

Assessment of Digital Teaching Competence: Instruments, results and proposals. Systematic literature review

Evaluación de la Competencia Digital Docente: instrumentos, resultados y propuestas. Revisión sistemática de la literatura

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ABSTRACT

Teaching digital competency challenges the professional field of teachers. It also is an identified problem in the research attempting to answer particular questions. Specifically, the evaluation of digital competency in teaching (DCT) is crucial for making decisions regarding teacher training and future lines of research. Taking this challenge as a focus, this article aims to provide an updated overview of the tools used in teachers' digital competency evaluation processes. Our investigation focused on the research design, instruments, and analyses

used, the results obtained after its application, and its implications. The study involved a systematic review of the literature, following the guidelines set out in the PRISMA declaration, analyzing a sample of 66 articles published between 2017 and February 2022 in journals indexed in the Web of Science and Scopus, in which the DCT was evaluated. The results showed medium and low levels of diagnosed DCT and offered evidence that assessing DCT improves its effectiveness. Likewise, the results showed that researchers worldwide follow the European DIGCOMPEDU framework and the Spanish framework proposed by INTEF. However, it is common for researchers to develop their instrument to assess DCT with a self-assessment questionnaire in most studies. However, many recommended complementing the DCT with other qualitative tools to assess its actual and perceived levels. The conclusions were that researchers agreed on two fundamental aspects: to increase teacher training in digital competency and to progress in research designs that allow verifying how the DCT level improves through training proposals contextualized in specific educational stages or types of teaching.

Keywords: digital teaching competency, measurement instrument, teacher training, educational research, technology, educational innovation

RESUMEN

La competencia digital docente es un reto en la práctica profesional del profesorado y un problema identificado en la investigación al que dar respuestas. En concreto, la evaluación de la CDD es un elemento clave para tomar decisiones respecto a la formación de los docentes y a futuras líneas de investigación. Tomando este reto como foco, el objetivo de este artículo es proporcionar un panorama actualizado sobre las herramientas utilizadas en los procesos de evaluación de la competencia digital de los docentes, indagando en el tipo de diseño de investigación, instrumentos y análisis utilizados, así como los resultados obtenidos tras su aplicación y sus implicaciones. El estudio realizado se aborda desde una revisión sistemática de la literatura, siguiendo las directrices marcadas en la declaración PRISMA, con una muestra de 66 artículos publicados entre 2017 y febrero de 2022 en revistas indexadas en la Web of Science y Scopus, en los que se evalúa la CDD. Los resultados obtenidos muestran niveles medios y bajos de CDD diagnosticados y ofrecen evidencias de la relevancia de la evaluación de la CDD para su mejora. Así mismo evidencian que el marco europeo DIGCOMPEDU y el español propuesto por el INTEF, son seguidos por investigadores de todo el mundo. Sin embargo, es una práctica habitual que los investigadores elaboren su propio instrumento para evaluar la CDD, siendo el cuestionario de autoevaluación el utilizado en la mayor parte de los estudios, al tiempo que se recomienda complementarlo con otras herramientas cualitativas para evaluar el nivel real adquirido. Las conclusiones ponen de manifiesto que los investigadores coinciden en reclamar dos aspectos fundamentales: aumentar la formación docente en competencia digital y avanzar en diseños de investigación que permitan comprobar cómo mejora el nivel CDD a través de propuestas formativas contextualizadas a la etapa educativa o tipo de enseñanza.

Palabras clave: competencia digital docente, instrumento de evaluación, formación docente, investigación educativa, tecnología, innovación educativa

INTRODUCTION

Digital competency in teaching offers a substantial area for innovation and transformation in education. This work aims to provide scientific evidence to support progress in evaluating digital competency in teaching (DCT) as one of the necessary lines of research, as suggested by Cabero-Almenara and Palacios-Rodríguez (2020), to improve the level of DCT at any educational stage. The literature review aimed to exhaustively identify research published between 2017 and February 2022 whose focus was the evaluation of DCT, to inquire about the type of research design followed in the studies, the characteristics of the instruments used, and to know the results and the implications of their analyses.

DCT encompasses various conceptualizations. The European Commission, for example, defines digital competency as the set of essential knowledge, skills, and attitudes to guarantee the safe and critical use of Information Society Technologies (IST) for work, leisure, and communication. It is based on basic ICT skills with the computer used to obtain, evaluate, store, produce, present, exchange information, and communicate and participate in collaborative networks through the internet (European Parliament, 2016). On the other hand, Gisbert Cervera et al. (2016) defined DCT as a new set of skills and knowledge that must guarantee excellence in professional practice and support student learning in the digital world. Close to these conceptions, Gudmundsdottir and Hatlevik (2018) saw it as necessary in a reality where resources and digital media are part of daily educational practice.

The European Commission's concern about improving citizens' digital literacy is worth noting. It launched the Digital Education Action Plan for 2021-2027, aiming to increase the proportion of European citizens with digital skills to 70% by 2025 (European Commission, 2021). They highlighted the teacher as responsible for their students' digital literacy (García-Ruiz & Pérez Escoda, 2021; Redecker & Punie, 2017). DCT, in the last decade, and notably as of 2020, has been recognized as one of the core competencies for the exercise of the teaching profession at any educational level (Dervenis et al., 2022; Fernández-Luque, 2021).

