

Development of teaching digital competence in initial teacher training: A systematic review.

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Abstract

This article presents the results of a systematic review of different studies published in high-impact journals on the development of teaching digital competence (TDC) in initial teacher training. The methodology of the study is based on the documentary research approach, with the application of a systematic literature review covering the period between 2009 and 2019 in different databases. The sample is made up of 102 articles that are registered in a multidimensional analysis and classification matrix. One of the main findings is that in the last ten years there has been a significant increase in the literature related to teaching digital competence with the prevailing use of the quantitative methodological approach. Likewise, 50.98% of the articles are the result of the application of instruments to assess TDC. It can be concluded that TDC is a line of research with multiple dimensions of analysis and in constant evolution.

Keywords: teaching digital competence, initial teacher training, educational technology, information, communication technology, systematic review

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1. Introduction

Currently, there is a consensus among the academic and scientific community regarding the need to transform the role of the teacher as the facilitator of learning experiences within the different educational models. The educator's functions must be placed in context, incorporating changes and pedagogical and methodological innovations and digital tools necessary to redefine the educational act. From the same multiparadigmatic evolution of teacher training models and processes, digital teaching competence (DTC) arises as a fundamental and indispensable element in initial teacher training (ITT) programs (Admiraal et al., 2016; Baz et al., 2018; Çetin, 2021; Falloon, 2020).

Under the perspective of the transformation of the teaching role and with the understanding of the dynamics and challenges of society mediated by digital, TDC are the skills, knowledge and capacities to use digital technologies in pedagogical processes and professional adaptation (Borthwick & Hansen, 2017; Silva et al., 2018). Likewise, it is argued that professional digital competence is needed to understand educational technology and learning processes from a sociocultural perspective (Lund et al., 2014). Furthermore, it enhances the professional profile of the teacher (List et al., 2020), makes pedagogical practices in the school setting more relevant (Harangus et al., 2016; Kimmons & Hall, 2018), and calls for the urgent redesigning of teacher training (Graciano et al., 2017; Zhumash et al., 2021).

Consequently, TDC is multidimensional in nature (Ramírez-Montoya et al., 2017) and, therefore, it is considered as a horizon of educational innovation oriented toward the development of capacities and attitudes in ITT to improve professional teaching practice (Castañeda et al., 2018; Falloon, 2020). This perspective implies certain pedagogical action in ITT: fostering the ability to adapt to change (Admiraal et al., 2016; Silva et al., 2018), innovating by diversifying teaching and learning and permanently unlearning past practices (Tejada & Pozos, 2018).

In ITT, it is essential that DTC is developed from a transversal and permanent perspective (Silva, 2012; Villant, 2014; Flores-Lueg & Vila, 2016). Consequently, the relevance of developing explicit curricular activities and scenarios on TDC from the ITT is identified: their purpose is to guarantee knowledge and capacities enriched by information and communication technologies (ICT) at a professional level. It is important to bear in mind that the fact of belonging to a generation that has been influenced by digital technology does not guarantee the development of DTC in teachers (Flores-Lueg & Vila, 2016; Silva et al., 2019). In the case of Latin America, teacher training does not have guidance and support from the Ministry of Education (Silva et al., 2018) and does not respond to the transformations and complexities of the information society (Villant, 2014).

It is evident that in recent years there has been a considerable increase in various studies related to the competencies that future teachers must achieve to take advantage of ICT in the teaching profession. However, it is necessary to identify, classify and observe the literature, make a rational synthesis of the research carried out, analyse the contributions generated, and propose new lines of research and innovation. In this sense, this systematic review study has as its main purpose to identify the main themes and contributions that have been reported in scientific articles on the development of DTC in ITT.

2. Methods

This study employs a methodology supported by the documentary research approach and the procedural model of a systematic literature review (González & Balaguer, 2008; Sanchez-Meca, 2010) on DTC, available in the databases having specialised consultation with indexed journals with high-

impact articles, including *Scopus* and *Web of Science*, as well as regional databases including Eric, Scielo, Dialnet and Redalyc.

