

Teacher digital competence development in higher education: Overview of systematic reviews

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The scope of digital technology integration in university teaching has changed our understanding of teacher readiness and teacher competence. Recently, faced with the digitalisation of higher education (HE), the construct of teacher digital competence (TDC) has emerged. Although there are many recent systematic reviews on digital competence from a range of perspectives and geographic settings, such reviews often show a limited view of a larger digital competence landscape in HE. The current study on TDC development in HE aims to synthesise knowledge to provide an integrated and global assessment of existing evidence. We carried out a systematic overview, especially suited for identifying, synthesising and critically appraising published reviews on a given topic amidst an abundance of research. We identified three clear settings by synthesising 740 studies across 13 systematic reviews. Results reveal a significant interest in TDC in Spain, conducted by researchers in the field of educational technology concerned with teacher training and teacher professional development. We make recommendations to reorient the field by understanding TDC development through an integrated, transversal and holistic perspective; moving away from basic forms of research; and conducting and reporting research in line with methodological guidelines to ensure the highest possible standards.

Implications for practice or policy:

- Stakeholders interested in better fostering TDC could complement training and evaluation with an integrated and systems-based approach, including sustaining an institutional culture that strategically supports TDC development.
- Researchers could move away from basic forms of research design in order to advance the field beyond self-assessment and evaluation studies.
- Systematic review research can be improved by following rigorous methodological guidelines, including critical appraisal and transparent methods to synthesise studies, to ensure the highest academic integrity.

Keywords: teacher digital competence, higher education research, systematic review, methodological guidelines, teacher training

Introduction

Developing the set of skills and knowledge required by educators to enable student learning in diverse digital environments has been an important and consistent debate within educational technology (EdTech) and higher education (HE) research (McGarr et al., 2021; Zhao et al., 2021). In the past decade, the construct of teacher digital competence (TDC) has emerged, defined as the set of skills, attitudes and knowledge required by educators to function productively, safely and ethically in diverse and digitally mediated environments (Esteve-Mon et al., 2020; Falloon, 2020). The prominence of policy and practice initiatives related to TDC is largely motivated by the increasing demands placed on faculty, connected to the velocity of digital transformations across all aspects of professional life, including the duty to support students in becoming digitally competent. The current global pandemic has only exacerbated the need for educators to function productively and (often) remotely using a range of digital tools. The immense popularity and growth of a systematic review industry in education research has meant that literature reviews on the same topic will have been carried out, often simultaneously, resulting in varying conclusions concerning the same

research problem and thematic domain (Polanin et al., 2017). Systematic reviews are increasingly common, especially with semantic variations between neighbouring concepts such as DC or digital literacy across geographic boundaries (Reis et al., 2019; Spante et al., 2018).

Although the boom in DC research initiated well before the shift to emergency remote teaching, justification for such research has only been amplified by the current mode of teaching in HE. Recent research has examined integrating DC into curricula (Sánchez-Caballé et al., 2021), defined a new dimension of pedagogical DC which intersects values, knowledge and skills (From, 2017), and examined the role of DC in enabling teaching innovation through teacher training (Garzón Artacho et al., 2020). Recently, supranational frameworks related to TDC have had increasing influence on national policies (McGarr et al., 2021), most notably with the common European framework for the DC of educators (DigCompEdu), aimed at guiding policy and implementing regional and national training programs (Redecker & Punie, 2017). Specifically, the DigCompEdu framework has influenced the expansion of research which develops scales and self-assessment instruments for measuring TDC (Cabero-Almenara, Barroso-Osuna, et al., 2021; Ghomi & Redecker, 2019). Needless to say, facing an abundance of recent evidence, keeping up to date in the field can be a challenge for practitioners and researchers and thus systematic reviews can be a starting point for developing research and practice guidelines.

TDC in HE

Throughout the 2010s, the concepts of DC, digital literacy and digital skills have been increasingly intertwined in education policy discourse, with implications for classroom practice, teacher education and continuing teacher professional development. Often these concepts have been used interchangeably, and despite an abundance of research whose aim has been to clearly delineate definitions, there remains some murkiness around their use and development over time and across geographic, disciplinary and methodological boundaries (Reis et al., 2019; Spante et al., 2018). Recent work has been carried out to propose and validate conceptual frameworks to support DC in education (Castañeda et al., 2018; Falloon, 2020; Redecker & Punie, 2017), and research has become aligned to specific contexts of HE, most notably teacher education (Krumsvik, 2014).