Various international institutions have proposed models and conceptual frameworks to develop DCT (Barbazán et al., 2021; Caena & Redecker, 2019; Pérez-Escoda et al., 2019), allowing various research groups to analyze DCT with tools inspired by them. At different contextual levels, there is the UNESCO ICT Competency

Framework for teachers and the European Digital Competency Framework for Teachers (DigcompEdu). At the national level, we found the Common Framework for Digital Teaching Competency in Spain, the ICT Competency Model for professional teacher development in Colombia, the Model of ICT Competencies and Standards for the teaching profession in Chile, and the Digital Teaching Framework in the United Kingdom. Likewise, other organizations and researchers have contributed essential models such as the ISTE Standards for Educators of the International Society for Technology in Education or the T-PACK model. Caber et al. (2020a) highlighted the models' commonality of working with competencies, criteria, and descriptors, in addition to profiling each standard to determine how to use and integrate ICT, identify needs, and define personalized training itineraries.

Previous literature reviews focused on DCT, from which it has been possible to understand the scope and the need to improve this competency in teachers. Research and literature reviews focused on DCT in higher education stand out relevantly (Barbazán et al., 2021; Basilotta-Gómez-Pablos et al., 2022; Durán et al., 2016; Esteve-Mon et al. al., 2020; Farias-Gaytan, 2021; Sillat et al., 2021), with few focused on other educational stages (Fernández-Batanero, 2021).

The review carried out by Pinto et al. (2022) on the development of DCT in initial teacher training, based on research published between 2009 and 2019, highlighted the significant increase in publications in the last decade, especially those derived from research in which the results of the evaluation of this competency are shown. Along the same lines, Saltos-Rivas et al. (2021) pointed out a considerable increase in research that aimed to evaluate DCT in higher education since 2010.

Most of these publications highlighted the need to improve teacher training in digital competency for current teachers and teachers in training (Melash et al., 2020). They also recommended expanding research on DCT to guarantee the effectiveness of this training (Gisbert Cervera et al., 2016; Guillén-Gámez and Mayorga-Fernández, 2020), discover which factors positively affect its improvement, and reduce those that generate dysfunctions (Frolova et al., 2020).

Given this prolific DCT research productivity of research, the absence of literature reviews regarding how DCT is evaluated, what information collection instruments exist, or the results obtained in the various studies is striking. Thus, this work has been undertaken from a systematic review of the literature considering the databases of the most prestigious scientific journals.

This work focuses on knowing which digital competency frameworks have been considered by researchers to carry out their studies, taking as references the European framework DIGCOMPEDU (European Commission, 2017) and the Spanish (INTEF, 2017), in force until its update in May 2022. The motivations that drive the interest in these frameworks coincide with the proposals of the study by Cabero et

al. (2020b), being endorsed by experts as the most internationally transcendental, also serving teachers to know what digital skills they should develop.

From this context, the objective was to review the most relevant scientific literature on the evaluation of DCT in three areas of research:

- Research area 1. Identify research focused on assessing DCT and its quality indicators concerning the journals in which they were published.
- Research area 2. Describe the research methods used to assess teachers' DCT.
- Research area 3. Analyze the evaluations of the DCT and the experts' recommendations.

METHOD

This study provides a synthesis of DCT assessments based on the systematic review of the literature that takes the PRISMA 2020 (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) standards as a reference. To answer specific research questions, we used this updated guide to direct the review process in identifying information sources, eligibility criteria, search strategies, study selection, data analysis, and the systematization of the findings (Kitchenham et al., 2010; Yepes-Núñez et al., 2021).

Phase 1: Research questions

In Table 1, the research questions have been structured according to the three areas previously described.

Table 1
Research questions associated with the areas raised

Research fields	Research questions
Research field 1	Q1. What is the distribution of articles in the WOS and SCOPUS databases between 2017 and February 2022 published in the best-ranked journals in JCR, SSCI, and SJR? Q2. What is the temporal and geographical distribution of these items?
Research field 2	Q3. What types of research designs are carried out to assess DCT? Q4. What characteristics do the samples of these studies have? Q5. What are the peculiarities of the tools used to assess DCT? Q6. What types of analyzes do these studies perform?

Research fields	Research questions
Research field 3	Q7. What were the main contributions of the studies to knowledge evaluation of DCT based on the results obtained? Q8. What were the implications and recommendations of these studies for future research?

Phase 2: Information sources and eligibility criteria

The two most prestigious databases, Web of Science (WOS) and Scopus, were consulted to search for the studies. The search was confined to studies that contained the descriptors in the title, abstract, or keywords, were open access and in article format, written in English and Spanish, and belonged to the area of educational sciences in WOS or social sciences in SCOPUS. In the case of WOS, studies from the entire collection of databases were included. The time frame established was from 2017 to February 2022 because it coincided with the publication of the European Framework for the Digital Competency of Educators DigCompEdu (Redecker & Punie, 2017) and with the increase in studies on DCT assessment in both databases (Sillat et al., 2021).