The review model is based on the basic steps of the systematic review proposed by Beltrán (2005). Each of the six stages carried out during the process is described below, with their main characteristics and methodological specifications:

1) Delimitation of the central question and identification of the dimensions of analysis. From the delimitation of the object of study, the following central guiding question of the systematic review was formulated: What are the main themes and contributions that have been reported in scientific articles on the development of DTC in ITT?

2) Formulation of the inclusion and exclusion criteria of the articles. At this stage, the exercise of defining the inclusion and/or exclusion criteria in the search exercise was carried out according to the following criteria:

- **Temporality:** The observation window includes a general period of publication between January 2009 and June 2019. The period of the last ten years was selected since the guiding question of the systematic review implies the need to systematize studies and experiences that make it possible to give an account of how TDC has evolved both at a conceptual and methodological level.
- **Typology:** Research articles, articles of systematic review and articles of methodological reflection were analysed.
- **Knowledge Areas:** The search was limited to the general area of social sciences and the specific area related to educational sciences.
- **Languages of Publication:** Articles were selected in English, Spanish and Portuguese.
- **Specialised Consultation Databases:** The *Scopus* and *Web of Science* consultation databases were selected since they concentrate on journals with the greatest influence worldwide. The query window was also generated for the Eric, Scielo, Dianet and Redalyc regional databases given their relevance to the need to identify regional expertise in studies on TDC in the Iberoamerican context.

3) Table 1 provides information about sample delimitation, consultation of specialised databases, and systematic selection of articles. The articles were searched and selected according to the thematic descriptors: Digital teacher competence and initial teacher training (teaching digital competence and teacher education students or initial teacher training). The Boolean operators used were 'or', 'and'. Table 1 shows the search results after applying the inclusion and exclusion criteria:

Table 1. Sample Configuration of Articles in the Systematic Review Process

Databases for specialised consultation	Initial base of articles	Application of inclusion/exclusion criteria	Final debugging by content analysis
<i>Scopus</i> (Sjr)	219	45	
<i>Web Of Science</i> (Jcr)	323	61	
Eric	134	55	102
Scielo	82	16	
Dialnet Plus	155	34	

Redalyc	75	16
Total	913	223

Using of thematic descriptors, the first search identified a total of 913 articles. Subsequently, applying inclusion and/or exclusion criteria reduced the sample to 223 articles, most of them located in the Sjr and Jcr databases. Finally, 54 articles, which were duplicates found in different databases, were purged. Then the abstracts were read to determine the validity of the articles in relation to the central question of the study. Consequently, 67 articles were eliminated for not being directly related to TDC in the ITT. After configuring the final sample, 102 articles remained (Pinto et al., 2020).

4) The next step involved design, coding and recording of information. A multidimensional analysis and classification matrix of the articles was constructed having the following categories of analysis: Year, language, keywords, methodology, number of citations, and subject. Each of them is described below with the article's coding and classification system.

- Year: The category corresponds to the year of publication of the article, which was indicated with three digits containing the letter A and the last two digits of the year of the observation window (A09 - A19)
- Language: The article was classified according to the languages selected in stage 2. The identifiers were (E) for English, (S) for Spanish and (P) for Portuguese.
- Keywords: The central descriptors of the articles were identified from the keywords presented.
- Type of work: This category's purpose was to identify the type of study developed. Research articles were coded as (T1) and review/reflection articles as (T2). The research articles were further classified in the subcategory (T11) for quantitative articles, (T12) for qualitative articles and (T13) for mixed research.
- Number of citations: Based on the citation index in Google Scholar, the number of citations credited to each of the selected articles was recorded.
- Predominant theme: From the preliminary review of 20% of the articles in the systematic review, four central themes were defined to which the articles on TDC generally contributed. In this sense, the entire article was assumed as the content unit, and it was classified in the thematic dimension to which it generated the greatest contribution. Those that dealt with ideas and conceptions about TDC were coded as (D1). The other classifications were (D2) holistic models of training in educational technology, (D3) those related to indicators and evaluation instruments, and (D4) those associated with training experiences to promote TDC.

5) Content analysis: This included the multidimensional analysis of the 102 selected articles regarding the development of the TDC, taking into account the classification established in stage four by the predominant thematic category. In this sense, the content analysis was carried out and the contributions generated by each of the articles to the different thematic dimensions were registered qualitatively. This exercise allowed, for example, an article to contribute to the first dimension (D1) – Conceptualization, to the second (D2) – Holistic models, to the third (D3) – Evaluation, and to the fourth (D4) – Training, or only one of them.