Broadly speaking, DC often refers to the skills and literacies needed for the average citizen to be able to productively learn, navigate and participate in society (Ilomäki et al., 2016), while TDC is characterised as the set of skills, attitudes and knowledge required by educators to function professionally and productively in diverse and digitally mediated environments (Esteve-Mon et al., 2020; Falloon, 2020). Further, as outlined by Redecker and Punie (2017) in the widely cited DigCompEdu framework, TDC involves supporting and empowering student DC through the use of digital technology. A range of competency areas related to common teaching practices are emphasised in this framework, including developing educational resources, designing and enacting teaching and learning activities, assessment practices as well as engaging in professional learning communities. One of the most recurrent justifications for TDC development in HE is the scale and scope of technology integration into all dimensions of professional life, and the associated demands placed on teachers in meeting the challenges posed by a global digital society (Esteve-Mon et al., 2020).

Research has established that regional differences exist around the use of the constructs of DC and digital literacy in HE research, the former being favoured in continental Europe (Spain, Italy, Scandinavia), the latter being used in English speaking countries (United Kingdom, United States of America) (Spante et al., 2018). Research has revealed that digital literacy studies in HE have been more frequent and over a longer period of time, while DC research has emerged in the last decade. There is also a divide between research which focuses on teacher education programs and research which centres on TDC more broadly at an institutional level and across disciplinary boundaries. Specific to teacher education programs, the technological pedagogical content knowledge conceptual framework has been immensely influential for teachers-in-training in understanding the types of knowledge and competencies required to effectively teach with technology (Mishra & Koehler, 2006). More recently, research has developed teacher educator technology competencies to support teacher educators in understanding what knowledge, skills and attitudes are needed to effectively integrate technology during teacher preparation programs and beyond (Foulger et al., 2017).

Research questions and purpose

Although there is an abundance of systematic reviews on DC in educational contexts with increased attention on TDC, these reviews cover a range of perspectives and levels of analysis, often showing one piece of the larger DC landscape in HE. Much of the previous work on TDC focuses on teacher education and teacher preparation programs (Krumsvik, 2014; Spante et al., 2018) or is centred on the pre-university level of teaching (Esteve-Mon et al., 2020). It is clear that the post-pandemic university will continue to shift towards emerging and intensified models of hybrid and blended forms of digital learning. In this regard, from a transdisciplinary perspective, TDC will be increasingly critical for carrying out core teaching and learning activities across institutions. Despite a recent upsurge in TDC research, much of the existing literature on integrating digital technologies in HE emphasises student learning rather than focusing on the development of faculty teaching (Esteve-Mon et al., 2020; Guri-Rosenblit, 2018).

We aim to build upon previous reviews by providing an integrated synthesis of existing knowledge on TDC. Our research team represents a diverse group of university professors and researchers with a multi-disciplinary and international focus, from a fully online university in Barcelona, Spain, where TDC is a fundamental aspect of professional life. The current study stems from our interest in faculty professional development through a TDC framework, an interest in understanding how research has been conducted in this field and how it can be improved. We hope to inform future teacher education and continuous faculty professional development by identifying future lines of inquiry in this field, guided by the following research questions:

- RQ1: What are the characteristics of published systematic reviews in relation to TDC research in HE?
- RQ2: What are the implications for practice for TDC development in HE suggested in these reviews?
- RQ3: What is the quality of these reviews?

Methodology

We carried out an overview of systematic reviews following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (see Appendix A) (Moher et al., 2009) and the procedures described by Polanin et al. (2017). Identifying, appraising and synthesising published reviews on a given topic using an overview approach is especially suited when facing an abundance of research. Although overviews are performed in many similar ways to traditional systematic reviews, one of their most significant distinctions is the need for researchers to consider multiple levels of analysis (i.e., the overview, review and primary study levels) (Polanin et al., 2017).