Phase 3: Search strategies

For the search of the studies in the databases, the most used keywords in the scientific literature on this subject were established, considering the research questions. They were the following: digital competency, digital teaching competency, evaluation, assessment, educator, teacher, lecture, preservice teacher, teacher training, and future teacher. Based on these terms and the use of different Boolean operators, the following search equation was designed in both databases: (“digital competency” OR “digital teaching competency”) AND (evaluate* OR assess*) AND (educator* OR teacher* OR lecturer* OR “preservice teacher*” OR “teacher* training” OR “future teacher*”).

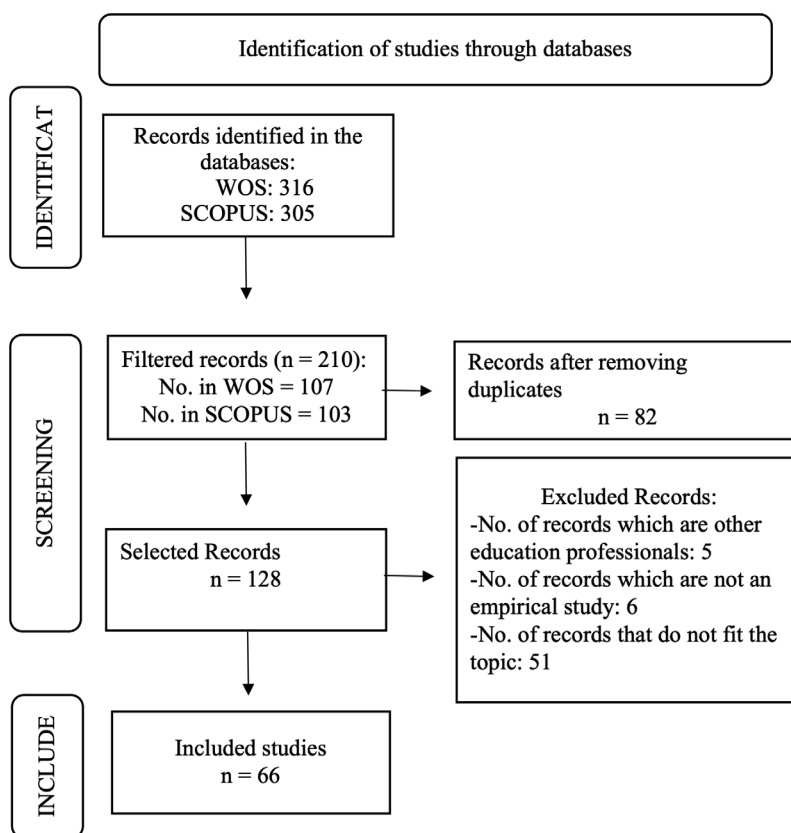
Phase 4: Selection process

Applying the eligibility criteria and the search equation in both databases resulted in 210 articles, of which 82 were duplicates. The remaining 128 were screened by reading the title and abstract (in the case of not being clear, the full text was read); the exclusion criteria were other education professionals (education

inspectors and social educators); studies that were not empirical; and studies that do not involve this topic. This screening process resulted in the selection of 66 articles (Figure 1).

Figure 1

Flowchart of the study selection procedure per PRISMA



RESULTS

The presentation of the results of the systematic review of the literature was structured per the different research questions. The results emanated from a content analysis of the articles (referenced in Table 2 at <https://doi.org/10.6084/m9.figshare.21125797>) based on the three areas outlined for this study.

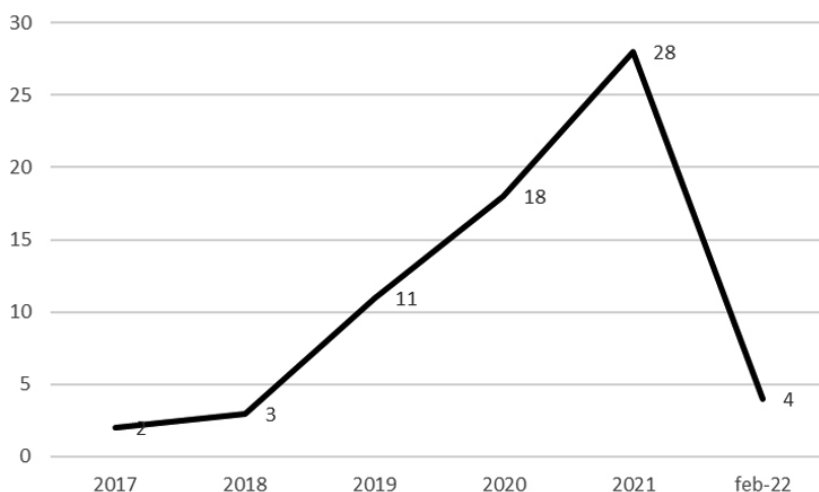
Research area 1. Identify research focused on assessing DCT and its quality indicators concerning the journals in which they were published

