 5.2. Identifying technological needs and responses Competence 5.3. Innovation and use of digital technologies creatively Competence 5.4. Identifying gaps in digital competence

Thus, the study conducted by Silva, Usart and Lázaro-Cantabrana [16], on a sample of final-year pedagogy students from Chile and Uruguay, used a model proposed by Lázaro and Gisbert [17], conceived under [15] framework. This proposal established four dimensions of DTC (curricular, didactic and methodological; planning, organisation, and management of digital technology spaces and resources; ethical, legal, and safety aspects; and personal and professional development).

Studies in European countries, such as Portugal [18], used the European Digital Competence Framework for Educators as a reference. However, in studies referring to initial teacher training populations in European countries, such as Sweden and Norway [19,20], they used the Technological Pedagogical Content Knowledge (TPACK) model as a reference. In the case of Viberg et al. [20], the Unified Theory of Acceptance and Use of Technology (UTAUT) model was used to establish the assessment factors for digital technology learning (usage skills; influence and social support; intention of use; usefulness and efficiency; awareness of limits; pedagogical potential; and safety awareness).

The study conducted by Starkey [21] on a sample of trainee teachers undergoing initial teacher training in New Zealand used the TPACK model, which presents three key components for adequate digital teaching competence: content, pedagogy, and technology [22]. The UTAUT model, for its part, establishes four main components that determine usage behaviour (performance expectation, effort expectation, social influence, and facilitating conditions).

The concept of digital teaching competence, in general, is understood as the set of skills and abilities that teachers have or should develop in order to methodologically incorporate technologies in the classroom. Tourón et al. [10] define digital teaching competence as a:

> ... set of skills and abilities that lead us to incorporate—and properly use—information and communication technology (ICT) as a methodological resource that is integrated into the teaching-learning process, thus becoming Learning and Knowledge Technologies with a clear didactic application.

Similary, Lázaro, Usart, and Gisbert [23] define digital teaching competence as a "set of skills, abilities and attitudes that teachers must develop in order to incorporate digital

technologies in their teaching and their professional development". These last authors, in previous definitions also used in the study by Girón-Escudero and collaborators [11], understood digital teaching competence as the need of the teacher to acquire these competences that will enable them to make adequate use of technologies in the classroom, positively influencing the learning of their students. Krumsvik et al. [24] point out that this is an individual capacity of the teacher, thus differentiating it from the capacities or skills that a teacher is understood as possessing, associated with the training that should be offered to them by their initial teacher training.

On the other hand, in studies such as that of Viberg et al. [20], the definition adopted does not refer directly to the use of technology in the classroom by the teacher; rather, it refers to learning in general, and to understanding today's society. Nevertheless, teacher training is defended as the backbone of DTC, as it affects the teachers' disposition and attitude towards the integration of ICT in the classroom.

RQ.6. *What models of DTC assessment exist at the international level (political vision)? What typologies exist? Are they theoretical and/or practical?*

The implementation of this competence in educational systems is mainly due to the fact that the world of future students will be eminently technological, and they will need competences that will help them understand and develop in new social, educational, cultural, and labour-related scenarios. Therefore, being digitally competent means improving the quality of educational processes. In fact, the European Commission [3,25] found digital competence to be an essential competence for the active participation of citizens. Based on this, different models should enable teachers to train their students in this competence.

The data collected allow us to observe that there is no single or principal model for the implementation of digital teaching competence. However, there are other—more circumstantial—typologies adhering to the different contexts in which DTC is applied. Most of the existing models come from Europe and, to a lesser extent, North America. Some of these models—as pointed out by Cabanillas García, Luengo González, and Torres Carvalho [26]—are the TPACK model [27,28]; the Norwegian model [29–31]; the ISTE Standards for Educators; NETS-T [32], which was developed in the United States; and European documents such as the ECD-ICT Project [33], the AMI Curriculum, and the national models such as European Digital Competence Framework for Educators [34] and the Spanish model [15]. Although these models articulate digital teaching competence to some extent, not all of them develop it in a complex manner. Lázaro, Usart, and Gisbert (p. 74, [23]) summarize the main models in Table 4**.**

Table 4. Reference frameworks and models of digital teaching competence.