Search strategy

To identify potentially relevant documents, Scopus, Web of Science and Dialnet were searched from inception to January 2021. Scopus and Web of Science were selected because they are among the most relevant in international multidisciplinary literature (Aghaei Chadegani et al., 2013), while Dialnet offers the most relevant bibliometric information in Spanish. The search terms used – reported in Table 1 – were initially developed by the research team and further refined with an information scientist working at the Universitat Oberta de Catalunya. The search was carried out in January 2021. To ensure complete coverage, a complementary search was also carried out in Google Scholar. In total, 1608 records were identified through the search strategy, shown in Figure 1.

Table 1

Search terms

Concept	Search terms (in title, abstract, or keywords)
TDC	“digital competenc*” OR “teach* digital competenc*” OR (teach* AND “digital competenc*”) OR “digital literac*” OR “teach AND “digital literac*”
Systematic review or meta-analysis	“systematic review*” OR “meta-analys*”

Inclusion criteria

Publications that reported a systematic literature review of empirical research on TDC development in HE were included. Publications reporting bibliometric studies were also included. Systematic reviews had to synthesise studies that had been totally or primarily carried out in HE settings and focused all or part of their research questions on TDC or DC development in HE. Only publications in English or Spanish were included.

Study selection

The study selection was conducted in two phases. First, after duplicates were removed, the first three authors acted as reviewers, screening publications by title and abstract. To iteratively establish a common understanding and application of the inclusion criteria, the screening was performed in four cycles of 100 publications each. The remaining documents were then screened, and any disagreements between the reviewers were discussed and reconciled using EPPI Reviewer software (<https://eppi.ioe.ac.uk/cms/Default.aspx?alias=eppi.ioe.ac.uk/cms/er4>). In the second phase, the same three reviewers assessed the eligibility of the remaining publications using a full text assessment. Reasons for exclusion were documented. Any disagreements between the reviewers were also resolved through consensus.

Critical appraisal criteria

To critically appraise the included reviews and assess if they were conducted and reported according to high-quality standards (Pollock et al., 2021), the Joanna Briggs Institute (JBI, (2017) checklist for systematic reviews and research syntheses was used (see Appendix B). A scoring system consisting of assigning scores to each review based on each of the 10 checklist questions was used. When the specific criteria under consideration were explicitly and clearly reported in the review, one point was assigned; when the review only partly or ambiguously described the criteria, a half point was assigned; and when the criteria were missing, zero points were assigned. The scores were then summed to yield the final quality score out of 10. To be included in the final synthesis, reviews had to meet a quality threshold of 5. The results of the quality assessment were used to contextualise the overview's evidence base and assess how the systematic review methods may have affected the overview's overall results (Pollock et al., 2021), including implications for practice and research (Aromataris et al., 2015). After critical appraisal, 10 studies were excluded, leaving 13 studies for evidence synthesis.

Data collection and synthesis

EPPI Reviewer software and an Excel worksheet were used to extract and code the data from the included reviews. Data collection and synthesis were carried out in three phases. In the first phase, a data extraction form was developed in an Excel worksheet as a logical approach for storing extracted information (i.e., review characteristics, purpose, synthesis methods and findings). Two reviewers who had been involved in the screening and eligibility phases independently extracted the information from a random sample of 20% of the included reviews. As in the screening phase, disagreements between the reviewers on the application and interpretation of the extraction form were resolved through consensus. After reaching agreement, data extraction was conducted on the remaining reviews by two independent reviewers. Using guidelines by Aromataris et al. (2015), the following aspects of each publication were extracted: publication metadata (i.e., publication year and type), review purpose, type of review, setting and context, number of databases used, date range of included studies, number and types of studies included and country of origin of each review, method for evidence synthesis, reported findings, implications for practice and future lines of research.

In the second phase, after the extraction was completed, a hybrid coding scheme was developed, which allowed for both, deductive (closed) and inductive (open) coding to occur in relation to the specific objectives of the study in a flexible and emergent manner. This coding phase, which was implemented by two independent reviewers, emphasised double-checking for accuracy, reliability and consistency of the hybrid code scheme. In the third and final phase, qualitative content analysis (Schreier, 2012) was used to generate literature summary tables of the included reviews and identify patterns in the coded data.

Descriptive statistics were used to calculate the percentage of study characteristics reported across different methodological aspects and systematically describe and synthesise the range of variables studied.