6) Generation of results of the systematic review: In this stage, the interpretation and presentation of the results were carried out, which implied an analysis of each of the categories generated, as well as

the measurement of the central bibliometric indicators. Finally, the entire process of preparing the tables, figures and semantic maps, which present the main findings of the study, was carried out.

3. Results

This study found that publications on TDC have been increasing in recent years. Bearing in mind that this systematic review was carried out during the period between 2009 and 2019, Figure 2 shows that most of the publications have been issued in the last five years. For example, in 2016 and 2018 the highest number of publications were found with 18.62% and 20.58% respectively. In this sense, it is likely that teaching methodologies and the development of teachers' professional skills is an attractive current line of research with many facets.

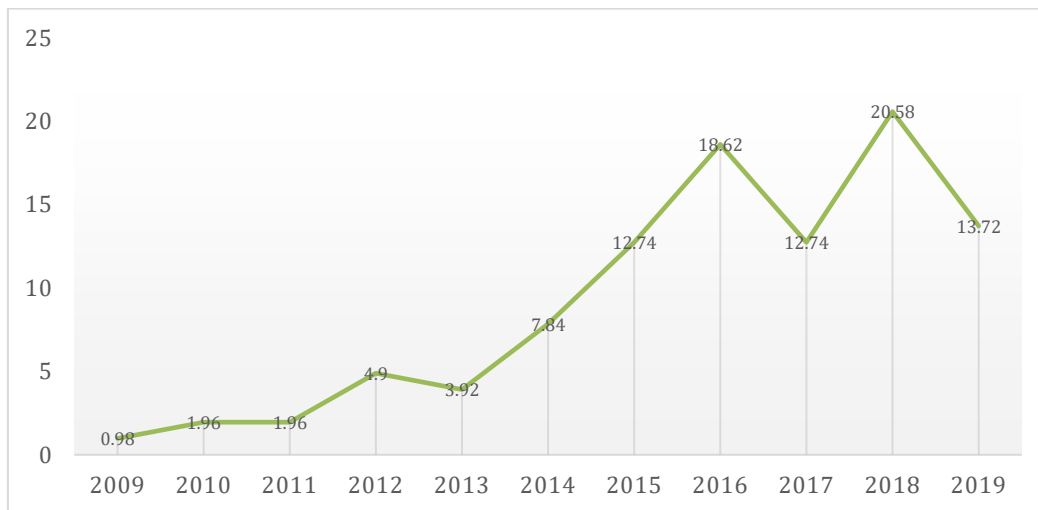


Figure 2. Historical evolution of the number of publications on TDC per year

Table 2 focuses on the language of the publications. It reveals that many publications (73,52%) of this systematic review are in the Spanish language. This is attributed to the use of thematic descriptors and to consulting different regional databases.

Table 2. Characterisation of the sample of articles by language of publication

Publication language	Frequency	Percentage
Spanish	75	73.52%
English	26	25.49%
Portuguese	1	0.98%
Total	102	100%

After carrying out a bibliometric analysis on the central descriptors, the main categories that emerged correspond to ICT, followed by general digital competence, DTC, ITT and teacher training, mainly.

Table 3. Bibliometrics based on keywords

Keywords	Frequency	Percentage	Accumulated percentage
ICT	36	17.91%	17.91%
General Digital Competence	35	17.41%	35.32%
TDC	21	10.45%	45.77%
ITT	20	9.95%	55.72%
Digital training for teachers	18	8.96%	64.68%
Higher education	13	6.47%	71.14%
Teachers	11	5.47%	76.62%
Digital communication	10	4.98%	81.59%
Educative technology	10	4.98%	86.57%
Teacher training	9	4.48%	91.04%
Professional Competencies	8	3.98%	95.02%
Standards and Digital Competition	5	2.49%	97.51%
Pedagogy	5	2.49%	100%

In contrast to the type-of-work category, Table 4 reports the quantity of items that are classified by research in each of the dimensions of content analysis: 52.9% of the articles are quantitative studies, where the application of TDC self-perception questionnaires from students in training dominates; 13.7% are qualitative studies; and 10.7% correspond to studies mixed. Likewise, it was found that 22.5% of the articles in the systematic review correspond to review and reflection articles.