Reference Model	Institution	Reference	Areas or Dimensions of DTC
UTAUT	University of Maryland	[35]	This theory states that there are four key constructs: (1) performance expectancy, (2) effort expectancy, (3) social influence, and (4) facilitating conditions.
ICT standards for initial teacher training (ITT)	Ministry of Education, Chile	[16,36]	Pedagogical, technical, school management, social, ethical, and legal aspects of development.
NETS-T	ISTE	[32]	Student learning and creativity, learning experiences and assessment, work, citizenship, and professional growth.
ICT competency standards for teachers	UNESCO	[33]	Policy and vision, syllabus and assessment, pedagogy, ICT, organisation and administration, teacher training.
TPACK	Michigan State University	[22]	There are three areas in this model: the disciplinary or content area that they base their teaching on, the pedagogical area, which includes the different methodologies or ways of teaching that they apply in the classroom, and the technological area (TK), which includes the technological resources and tools they use to teach different content.

Table 4. *Cont.*

Reference Model	Institution	Reference	Areas or Dimensions of DTC
Teachers' ICT competences	Ministry of Education, Chile	[37]	Pedagogical, technical, managerial, social, ethical, legal, and professional development.
DigiLit Leicester	Leicester City Council	[37]	Searching, evaluation and organisation, creating and sharing, evaluation and feedback, communication, collaboration and participation, safety, identity, and development.
ICT competences for professional teacher development	Ministry of National Education, Colombia	[38]	Technological, communicative, pedagogical, management, and research.
Common Framework of DTC	Ministry of Education, Government of Spain	[15,39]	Information, communication, content creation, safety, problem-solving.
COMDID	ARGET, Rovira and Virgili University	[17]	Didactic, curricular and methodological; planning, organisation and management of digital technological resources and spaces; relational, ethical, and safety; personal and professional.
DTC definition	Government of Catalonia	[40]	Didactic design, planning, and implementation; management of digital technological resources and spaces; communication and collaboration; ethics and digital citizenship; professional development.
DigCompEdu	European Commission	[34]	Social and professional engagement; digital resources; digital pedagogy; assessment and feedback; training of students; facilitating students' digital competence.

Sources (adapted from): Lázaro [23] and Gisbert [17].

The different general reference frameworks are drawn up from perspectives that contain some interesting aspects, as explained below.

The first models and reference frameworks serve to establish the structure of digital teaching competence. It can be observed that while ICT Standards for ITT [36,41] and NETS-T [32] focus on dimensions such as citizenship, personal growth, and learning processes, UNESCO's [33] ICT Competency Standards for Teachers focus on providing dimensions related to the management of this competence from a broad perspective, which is transferable to different educational contexts.

The DigiLit Leicester model [37] adds dimensions related to the culture of collaboration and sharing data and knowledge, which are typical of the philosophy of free software and the creation of open materials.

The DigCompEdu model [42] points out the digital competences that a current teacher must possess and know how to put into practice in order to optimally exercise their professional activity. This model serves as a reference for variants to be developed, starting from the same premises and with the same objectives, such that variant models share a common thread [23].

In Spain, the main model is INTEF [15], which defines digital teaching as a competence that teachers must acquire in order to improve their praxis, and as a competence that must be continuously developed during their careers. Acquisition is evaluated on the basis of the dimensions, indicators, and levels of competence development expressed in a rubric. However, in regions such as Catalonia, there is an adapted model [40] in which digital teaching competence is approached as the teacher's ability not only to apply this competence but also to transfer aspects such as knowledge, skills, strategies, and attitudes to a real learning context related to their career [23].

It can be pointed out that although all of the reference frameworks start from a theoretical basis, they appear to have been implemented in the documents that we have found, thus leading us to believe that the models have been implemented over the years. Some models recur in successive research studies, while others disappear after their theoretical exposition. All of them show a kaleidoscopic framework in which—in spite of the different versions—a common training model is sought.