Results

The search yielded 1608 publications, of which 1603 were identified through the search in databases, and five were identified through Google Scholar. After discarding the duplicate publications, applying the inclusion criteria and excluding those studies that did not meet the quality threshold, 13 publications reporting systematic reviews on TDC development were included in the overview. Figure 1 shows the PRISMA flow diagram of the review process.

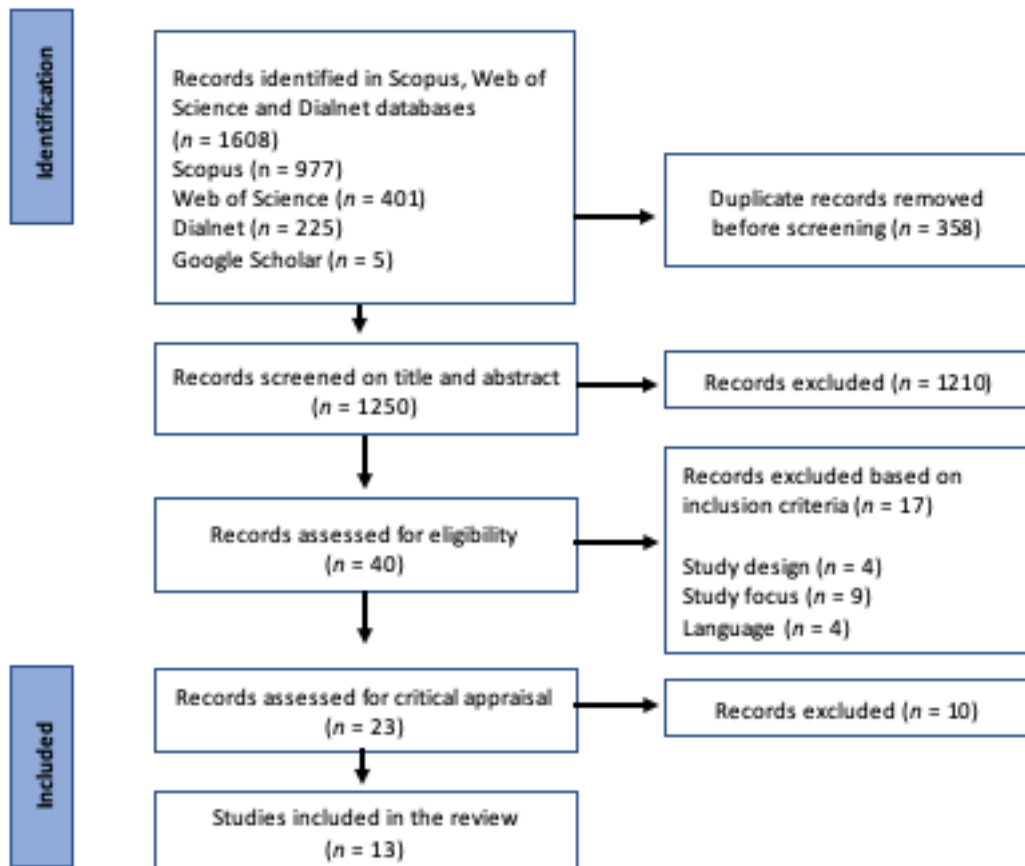


Figure 1. Study selection PRISMA flow diagram

- RQ1: What are the characteristics of published systematic reviews on TDC research in HE?

Table 2 shows the synthesised characteristics of the 13 included reviews (see full characteristics on Figshare at https://figshare.com/articles/dataset/Table_2_Full_characteristics_of_included_reviews/14785314/1). Three distinct settings and contexts were identified, the most frequent being general DC development in HE ($n = 5$). Contexts analysed in these settings looked at faculty, students, teaching and learning, research, organisation, governance and infrastructure. Four reviews focused on teacher training and teacher professional development, much of which was conducted in faculties of education. Finally, four reviews focused specifically on TDC in HE in their analysis. In total, 740 studies were synthesised across 13 reviews. The review with the most included studies was 154, while the review with the least was 13. Most reviews were published in English (69%), the rest in Spanish (31%). The majority of the reviews were geographically affiliated with Spain (61%), while studies also originated in Sweden (15%), Norway (7.5%), Peru (7.5%) and New Zealand (7.5%). Five reviews searched only in English, while the rest searched in

multiple languages related to their geographic origin. Combining English and Spanish (22.5%) was the most common search combination. Publication dates ranged from 2000 to 2021, with the average range from 2007 to 2016. Although some reviews used only one database to search (15%), most used two (38%) or three (23%). The most commonly used databases were Web of Science (61%), Scopus (54.5%) and ERIC (54.5%).