The total number of articles satisfying the exclusion and inclusion criteria was 66. In response to Q1, they were mainly distributed in the WOS ESCI/SCOPUS ($n=26$) and WOS SSCI/SCOPUS ($n=22$) databases, unlike WOS ESCI ($n=7$) and SCOPUS ($n=11$). On the other hand, the articles published in the best positioned journals (Q1) in WOS SSCI and SCOPUS were those of Cattaneo et al. (2022), Gallego-Arrufat et al. (2019), Gudmundsdottir et al. (2020), Hämäläinen et al. (2021), Pérez and Hernández (2020), Pongsakdi et al. (2021), Silva et al. (2019a), Tomczyk et al. (2021), and Usart Rodríguez et al. (2021).

Regarding P2, it should be noted that between 2017 and 2019, 24.24% of the articles were published. There is evidence of a growing interest in this topic since 2020, with 75.75% of the accumulated productivity through February 2022, highlighting 28 articles published in 2021 (Figure 2).

Figure 2

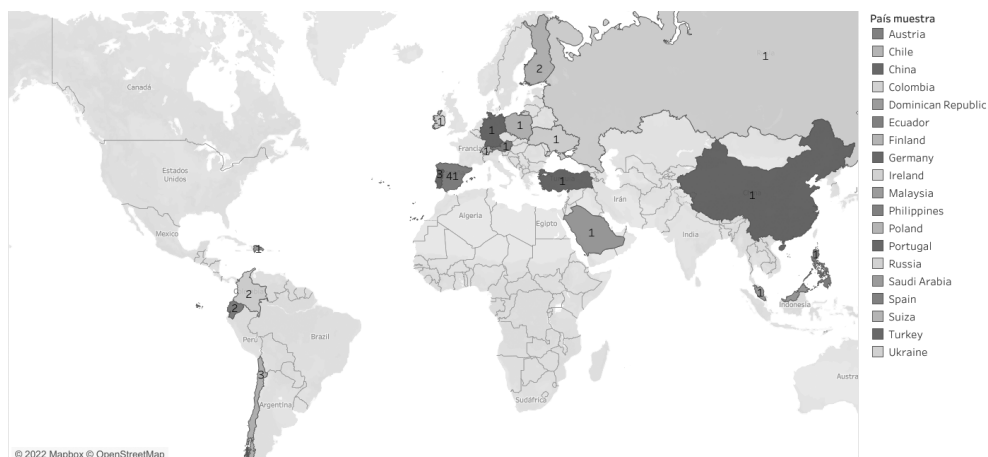
Evolution of scientific production on the evaluation of DCT



The geographical distribution of the authors indicated that Spaniards authored 75.75% of the investigations, and only 24.24% of the articles were signed by authors from countries outside the European Union. Regarding the geographical distribution of the *first author* of the articles, we found a great diversity of researchers worldwide, as reflected in Figure 3.

Figure 3

The geographical location of the first authors in the studies on the evaluation of DCT



Research area 2. Describe the research methods used to assess teachers' DCT

The research design of the analyzed studies (P3) was mostly quantitative with 89.39% of the cases (Falcó Boudet, 2017; Jiménez-Hernández et al., 2020) and, to a lesser extent, qualitative with 6.06% (Sales et al. al., 2020; Suárez-Guerrero et al., 2021), and mixed with 4.45% (Llopis Nebot et al., 2021; Ruiz-Cabezas et al., 2021). Of the total studies with a quantitative approach, studies with non-experimental designs predominated with 77.27%, compared to experimental ones with 13.63% (Marín Suelves et al., 2019; Pongsakdi et al., 2021; Romero-García et al. al., 2020).

Regarding the sample of these studies (P4), those of active teachers ($n = 39$) predominated compared to future teachers ($n = 27$). In the case of studies on the evaluation of the DCT of future teachers, more samples were found with undergraduate students or equivalent degrees in other countries ($n_{\text{undergrad}} = 13$; $n_{\text{graduate}} = 8$; $N_{\text{both}} = 6$). On the other hand, more studies were identified that brought together active teachers in different educational stages ($n = 15$) and university teachers ($n = 13$), than other stages or teachings in the educational system ($n_{\text{Adults}} = 1$; $n_{\text{Artistic}} = 1$; $n_{\text{F.P.}} = 2$; $n_{\text{Secondary}} = 5$; $n_{\text{Primary}} = 1$; $n_{\text{Kindergarden}} = 1$).

As occurred with the geographical distribution of the authors, 78.79% of the studies had samples from e European Union countries (78.79%), and the majority were Spanish (63.63%). Likewise, there were six studies with data from samples from different countries, highlighting two that collected them in 7 and 11 countries, with 873 and 53,390 active teachers, respectively. Logically, there was no homogeneity

in the sample sizes in the studies. In the case of studies focused on validating a DCT measurement instrument, the sizes were small when they only focused on expert judgments and ranged between 142 and 1,098 participants when validating the subjects under study. Regarding the sample size when the DCT was evaluated, it varied between 40 and 867 participants in quantitative approaches and 11 to 26 when qualitative techniques were used.