RQ.7 *How are such DTC models being implemented? What are the levels?*

In carrying out this review, we detected that there is no single specific model for the implementation of digital teaching competence, i.e., we found that the vast majority of authors conduct evaluation studies—mainly with self-perception questionnaires—with instruments which are designed ad hoc or validated to obtain conclusions.

In Spain, INTEF's Common Digital Competence Framework for Teachers—based on the European DigCompEdu model—is assumed as the model that will guide the training and evaluation of digital teaching competence. Based on this model, researchers created and validated a self-perception instrument that they submitted for consideration in different samples. Studies consider this procedure as a limitation, as the subjects may be influenced by social-desirability biases when answering self-perception questionnaires, which will predominate over authentic, honest, and realistic personal evaluations, as would be expected. Furthermore, it has been indicated that the assessment of digital competence is a complex process, and reducing it to the use of a single instrument is a limitation in itself [23]. According to the study by Lazaro-Cantabrana et al. [23], it is better to propose models of competence assessment—rather than self-assessment—through performance questions.

However, the proposal by Krumsvik et al. [24] includes a model (Figure 4)—obtained from several decades of research on what is referred to as the journey of digital teaching competence—which includes the stages of adoption, adaptation, appropriation, and innovation. Usually, in the first two stages, the teacher focuses their attention on the acquisition of artefactual technological skills. In the following stages of the journey, the teacher mentally assesses the value of the real possibilities of using their professional competence and authority so as not to be interrupted by technical obstacles. It is only at this point that the teacher realizes the need to acquire a higher level of knowledge.

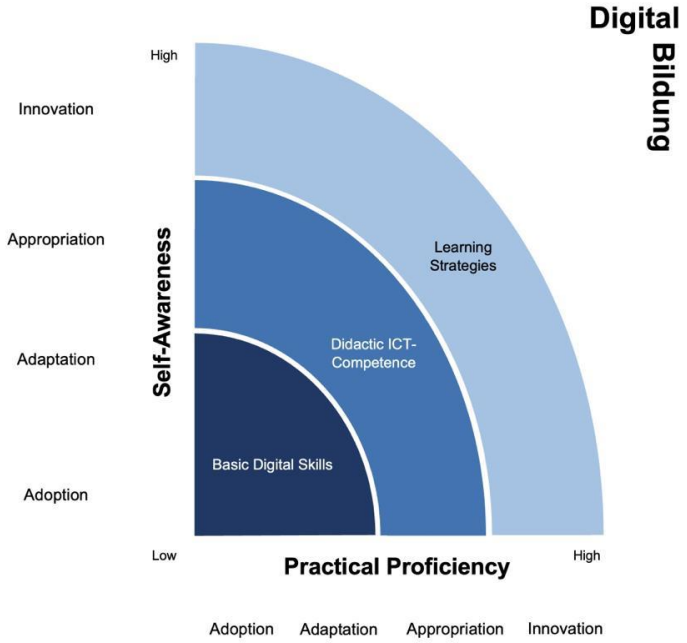

Figure 4. Adapted from Krumsvik et al.'s [24] model of the transition and development of digital teaching competence.

Elementary digital skills refer to fundamental technical skills, such as being able to use PCs, laptops, tablets, and cell phones as a teacher. The second category, basic digital skills, means that the teacher must be able to handle administrative and thematic tools for teaching in schools, such as e-mail, a Learning Management System (LMS), interactive whiteboards, and digital teaching aids, etc. The third category, didactic ICT competence, is related to the pedagogical use of digital teaching aids by teachers in the classroom. The

new digital learning strategies used before, during, and after teaching in the classroom can enhance the ways in which teachers teach and students learn.

RQ.8. *What DTC models exist for initial teacher training?*

Training competent teachers in digital environments is urgent and necessary in the current global context, where digitalisation is a trend in every sector, including education. Although great efforts have been made in recent years to advance, the truth is that we are sometimes overwhelmed by the rapid advancement of technologies and their impact on teaching. Hence, it is necessary to study this issue broadly, considering that new advances in digital technologies have the potential to change teachers' work [21].