Table 2
Characteristics of included reviews

Author	Setting and context	Included studies	First author geographic affiliation and language	Date range of included studies
Duran et al. (2016)	TDC in HE	13	Spain; Spanish	2005–2016
Esteve-Mon et al. (2020)	TDC in HE	43	Spain; English	n/r
Fernández-Batanero et al. (2020)	TT & TPD	21	Spain; English	2008–2018
Palacios et al. (2020)	TDC in HE	68	Spain; English	2009–2018
Perdomo et al. (2020)	TDC in HE	26	Peru; Spanish	2010–2020
Pettersson (2018)	DC development in HE	41	Sweden; English	2008–2017
Recio et al. (2020)	DC development in HE	18	Spain; Spanish	2014–2019
Rodríguez-García et al. (2019)	TT & TPD	154	Spain; Spanish	2009–2017
Røkenes & Krumsvik (2014)	TT & TPD	42	Norway; English	2000–2013
Sanchez-Caballe et al. (2020)	DC development in HE	126	Spain; English	2006–2017
Spante et al. (2018)	DC development in HE	107	Sweden; English	1997–2017
Starkey (2020)	TT & TPD	48	New Zealand; English	2008–2018
Zhao et al. (2021)	DC development in HE	33	Spain; English	2015–2021

Note. TDC in HE = teacher digital competence in higher education; TT & TPD = teacher training and teacher professional development; DC = digital competence development in HE; n/r = not reported.

In relation to the types of studies included in the reviews, many (38%) omitted this information. Among those that reported (62%), the most commonly included study type was quantitative (61%), followed by qualitative (46%), mixed methods (38%) and theoretical papers (38%). A total of 84% reported including peer-reviewed and indexed studies as a criterion for inclusion. Turning to the type of review reported by the authors, the majority reported a systematic literature review (53%), while others reported using a meta-analysis and/or bibliometric study (15%), or variations such as bibliometric study (7.5%), bibliometric and documental review (7.5%), literature review method (7.5%) or qualitative literature review (7.5%). When examining whether review authors used critical appraisal tools, we were surprised to find that few (15%) reported assessing for quality of the included primary studies. Concerning the method of synthesis reported by review authors, the majority involved a form of content analysis and descriptive synthesis. Qualitative content analysis (46%) was inferred in just under half the studies, as the authors did not explicitly report synthesis methods in these cases, while content analysis (15%) and thematic content analysis (15%) were also used. To support the critical synthesis and presentation of evidence, literature summary tables are an essential technique, reported in a majority of studies (77%).

- RQ2: What are the implications for practice for TDC development in HE suggested in these reviews?

The phenomenon of interest, synthesised findings and implications for practice are shown in Table 3. When examining the phenomenon of interest, we grouped selected studies into the following categories: research trends on DC in HE ($n = 6$), pedagogical aspects on DC ($n = 4$) and revising the concepts and models of DC ($n = 3$).

Table 3
Presentation of phenomenon of interest, synthesised findings and implications for research and practice