In response to Q5 about the particularities of the DCT assessment tools, the types of tools, and information collection techniques, it was found that 89.39% of the studies used a self-perception questionnaire about the DCT. Three studies used a mixed approach, combining the questionnaire with focus groups (Llopis Nevot et al., 2021; Ruiz Cabezas et al., 2020), interviews, documentary analyses, and systematic observations (Prieto-Ballester et al. al., 2021). Two qualitative studies used the interview (Suárez Guerrero et al., 2021); in one, they also conducted discussion groups (Sales et al., 2020). On the other hand, studies were found that evaluated the DCT with a rubric (Marcano et al., 2020) or with a platform in which the teacher obtained the result of the self-assessment, and based on this, proposed training activities (Viñoles -Cosentino et al., 2021). There were studies such as the one by Tomczyk et al. (2021, in which they combined tools that measure DCT through self-perception with competency tests that measured the actual level acquired.

Regarding the design and validation of the tools to assess DCT, 49 studies (74.24%) used an ad hoc instrument or adapted it from others. Among these, nine studies stood out in which design and validation were the central objects of the investigation. Five addressed active teachers (Barragán et al., 2020; Guillen et al., 2021; Medina et al., 2018; Tourón et al., 2018; Viñoles-Cosentino et al., 2021) and four concerned future teachers. (Cabero et al., 2020a; Lázaro Cantabrana et al., 2019; Marcano et al., 2020; Usort et al., 2021). The remaining 17 studies used an instrument already validated. Specifically, the instruments that used by more researchers were the DigCompEdu Check In instrument by Redecker and Punie (2017) in six studies (Cabero et al., 2021; Dias-Trindade & Moreira, 2020; Dias-Trindade et al. , 2021; Karunaweera et al., 2021; Torres Barzabal et al. 2022; Yazon et., 2019), the questionnaire to assess DCT by Tourón et al. (2018) in three studies (Domínguez-Lloria et al., 2021; Prieto et al., 2021; Romero et al., 2020), and the COMDID-A by Lázaro Cantabrana et al. (2019) in two studies (Palau Martín et al., 2019; Paz Saavedra et al., 2022).

Logically, no published study was found that developed or adapted a tool or used an already validated one that did not meet the validation and reliability parameters established in educational research.

Regarding the content of the study tools, there were a greater number of studies that took competency frameworks from different institutions as a reference ($n =$

32) compared to tools in which no referents were indicated ($n = 11$) or in which various sources were used (frameworks or tools from other authors) ($n = 23$). The DIGCOMPEDU framework (Redecker and Punie, 2017) and the Digital Competency Framework (INTEF, 2017) stood out especially, as they were followed by 11 and 12 investigations, respectively, when defining the dimensions around which the evaluation tools were structured. It should be noted that these frameworks were taken as references in studies of countries outside the European Union, such as the Philippines, Sri Lanka, Saudi Arabia, Ukraine, and Turkey (Al Khateeb, 2017; Çebi and Reisoğlu, 2020; Karunaweera & Lee, 2021; Maiier & Koval, 2021; Yazón et al., 2019).

To a lesser extent, other frameworks were followed, such as the UNESCO ICT Competency Framework for Teachers (2019), the Russian Teachers' Digital Literacy of the Analytical Center NAFI (2019), the Definition of DCT by the Department of Ensenyament Generalitat of Catalonia (2016), the DIGCOMP (CE-JRC) of Ferreri (2013), the European Certificate of Computer Skills of CEPIS (1995) and the ICT Standards for Initial Teacher Training of the Ministry of Education Chile (2009), as shown in Table 3 (<https://doi.org/10.6084/m9.figshare.21125842>).

Among the studies that did not provide references or used various sources for the construction of their instruments, some established the DCT assessment dimensions, considering the types of knowledge that the concept of competency suggests: knowledge, skills, and attitudes (Escobar-Zúñiga, 2021; Hämäläinen et al., 2021; Pongsakdi et al., 2021; Ruiz Cabezas, 2020). Some designed dimensions that linked DCT evaluation with specific functions assigned to teachers, such as focused attention to students with disabilities (Medina-García et al., 2021), the development of active and innovative learning methodologies (Hosseini-Mohand et al., 2021), or tutoring (Guillen-Gamez et al., 2021). On the other hand, some designed DCT instruments adjusted to specific topics like cyberbullying (Gudmundsdottir et al., 2020), responsible internet use (Baena-Morales et al., 2020; García-Ruiz & Pérez-Escoda, 2021), and digital security (Gallego-Arrufat et al., 2019).

Finally, the types of analysis carried out in the investigations (P6) were addressed. Although most of the studies that designed their evaluation tools conducted preliminary validation and reliability analyses, there were nine studies whose main objective was to design and validate an instrument to evaluate DCT. These studies carried out construct-validation processes through internal consistency and reliability analysis and exploratory and confirmatory factor analysis (Barragán-Sánchez et al., 2020; Cabero-Almenara et al., 2020; Guillén-Gámez et al., 2021; Medina-García et al., 2021; Tourón et al., 2018) and content validation through expert judgment (Lázaro Cantabrana et al., 2019; Marcano et al., 2020; Usort Rodríguez et al., 2021; Viñoles-Cosentino et al., 2021).