The European Commission [25] highlights the fact that digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, working, and participation in society. On this basis, it is understood that today's teachers must be prepared to train citizens in the use of digital technologies as a natural part of their daily lives [23], linking the skills and competences acquired in the digital era with the optimal development of their personal and professional careers [43].

In order to move forward with some existing models for the development of digital teaching competence in initial teacher training, first of all, we highlight the Government of Catalonia's model [40], which indicates that DTC is:

> ... the ability of teachers to apply and transfer all their knowledge, strategies, skills, and attitudes regarding learning and knowledge technologies to real and concrete situations in their career, with the aim of (a) facilitating student learning and the acquisition of digital competence; (b) implementing processes of improvement and innovation in teaching in accordance with the needs of the digital era; and (c) contributing to their professional development in accordance with the processes of change occurring in society and in educational centres. [23]

For this purpose, they constructed an instrument (COMDID-C) with the objective of evaluating the DTC of trainee teachers in initial teacher training.

Secondly, the TPACK model—or the technological, pedagogical, and content knowledge model—proposed by Mishra and Koehler [27] should be highlighted. This model emphasizes the ability and capacity to select, critique, and use ICT applications in teaching, and focuses on preparing the teacher to teach in a teaching–learning context in which digital technologies are integrated, and in which both the teacher and the learner use the technologies. However, some of this model's limitations are related to the fact that it rarely specifies technological, pedagogical, and content knowledge. For example, for the technological knowledge, it is possible to explore the perception of trainee teachers regarding issues such as mastery in the use of presentation software, word processors, spreadsheets, image capture, internet searches, online file management, online communication, the use of simulation software, and interaction with the digital whiteboard. Pedagogical knowledge also varies [21], from how to use technology to replace learning tools to how to implement new digital pedagogies or evaluate student participation. Masoumi [19] recommends exploring the TPACK model and reinforcing the development of digital competence in teacher training programmes.

In order to effectively integrate digital technologies in education, Viberg et al. [20] propose an instrument to measure teacher training in the use of ICT for teaching and learning. This instrument is made up of a series of items that were established and developed on the basis of the UTAUT and the TPACK model. It aims to measure the (self-perceived) DTC of teachers as an attitudinal aspect of their digital competence, in order to integrate technology in their classrooms through seven factors: (1) skills to use digital technologies for learning; (2) social influence; (3) intention to use; (4) usefulness and efficiency; (5) perceived limitations; (6) pedagogical potential; and (7) perceived assistance. The results reveal that the UTAUT model has four key constructs that are important for the assessment of teacher training regarding the essential use of ICT in education as a part of their digital competence, which are also related to teacher behaviour: performance

expectancy, effort expectancy, social influence, and facilitating conditions. Although this model is implemented with secondary school teachers, it could be transferable to the field of initial teacher training in order to build more personalised training itineraries in higher education, based on the self-perception of trainee teachers regarding the use and integration of technology in teaching practice.

Starkey [21] goes a step further, and develops a detailed literature review of the last ten years, focusing on key issues such as the digital competence of trainee teachers, the integration of technology in teaching practice, the personal characteristics of teachers, and the pedagogical practices of teacher trainers, as well as considering the views of trainee teachers, teachers, and the information contained in initial teacher education programmes. In this way the Professional Digital Competence model emerges [44], which originated in Norway and emphasizes three key aspects: technological competence, pedagogical compatibility, and social awareness. Social awareness is the teacher's understanding of and ability to negotiate the social aspects of school culture [21]. This model is based on the notion that a teacher needs to be able to negotiate and solve problems in order to successfully integrate digital technology into teaching and learning.

4. Discussion and Conclusions

The aim of this review was to discover the current state of research on the concept of digital teaching competence and the assessment of its levels and dimensions. To this end, a systematic review was carried out, which allowed us to propose and answer a set of nine research questions on the concept of digital teaching competence, its dimensions, national and international models of both in-service and pre-service teacher training and evaluation, and the strategies implemented to develop and evaluate it.

Firstly, the main findings of this systematic review concern the conceptual network that emerges from the selected articles. We presented a dispersed, focalised network of which the main dimension seems to be biased by the number of articles identified using a Spanish sample. This imbalance was foreseen due to the great interest of the Spanish scientific community in the assessment of the level of digital competence of in-service and pre-service teachers.