Table 4. Analysis dimensions

TDC analysis dimensions	Relationship between item type and TDC dimensions					Frequency b y Dimension	Percentag e
	Study quantitativ e	Study qualitativ e	Study Mixe d	Review / Reflectio n Article			
D1. Conceptualization	3	3	0	8	14	13.72%	
D2. Models	0	0	2	4	6	5.88%	
D3. Evaluation	40	7	2	3	52	50.98%	
D4. Training	11	4	7	8	30	29.42%	
Total	54	14	11	23	102	100%	

Next, a synthesis derived from the most relevant contributions in each of the four dimensions of content analysis is presented, identifying the ‘top five articles’, that is, those that have been most referenced and have greater international recognition, based on the number of citations reported from the Google Scholar search engine. It should be noted that the bibliometric reports of citation are different in each of the databases and are mostly smaller, given that, for example, in the case of articles referenced in *Web of Science* or *Scopus*, only citations present in the same database are reported. Consequently, the identification of the top articles obeys a set analysis of criteria that specifically incorporates their impact related to the level of citations they have received, together with the content

analysis that accounts for their pertinence and relevance as a representative article in each one of the four dimensions.

At a general level, in the articles that relate to the conceptualization dimension of TDC, there is a consensus on the need for the 21st century teacher to be an expert in the use of educational technology, to continuously update their knowledge, to employ innovative educational practices, and promote open, creative, flexible and active learning spaces. Likewise, to define the professional competence of the educator associated with the appropriation of educational technology, these concepts are used: Usability of ICT in educational practice (Colorado-Aguilar & Edel-Navarro, 2012), Teacher digital literacy (Regalado, 2013), ICT competence for teachers (Hepp et al., 2015), and TDC (Gisbert et al., 2016; Castañeda et al., 2018).

Table 5 shows the contributions of Ilomäki et al. (2016), who analyse the conceptualization of DC and suggest that digital technology is ubiquitously associated with pedagogy. For their part, Regalado (2013), Salinas et al. (2014) and Cabero and Llorente (2015) refer to the new role of the teacher and the need to develop skills in the management of information, communication in various environments mediated by ICT, and the management and organization of resources for learning. Gisbert et al. (2016) differentiate DC and TDC: the first as the one that must be developed to manage learning and the second relates it to a set of knowledge and skills to appropriate ICT in teacher tasks.

Table 5. Top Dimension Articles (1) Conceptualization of TDC

Qualification	Author (s)	Year of publication	Google Scholar citations
Digital competence – an emergent boundary concept for policy and educational research in Education and Information Technologies	Ilomäki, Paavola, Lakkala and Kantosalo	2016	116
Teaching competencies for new learning scenarios	Salinas, de Benito and Lizana	2014	94
ICT: Formative Scenarios and Learning Theories	Cabero and Llorente	2015	73
Students’ and Teachers’ Digital Competence: an overview on research status	Gisbert, González and Esteve	2016	48
Why rethink teaching competence for the digital world?	Castañeda, Esteve and Adell	2018	47

In Table 6 it can be observed that the article with the highest reference regarding the professional training of teachers is the TPACK Model (Koehler & Mishra, 2009), which has founded the conceptual bases of different evaluation and teacher training proposals that are They are classified in dimension 3 and 4, and that it is associated with the knowledge that the teacher must have about the discipline that

guides, pedagogical practices and the productive use of technology. Likewise, the TICTACTEP model (Pinto et al., 2017) proposes a spiral advance of the Technology, Pedagogical, Communicative, Management and Investigative competence of the teacher from constructionist learning strategies. For its part, the Holistic Model (Esteve et al., 2018) is a proposal that seeks to move from the instrumental vision of the use of ICT by other models, and raises the need to make situated, critical and empowered use of the TIC. Finally, Tejada and Pozos (2018) make six proposals to develop teaching digital skills, and Cela-Ranilla et al. (2017) propose transformative pedagogy.