Most of the studies based on a quantitative approach conducted descriptive, correlational (Jorge-Vázquez et al., 2021; Paz Saavedra et al., 2022), inferential (Gallego-Arrufat et al., 2019; Muñoz and Ruiz-Domínguez, 2021; Pongsakdi et al., 2021), predictive (Çebi & Reisoğlu, 2020; Guillen-Gamez & Mayorga-Fernandez, 2020; Myyry et al., 2022) and regression analyses (Cattaneo et al., 2022; Hämäläinen et al., 2021; Jiménez-Hernández et al., 2020; Muñoz & Ruiz-Domínguez, 2021; Tomczyk, 2021; Tomczyk et al., 2021). Studies based on a qualitative approach focused on inductive and deductive content analyses (Sales et al., 2020; Suárez-Guerrero et al., 2021).

Research area 3. Analyze the evaluations of the DCT and the experts' recommendations

Considering the results in each investigation of this systematic review to answer Q7, we found evidence that, at a general level, the DCT of teachers must be improved. Although some studies indicated differences depending on the dimensions analyzed, there was no unanimity in the results (Al Khateeb, 2017; Dias-Trindade & Moreira, 2020; Hämäläinen et al., 2021; Muñoz-Pérez & Cubo Delgado, 2019; Muñoz & Ruiz, 2021). We observed differences in some research in the knowledge, skills, and attitudes that a teacher must master to be considered digitally competent (Gallego-Arrufat et al., 2019; Napal Fraile et al., 2018). This is pointed out by Hämäläinen et al. (2021) when analyzing data from teachers in 11 countries, revealing differences in the skills and knowledge acquired and, to a lesser extent, in the attitudes of teachers, recognizing the importance of digitalization in the educational field and the interest in improving their DCT; as reported in the studies by Muñoz Pérez & Cubo Delgado (2019), Ruiz Cabezas et al. (2020) and Tomczyk et al. (2021).

In this regard, it should be noted that a large part of the DCT evaluations collected the self-perception of teachers, which does not necessarily coincide with the actual level; even in some studies, it was evident that the self-perceived level of competency is higher than the acquired one. (Silva et al., 2019a; Tomczyk, 2021; Viñoles-Cosentino et al., 2021; Zhao et al., 2021). For this reason, authors such as Rossi Cordero and Barajas Frutos (2018) proposed reducing the gap between the desired digital competency and that acquired through training, which teachers favor (Muñoz & Ruiz-Domínguez, 2021).

The results found in the evaluation of the DCT level show that a series of factors influence it. The contextual factors include teachers' workloads or the availability of technological resources (Cattaneo et al., 2022). The personal factors (Hämäläinen et al., 2021) included age (Paz Saavedra et al., 2020), professional commitment (Falcó Boudet, 2017), one's attitude towards digital competency (Al Khateeb, 2017),

the number of research and innovation projects in which they participated (Guillén-Gámez & Mayorga-Fernández, 2020), the perceived level of digital competency (Çebi & Reisoğlu, 2020) and the educational level of teachers (Santos et al., 2021). The study by Yazón et al. (2019) showed that the higher the DCT level, the higher the scientific productivity of the teaching staff. However, Heuling et al. (2021) found the reproduction of digital-divide patterns caused by the influence of socioeconomic origins and gender on future teachers.

The authors of the 66 articles analyzed, in addition to presenting their diagnostic results, made a considerable effort to provide recommendations and proposals for improving the DCT and its evaluation; their analyses and syntheses attempted to respond to question 8 in this literature review.

The researchers called for an effort to improve the level of DCT through an adapted training offering and the proper use of digital resources and technologies:

- Permanent training specialized in DCT (Al Khateeb, 2017; Cabero-Almenara et al. 2020c; Falcó Boudet, 2017; Silva et al., 2019a).
- Initial training in universities with a greater focus on DCT (Falcó Boudet, 2017; Gómez-Trigueros et al., 2021; Moreno-Guerrero, 2020; Silva et al., 2019b) and transversal training in the curriculum (Jiménez- Hernández, 2020; Marín Suelves et al., 2019; Sales et al., 2020). This training should focus on managing digital and methodological resources to guarantee correct implementation in the teaching-learning process (Maiier & Koval, 2021).
- Encouraging the frequent use of technology in pedagogical practices, which requires providing more resources in schools (Al Khateeb, 2017) and a positive attitude towards their use (Al Khateeb, 2017; Cattaneo et al., 2022; Hämäläinen et al., 2021), in addition to the responsible use of technologies (Baena-Morales et al., 2020; García-Ruiz & Pérez-Escoda, 2020; Gudmunds-dottir et al., 2020).