Phenomenon of interest	References	Synthesised findings	Implications for practice
Research trends on DC in HE	Fernández-Batanero et al. (2020); Perdomo et al. (2020); Rodríguez-García et al. (2019); Sánchez-Caballé et al. (2020); Starkey (2020); Zhao et al. (2021)	<ul style="list-style-type: none"> • ICT training main element for teacher professional development. • Teacher collaboration and use of technological resources as a factor for improvement. • Teachers unqualified in DC, with insufficient ICT training: despite favourable teacher attitude towards technologies. • TDC in HE research should be reoriented due to lack of research that goes beyond descriptive research based on teacher self-perceptions. • Significant impact identified in DC research in HE generated by the definition of the key competences that every citizen must possess. • Most frequently used terms are “digital literacy” and “digital competence” • Most frequently used DC elements: Information skills, technical skills, content creation/media skills, communication. • Proposed model frames DC in three ways: generic DC; TDC; professional DC. • DC in HE research defined in a general way by referring to policy documents and related research. • Students are more frequently studied than teachers. • DC level of teachers and students is at a basic or medium level. 	<ul style="list-style-type: none"> • Need for revising and/or developing curricula to incorporate TDC for future professionals. • Importance of digital teacher training for the development of student DC. • Recognise the link between teaching competence and pedagogical leadership for educational innovation • More clarity is needed around the concept of DC. • A need for DC development strategy for youth and/or students. • University staff and educators should adapt their training to the pace of technological evolution. • Emergence of a professional DC profile, setting new agenda for research & practice. • Applying a practical test of digital tasks may provide a better understanding of participants’ DC.
Pedagogical aspects on DC	Esteve-Mon et al. (2020); Pettersson (2018); Recio et al. (2020); Røkenes & Krumsvik (2014)	<ul style="list-style-type: none"> • Justifications for DC in HE: meeting the new challenges of the digital society, enriching the teaching-learning process, developing DC of students as a key competence and promoting content and professional development by using digital technologies. • TDC composed of a series of technical skills, didactic application in the teaching-learning process, inclusion in professional development and the ability to develop the DC of students. • Teaching staff show an adequate DC at a basic level. DC has become a shared object between stakeholders in educational contexts with no consensus or common understanding for what DC is. • Supportive institutional infrastructures and concrete support measures are needed. 	<ul style="list-style-type: none"> • HE institutions need to be able to respond to the new demands of digital education with adequate DC training for educators. • DC development goals and visions should preferably be formulated in policy-related documents on multiple levels of the educational system. • School organisations should develop institutional infrastructures to develop competences needed for work in digitalised schools. • School leaders should help staff formulate goals and recognise specific needs to reach these goals. • Digital competent leadership should be thought of as a school-level characteristic.

		<ul style="list-style-type: none"> • Teachers and teaching practices: assumption that teachers are responsible for developing their own DC to meet the needs of students. • DC can be expressed in different ways and initial training should reflect this. • Students' previous experiences can generate positive mastery opportunities. • Pedagogical approaches identified to develop DC: collaboration; metacognition; blending; modelling; authentic learning; student-active learning; assessment; and bridging theory/practice gap. 	<ul style="list-style-type: none"> • HE faculty must encourage self-regulation of learning, show the usefulness of digital technologies and encourage their incorporation into the teaching and learning process. • Reflective DC practice: Student teachers should be asked to discuss and reflect on the pedagogical and didactical value added when integrating ICT in their teaching.
Revising the concepts and models of DC	Duran et al. (2016); Palacios (2020); Spante et al. (2018)	<ul style="list-style-type: none"> • Propose TDC model in HE through three frames: TDC in HE; TDC; General DC. • Reviews 2 frameworks for DC development (Instituto Nacional de Tecnologías Educativa y Formaciond el Profesorado, 2017; Redecker & Punie, 2017), discussing central DC categories and areas for teacher training in HE. • DL has been used more frequently and over a longer period and hence a more established concept in HE research. • Regional differences of use appear: DL research often conducted in English speaking countries (UK, USA) and DC research in European countries outside the UK (Spain, Italy and Scandinavia). 	<ul style="list-style-type: none"> • Need for development of training proposals for TDC in HE • Need for ongoing evaluation of teacher-training centres to diagnose ICT culture, infrastructure and services. • Developing digital and media competency awareness during initial teacher training. • A need for informed and conscious referencing to the established definitions of the concepts to avoid mismatches and validation problems. • Increased attention to when and for what purposes the definitions are employed.

Note. ICT = information and communication technologies.

Tracking research trends on DC in HE, Sánchez-Caballé et al. (2020) examined the evolution of the concept of DC in relation to university students, concluding that the most frequently used DC dimensions include information skills, technical skills, content creation and media and communication skills. Aiming to explore teacher preparation for the digital age and identify what research focus is needed for the future, Starkey (2020) proposed a model which frames DC in three different ways: generic DC, digital teaching competence and professional DC and signalling the emergence of a professional DC profile which sets a new agenda for research and practice. Zhao et al. (2021) concluded that DC is often defined in a general way by referring to policy documents and related research. Several authors indicated that more clarity is needed around the DC concept (Sánchez-Caballé et al., 2020; Starkey, 2020), while Zhao et al. (2021) have argued for moving beyond TDC self-assessment research designs, proposing that applying practical DC tests may provide a better understanding of a participant's DC.