Table 6. Top articles of Dimension (2) TDC Models

Qualification	Author (s)	Year of publication	Google Scholar citations
What is technological pedagogical content knowledge?	Koehler and Mishra	2009	3057
Towards the transformation of teaching practice: Spiral Model of Competences TICTACTEP	Pinto, Cortés and Alfaro	2017	31
A Holistic Model of Teaching Competence for the Digital World	Esteve, Castañeda and Adell	2018	18
New scenarios and trainers' digital competencies: towards the professionalization of teaching with ICT	Tejada and Pozos	2018	17
Teachers in the digital society: a proposal based on transformative pedagogy and advanced technology	Cela-Ranilla, Esteve, González and Gisbert-Cervera	2017	15

It should be noted that TDC evaluation is the dimension of analysis that had the most classified articles in the systematic review. At the general level, articles that have self-perception questionnaires and TDC assessment scales predominate (84.61%). Most of the articles found in this dimension (73.10%) are the product of investigations where the design and application of a questionnaire to evaluate TDC was carried out. However, 21.15% of the studies implement an existing data collection instrument, and only 5.75% of the studies contribute to the formulation of TDC evaluation standards. Table 7 shows that the most cited articles involve the development, application and analysis of different questionnaires: the technological domain of the future teacher (Prendes et al., 2010; Roig & Pascua, 2012), the digital competence profile, including the pedagogical dimension (Rangel, 2015), the assessment of aspects related to skills in methodologies and technological management in education (Fernández-Cruz & Fernández-Díaz, 2016; Instefjord & Munthe, 2017).

Table 7. Top articles of Dimension (3) Evaluation of the TDC

Qualification	Author	Year of publication	Google Scholar citations
ICT competences of future teachers	Prendes, Castañeda and Gutiérrez	2010	152
Digital teaching skills: A profile	Rangel	2015	104

Generation Z's teachers and their digital skills	Fernández –Cruz and Fernández-Díaz	2016	75
Educating digitally competent teachers: A study of integration of professional digital competence in teacher education	Instefjord and Munthe	2017	58
The digital skills of future teachers: An analysis with students of early childhood education at the University of Alicante	Roig and Pascua	2012	57

Table 8 shows the most cited articles classified in the training experiences dimension. In the first place, there are the works of Silva (2012) and Cortes et al. (2015) that present a diploma aimed at teachers who train future teachers as an option to promote educational innovation processes supported by ICT at the ITT level. For their part, Aguirre and Ruiz (2012) developed a strategy to promote TDC based on the institutionalization of classroom projects for the transformation of teaching practices. Likewise, Lázaro and Gisbert (2015) and Papanikolaou et al. (2017) developed constructivist experiences based on interaction, collaboration and educational use of ICT in the school setting.

Table 8. Top Items of Dimension (4) Experiences of Formation in TDC

Qualification	Author	Year of publication	Google Scholar citations
ICT Standards for ITT: A public policy in the Chilean context	Silva	2012	47
E-portfolios as a tool for active constructionist learning in educational technology	Cortes, Pinto and Atrio	2015	37
Digital competences and teaching: An experience based on university practices	Aguirre and Ruiz	2012	26
The development of digital competence: A pilot experience in alternance training within the Bachelor in Education	Lázaro and Gisbert	2015	20
Learning design as a vehicle for developing TPACK in blended teacher training on technology enhanced learning	Papanikolaou, Makri and Roussos	2017	17

4. Discussion and conclusions

In light of the systematic review, it can be affirmed that the trends in TDC are directed towards a multidimensional process comprising the knowledge and articulated skills that allow the teacher to appropriate educational technology to learn permanently and continuously, teach in different settings while taking into account the context from the learner, manage the progress of students according to educational objectives, collaborate and work as a team, contribute to the different needs of the educational context, contribute to gaining knowledge, and innovate in their educational practice. In addition, it implies that the teacher must develop DC during their initial training and must have the capacity and willingness to use ICT in a critical and ethical way to improve their role as an educator.

Studies in TDC in future teachers are a current line of research of great interest and have been increasingly published in recent years. It should be noted that a sweep was carried out in the review of the period from 2009 to 2019. In this framework, the referencing of the studies on TDC generates an open door, where the main peaks are after the year 2015. Likewise, the predominant language of publication is Spanish, accounting for 73.52% of the publications. Regarding the type of study developed, quantitative studies (52.9%) prevailed, most of which are TDC evaluation questionnaires. Villant (2014) notes that although quantitative studies prevail, qualitative or mixed studies are necessary because they prioritize the comprehensive analysis of the teacher's reality from contextual and holistic TDC perspectives.