Concerning the improvements proposed concerning the research on DCT and its evaluation, the following should be highlighted:

- Adapt the information collection instruments to detect and solve the challenges that hinder and discourage teachers from improving their DCT (Al Khateeb, 2017).
- Combine quantitative and qualitative research methods and develop new evaluation methods (Al Khateeb, 2017; Hämäläinen et al., 2021), such as evaluation rubrics (Marcano et al., 2020) or evaluation accompanied by a formative intervention (Miguel-Revilla et al., 2020).

- Collect evidence of DCT through competency tests that complement the teacher's perception (Viñoles-Cosentino et al., 2021) and may lack objectivity (Baena-Morales, 2020; Myyry et al., 2022).
- Take into account factors that affect the results: sociodemographic factors, such as gender (Esteve-Mon et al., 2020), years of teaching experience (Zhao, 2021), age or educational level (Flores-Lueg & Roig -Vila, 2019), and structural factors, such as the provision of resources or training opportunities for teachers (Cattaneo et al., 2022).
- Expand the size of the samples and the geographical contexts in which data are collected to compare results (Jorge-Vázquez, 2021; Prieto Ballester et al., 2021)

DISCUSSION AND CONCLUSIONS

The systematic review of the literature addressed in this work analyzed the 66 publications in high-impact scientific journals between 2017 and 2022. The focus of the study was the evaluation of DCT to contribute to the improvement of one of the essential teaching competencies in the current educational and technological context, such as the digital one, considering that to improve it, one must know what mastery teachers have in this regard and, consequently, decide on the necessary improvement actions.

In the first area of research, the results highlighted the relevant role of DCT as one of the critical competencies of the teaching profession and educational quality to respond to today's societal demands, coinciding with the European Commission (2021), Dervenis et al. (2022), and Fernández-Luque (2021). Also, a publication boom in WOS and Scopus revealed the enormous scientific interest in DCT assessment since 2020, especially in Spain and other European countries. These findings coincide with other previous investigations (Pinto et al., 2022; Saltos-Rivas et al., 2021; Sillat et al., 2021) that highlighted the exponential growth of researchers' interest in this subject, especially during the pandemic, effectively verifying that 2021 had the most articles since 2017.

The literature review could answer the questions in the second area of research by showing that, although most research follows the non-experimental quantitative method to assess DCT, a wide variety of assessment instruments have been used, as highlighted by Silva et al. (2019b). These follow the frameworks established by the European Commission (Digcomp and DigcompEdu) and the Spanish INTEF (Common Framework for Digital Teaching Competency), providing relevant scientific recognition along the lines proposed by Cabero et al. (2020a; 2020b; 2021).

The third area of research proposed in this review sought to know the results provided by the experts regarding DCT. In this sense, we verified that, despite

the difficulty of reaching a single global diagnosis, a relevant part of the studies showed that the level of DCT perceived by teachers was lower than their actual mastery. However, agreeing with Melash et al. (2020), their interest in improving digital competency highlights a positive attitude towards using technologies in their practices and teacher training.

Finally, the results of this research revealed a series of recommendations proposed by the researchers who intend to improve the evaluation of DCT in two areas: formation (training) plans and lines of research so that the contributions are highly valuable and facilitate processes and proposals to improve the DCT. The analyzed investigations coincided with Melash et al. (2020) on the need to improve the design of training plans and with Frolova et al. (2020), Gisbert Cervera et al. (2016), and Guillén-Gámez and Mayorga-Fernández (2020) in continuing the line of research regarding the evaluation instruments used by the scientific community. Considering the list of recommendations extracted from the analyzed studies, we highlight the proposal by Al Khateeb (2017) because it synthesizes the most significant agreement of the experts: making teachers aware of the need to improve their digital competency through continuous training plans, offering more training in digital competency and technological resources to the centers, and increasing qualitative research that deepens the level of DCT.

The conclusions of this review highlight that DCT is recognized as a critical competency in the teaching profession; its improvement should guarantee success in the quality of teaching. The analyzed investigations also highlight the importance of designing training plans that promote their improvement, both for active teachers and teachers in training, even adapting said plans to the different educational stages in which they practice their professions in the different specialties. Likewise, the research analyzed shows the need to improve the evaluation of this competency to design training plans based on the results. For this, the experts recommend increasing research focused on assessing teachers in different stages and specialties, combining quantitative and qualitative methods, overcoming the limitations of self-perception questionnaires, using competency tests, and expanding the study samples to attain a global vision. Therefore, we can conclude in this work that knowing a) how DCT is currently assessed and b) the experts' recommendations can be a valuable resource for future research that responds to the initially posed challenge of improving DCT.

Therefore, the findings presented in this systematic review of the literature provide an overview of methods, participants, data collection instruments, results, and recommendations of the authors in high-impact publications on improving DCT as a critical piece of quality education in all educational levels of current and future society.

The study's limitations include that only the publications of two indexing systems (WoS and Scopus) were considered and selected for their breadth and prestige in the academic community. However, in future studies, it would be advisable to integrate other indexing systems where more articles on this subject might be found. The study results had implications for educational practice, such as training digital skills to facilitate educational innovations in the classroom. In the same way, implications for research in the designs and sample sizes are denoted by knowing the practices teachers carry out in developing DCT. Therefore, this study invites additional research on digital teaching skills with the vision to improve educational practices, analyzing, among others, the impact on DCT derived from updating the Framework of Reference of the Spanish Teaching Digital Competency.