In considering pedagogical aspects on DC, several authors have agreed that teacher's initial training is essential for DC development (Recio et al., 2020; Røkenes & Krumsvik, 2014). Esteve-Mon et al. (2020) claimed that HE teaching staff show an adequate degree of DC at a basic level, while Sánchez-Caballé et al. (2020) revealed that the current generation of students do not have a high level of DC. Pettersson (2018) underlined that school organisations should develop institutional infrastructures that support both their own and their staff's development of the competences needed for work in digitalised schools. Røkenes and Krumsvik (2014) proposed a reflective approach to DC as an implication for practice, asking student teachers to critically discuss and reflect on the pedagogical aspects and didactical value added when integrating ICT in their teaching.

Among those interested in revising concepts and models of DC in HE, Palacios et al. (2020) reviewed two frameworks – DigCompEdu (Redecker & Punie, 2017) and the common framework for DC from the National Institute for Educational Technology and Professional Development (Instituto Nacional de Tecnología Educativa y Formación del Profesorado, 2017) – which can serve to develop DC awareness during initial teacher training, while Duran et al. (2016) proposed a TDC model for HE through three frames to support professional practice: TDC in HE, TDC and general DC. In reviewing concept use of DC and digital literacy in HE research, Spante et al. (2018) concluded that digital literacy has been used more frequently and over a longer period and thus is a more established concept compared to DC, arguing for informed and conscious referencing to established definitions. Also, regional differences appear between the two concepts, where digital literacy research is often conducted in English speaking countries, while DC research in European countries outside the United Kingdom.

- RQ3: What is the quality of published systematic reviews on TDC research in HE?

To assess the quality of the included reviews, we used the JBI (2017) checklist, which consists of 10 items. As shown in Table 4, the quality of the included reviews ranged considerably, and this variability will impact on the interpretation and implications for practice and research. Three clusters of quality emerged, with those in the highest range scoring between 8 and 9 on a quality score out of 10. The middle-quality cluster scored between 6.5 and 7.5, and the lower third scored between 5 and 6, a relatively low threshold for inclusion. As noted earlier, 10 reviews were excluded by not meeting the pre-established quality threshold of 5, an unanticipated result. The average total quality score was 6.75, and no review met all the criteria.

Table 4
Critical appraisal of included reviews

Author	1	2	3	4	5	6	7	8	9	10	Score
Røkenes & Krumsvik (2014)	+	+	+	+	+	0	0	+	+	+	9
Spante et al. (2018)	+	+	+	+	0	0	+	+	+	+	9
Sánchez-Caballé et al. (2020)	+	+	+	+	0	0	+	+	+	0	8.5
Zhao et al. (2021)	+	+	+	+	+	-	-	+	+	+	8
Fernández-Batanero et al. (2020)	+	+	+	+	-	-	0	+	+	+	7.5
Starkey (2020)	+	+	+	+	-	-	+	+	+	0	7.5
Esteve-Mon et al. (2020)	+	+	+	+	-	-	-	+	+	+	7
Perdomo (2020)	-	+	+	+	0	-	+	+	0	+	7
Palacios et al. (2020)	-	+	+	+	0	-	+	+	+	-	6.5
Pettersson (2018)	-	+	+	+	-	-	-	+	+	+	6
Duran et al. (2016)	-	0	+	+	-	-	-	+	0	+	5
Recio et al. (2020)	-	+	+	+	-	-	-	+	0	0	5
Rodríguez-García et al. (2019)	+	+	+	+	-	-	-	+	-	-	5

Note. 1. Presence of a review question; 2. Use of inclusion criteria; 3. Use of search strategy; 4. Sources and resources used to search were reported; 5. Criteria for study appraisal; 6. Critical appraisal conducted by two or more reviewers; 7. Minimise errors in data extraction; 8. Methods used to combine studies; 9. Recommendations for policy and/or practice; 10. Implications for future research; + = Clearly reported; 0 = Partially reported; - = Not reported.