Secondly, this review provides a description of the main working models to assess the level of digital teaching competence achieved, with a view to implementing and developing digital teaching competence in active and pre-service teachers. A high percentage of studies opt for quantitative rather than qualitative research methodologies [45]. Quantitative research is carried out using self-perception models, such as Likert scales, with perception items in their instruments (e.g., [46]), to a greater extent in comparison with studies that, despite being quantitative, base their research paradigm on an evaluative model of competence performance that uses graduated items on a Likert-type scale (e.g., [18]).

The conclusions obtained under self-perception models pose a problem when interpreting the results, as all of the value is given to the subject who self-evaluates (or who self-perceives their level of performance). This value must be taken lightly, as the subject who responds may be (unintentionally) biased, such as dissonance between the self-perceived value and the real value (undervalued or overweighted) and/or social-desirability bias. Esteve-Mon et al. [47] 3D virtual system was highlighted as a comprehensive mixed methods model for the assessment of digital teaching competence.

Thirdly, it is important to highlight that, from the articles selected, only two ([19,21]) focus on offering a model that serves to rethink initial teacher training programmes at the university level. Therefore, these two models show that it is essential that trainee teachers receive didactic–pedagogical training in the use of technologies for learning, are aware of the importance of integrating technology in their careers, develop teaching–learning strategies with technology, and have a favourable attitude towards them. In other words, the development of the digital competence of trainee teachers in teacher training programmes can be seen as a process that enables trainee teachers to think about, interact with, and implement technological knowledge in future educational practices. This characterisation

aligns with Mishra and Koehler's [27] TPACK framework, which identifies multiple intersections between the core domains of basic knowledge that teachers put into practice: content, pedagogy, and technology. Therefore, it is necessary to educate trainee teachers on why they need to develop a rich learning environment where technological, pedagogical, and content knowledge interact, such that they understand why digital technologies are important, and how and when they can integrate them into educational practice.

The existing models are numerous, and all originate from needs that were detected. However, it is intended that the main lines of work become unified in order to obtain the same training and become competent in educational technology [4,48,49]. Based on this, models have incorporated elements from new models over time.

It can be observed that the different models aim to improve teacher training in the use of technology in different educational scenarios and, thereby, to improve the training standards of practising teachers and trainee teachers [50]. Therefore, the creation of an extensive, standardized model is sought that will somehow influence educational policies by demanding more training [11] and tools.

Finally, carrying out this review—through the overall discussion and conclusions—has made it possible to identify the critical aspects of the implementation, development, and evaluation of DTC in initial teacher training. On the one hand, the instrumental value of the research we have analysed stands out. Educational experiences, reflection processes, and the integration of artefactual technology prevail over training approaches that underestimate the aspects of digital citizenship, safety, or pedagogical knowledge, which are subjects that are not addressed in initial teacher training. Fallon [50] picks up on these trends and flags the abandonment of only implementing artefactual training systems that limit the development of digital competence in trainee teachers, as opposed to the simple development of their technological literacy.

The results of this systematic literature review allow us to conclude that there is a growing interest in the important task of developing the digital competence of pre-service and in-service teachers through training and assessment models. This development must be accompanied by a balanced system of in-service teacher training. As training actions are implemented that are aimed at understanding the development of teachers' digital competence, they must be accompanied by teacher performance observation, an adapted development of emotional competence, and a deep analysis of the social dynamics associated with the use of technology. We appeal to policymakers in order to inquire about training alternatives to the systems of continuous training that teachers have become accustomed to, and to design plans that advocate for training activities to be experiential, continuous, and comprehensive. In comparison with the current fragmented model, we propose an ambitious approach in which teachers transfer training directly to the classroom, without carrying out processes of reflection, critical assessment, or studying the implementation of models—which, until now, they have developed almost exclusively. Therefore, all of the the social actors involved in the development of the digital competence of trainee teachers should reflect, with the evidence in hand, and give this development the attention it deserves as a key turning point for future generations.

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