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APPENDIX 1. RELATIONSHIP OF FRAME OF REFERENCE, DIMENSIONS AND STUDIES THAT USE THEM

Table 2

Relationship of frame of reference, dimensions and studies that use them

Frame of reference	Dimensions	N	Studies
Common Digital Competence Framework for Teaching (INTEF, 2017)	1. Information and data literacy 2. Communication and collaboration 3. Digital content creation 4. Safety 5. Problem solving	12	Prieto-Ballester (2021); Touron et al. (2018); Domínguez-Lloria & Pino-Juste (2021); Dias-Trindade et al. (2021); García-Ruiz & Pérez-Escoda (2021); Marcano et al. (2020); García-Vandewalle García et al. (2021); Romero-García et al. (2020); Napal Fraile et al. (2018); Pérez & Hernández (2020); Moreno et al. (2020); Rodríguez-García et al. (2019)
DIGCOMP-EDU (EC-JRC) Redecker y Punie (2017)	1. Professional engagement 2. Digital resources 3. Teaching and learning 4. Assessment 5. Empowering learners 6. Facilitating learners' digital competence	11	Suarez et al. 2021; Garzón Artacho et al. 2020; Llopis Nebot et al. 2021; Dias-Tridante et al. 2020; Santos et al. 2021; Torres Barzabal et al. 2020; Cabero et al. 2021b; Karunaweera & Lee (2021); Viñoles-Cosentino et al. 2021; Jiménez-Hernández et al. 2020; Maiier & Koval (2021); Barragán-Sánchez et al. (2020) (este estudio se basa también en INTEF, 2017)
DIGCOMP (CE-JRC) (Ferrerri, 2013)	1. Information and data literacy 2. Communication and collaboration 3. Digital content creation 4. Safety 5. Problem solving	3	Trujillo-Torres et al. (2020); Al Khateeb (2017) (2017); Çebi & Reisoğlu (2021)
ICT Competency Framework for Teachers (UNESCO, 2019)	1. Understanding ICT in education 2. Curriculum and assessment 3. Pedagogy 4. Application of digital skills 5. Organization and administration 6. Teacher professional learning	1	Jorge-Vázquez et al. (2021)

Frame of reference	Dimensions	N	Studies
Russian Teachers' Digital Literacy del Analytical Center NAFI (2019)	1.Responsabilidades profesionales 2. Recursos digitales 3. Enseñanza y aprendizaje 4. Evaluación de los estudiantes 5. Empoderamiento de los derechos, oportunidades e independencia de los estudiantes en el proceso educativo 6. Desarrollo de la competencia digital de los estudiantes	1	Sorochinsky (2021)
TDC definition (Departamento de Ensenyament Generalitat de Catalunya, 2016)	Design, planning and didactic implementation Organisation and management of school environment and educational resources Communication and collaboration Ethical and digital citizenship Professional development	1	Lázaro Cantabrana et al. (2019)
European Certificate of Computer Skills (CEPIS, 1995)	1. Basic concepts of Information Technologies 2. Computer use and file management 3. Word processing 4. Spreadsheets 5. Databases 6. Presentations 7. Information and communication	1	Tomczyk et al. (2021)
ICT Standards for Initial Teacher Training (ITT) (Ministry of Education Chile, 2009)	1. Pedagogical aspects 2. Technical aspects 2. Aspects of school management 4. Social aspects 5. Ethical aspects 6. Legal aspects of development	1	Flores-Lueg & Roig-Vila (2019)

Frame of reference	Dimensions	N	Studies
Tools for which references have not been indicated		11	Rossi Cordero, et al. 2018; Ruiz Cabezas et al. 2020; Tomczyk et al. 2021; Medina-García et al. 2021; Pongsakdi et al. 2021; Muñoz & Ruiz-Domínguez. 2021; Sales et al. 2020; Escobar-Zúñiga et al.; 2021; Marín Suelves et al. 2019; McGarr & McDonagh, 2021; Hossei- Mohand, 2021
Tools for which various sources are used (frameworks, tools from other authors)		22	Cattaneo et al. (2022); Myyry et al. 2022; Yazón et al. (2019); Silva et al. (2019a); Silva et al. (2019b); Cabero et al. 2020); Gallego-Arrufat et al. 2019; Usar Rodríguez et al. 2021; Palau Martín et al 2019; Hamalainen et al., 2019; Falcó Boudet, 2017; Muñoz Pérez et al. 2019; Paz Saavedra et al 2021; Zaho et al. 2021; Baena-Morales, 2020; Guillen-Gamez et al., 2021; Esteve et al., 2019; Esteve-Mon et al., 2020, Miguel-Revilla et al., 2020; Gudmundsdottir et al., 2020; Gómez-Trigueros et al, 2021; Heuling et at., 2021)



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