Among the main results of the systematic review, four predominant thematic categories were found to which scientific articles generally contribute and from which the contributions of the following central dimensions of analysis derive:

1. Faced with the conceptualization dimension of TDC, this study found that it is a concept that has been evolving. It has moved from a conception of digital teacher literacy referring to the management of ICT tools and their pedagogical use in education (Regalado, 2013; Harangus et al., 2016) and ICT Competences for teachers that analyses pedagogical knowledge and the need for permanent, autonomous and collaborative training (Vaillant, 2013; Hepp et al., 2015), to propose the TDC with different scenarios and possibilities for professional innovation by the teacher. It is in agreement with Silva et al. (2018) that developing TDC implies basic skills, didactic knowledge, and the ability to adapt to change. We also agree with Gisbert et al. (2016) that it is inconceivable in the 21st century for a teacher who does not have an excellent command of educational technology and keeps their knowledge up to date in their professional disciplinary field.
2. In regard to the dimension of TDC models, there are few proposals to guide educational policies on teacher training and appropriation of TDC. The acceptance that the TPACK model has had is highlighted. It has originated different instruments and training proposals to promote TDC. Likewise, recognition is given to the research contributions that different authors have made in the Spanish context and that analyse TDC and stress the need to incorporate it into the initial training of teachers. However, in the Latin American context, there are few initiatives that remain and that affect the professional profile of the teacher and the transformation of educational practices. In this sense, further studies are required on institutional policies, learning models, and pedagogical practice scenarios that promote TDC in future teachers, as well as transparent and effective instruments to measure the level of TDC (Gisbert et al., 2016).
3. In the evaluation dimension of the TDC, the largest number of articles (50.98%) of the systematic review were classified as the application of self-perception and evaluation questionnaires. Other qualitative TDC assessment instruments based on rubrics, forums and tests were also found. Likewise, it was possible to identify the main evaluation instruments as those that reflect the authors' philosophy of education as a result of a rigorous review of the literature or based on TDC frameworks and standards such as NETS, UNESCO, DigCompEdu, and ICT Standards for ITT among others. Gilbert et al. (2016) rightly pointed out that most of the research focused on defining and designing DC and TDC measurement strategies.
4. In relation to the TDC training typologies dimension, it was possible to describe the main experiences that promote TDC. These are based on active learning, the use of digital environments, collaborative and project work, and contextualized and practical exercises. Likewise, it is necessary to promote comprehensive processes of the transversal use of ICT and the accreditation of the TDC as a requirement

of a professional teaching career (Gisbert et al., 2016). This proposal agrees with Cabero-Almenara & Martínez (2019), who voice the opinion that to develop TDC it is necessary to create authentic and meaningful activities that include the transversal use of ICT from different subjects and that are appropriate through practical and complex exercises. Also, it is necessary to incorporate ICT transversally into the ITT curriculum and practical experiences that allow the pedagogical appropriation of digital technology (Flores-Lueg & Vila, 2016; Zhumash et al., 2021).

Regarding the scope and limitations of this research, the study did not contemplate the review of other types of documents other than scientific articles, leaving aside the works that are presented as papers in academic conferences on education and technology although they certainly provide great contributions to the advancement of research. Neither were postgraduate degree works that also study the line of research on ITT and TDC analysed.

Finally, it is proposed prospectively to advance the development of new studies with a mixed methodological approach that provides scientific knowledge, needed to understand in a more holistic way, the realities, limitations, challenges and trends regarding the evolution of TDC in the ITT process and, at the same time, delves into studies related to the levels of TDC, based on the context in which it is found. Another relevant factor for the development of future studies includes the opportunity to strategically analyse the strengths, weaknesses, setbacks and opportunities that higher education institutions present in their educational model, with their pedagogical and technological innovation processes, in the face of contemporary challenges of teacher training, curriculum management, ICT resources, educational innovation strategies and social appropriation of educational technology.

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