Surprisingly, just over half of the reviews (61%) included a guiding review question, an essential step that helps define the scope when conducting systematic reviews and establish effective search strategies. Most reviews clearly reported inclusion criteria, search strategies and sources and resources used for the review process. However, critical appraisal was another surprising method that was absent from most reviews (85%). Only two reviews assessed the quality of included primary studies and no reviews explicitly reported critical appraisal being conducted by two or more reviewers independently. This finding has implications as there is no indication of the quality of the included primary studies in most reviews, bringing into question the reliability and validity of the overall findings. Data extraction was another clear limitation, as under half of the reviews (38%) reported methods to minimise errors in this critical phase. Another area of concern were the recommendations for policy and practice and specific directives for future lines of research. In both criteria, there should be a clear link to the results of the review. In the lower-quality cluster, three reviews had vague recommendations for policy or practice and one review did not report any. Concerning future lines of inquiry, three reviews had ambiguous implications for future research, which

did not clearly relate to the results of the review, while two reviews did not report any gaps in the research requiring future attention.

Discussion

The purpose of the current overview was to synthesise systematic reviews and provide an integrated view of existing knowledge that can be used to support TDC development in HE, including recommendations for practice and future research, given the current state of the evidence. Overall, a synthesised assessment emerged of an ever-expanding research field. Three clear settings were identified by synthesising evidence from 740 studies across 13 systematic reviews. The most frequent setting was general DC development, which took a broad view across different areas and levels of analysis (i.e., faculty, students, teaching and learning processes, governance and leadership) often concerned with identifying research trends or pedagogical aspects of DC development. A second setting was specifically concerned with TDC in HE, analysing the digital teaching competence of university teachers (Esteve-Mon et al., 2020) and proposing new DC conceptual models specifically for HE contexts. Research purposes here are concerned with revising concepts and models of TDC as well as pedagogical considerations, such as revising curricula, offering training proposals and developing TDC evaluation frameworks. A third setting focused on teacher training, relating most specifically to the faculty of education setting, a finding which is consistent with observations in the literature (Esteve-Mon et al., 2020; Krumsvik, 2014; Spante et al., 2018).

In regard to RQ1, the evidence synthesis revealed a significant interest in TDC research in Spain, consistent with other findings in the literature (Reis et al., 2019; Spante et al., 2018). It is clear that in Spain and elsewhere, there is increased attention on DC research, predominantly conducted by researchers in the field of EdTech affiliated with faculties of education. Building diversity in terms of disciplinary perspectives and methodological approaches (i.e., beyond self-perception surveys) on TDC development, advancing new and innovative ideas at the boundaries of social science and other disciplines such as health sciences, as in the case of Cabero-Almenara, Guillén-Gámez, et al. (2021), computer science or engineering, could help advance more rigorous research and reimagine TDC research in new directions from a multidisciplinary perspective.

Moving to the methodological characteristics of the synthesised reviews, there is a real concern about the quality of the conduct and reporting of research, a concern which has long been raised in the EdTech field (Bulfin et al., 2020; Castañeda et al., 2018), where basic forms of descriptive research continue to prevail (Hew et al., 2019). With regard to the types of studies included, the type of systematic review conducted, critical appraisal and the methods used to combine results of studies, there was a general sense of ambiguity when reporting, including significant underreporting, corresponding with the findings of Polanin et al. (2017). The methodological literature is clear regarding the critical importance of these reporting items to the value of systematic reviews and that “the conduct of a systematic review depends heavily on the scope and quality of included studies” (Moher et al., 2009, p. 2). In particular, the lack of critical appraisal in the majority of revisions leads to questions of validity and reliability of the results, including whether review authors conducted and reported their research to the highest possible standards (Pollock et al., 2021). TDC research could be more relevant and impactful if these methodological weaknesses are addressed.

In relation to RQ2, several authors (Pettersson, 2018; Sánchez-Caballé et al., 2020; Spante et al., 2018) highlighted the necessity of establishing rigorous definitions of concepts to avoid mismatches and validation problems. Once these concepts are clarified, research could focus on developing models with dimensions and specific indicators relevant for TDC in HE (Duran et al., 2016). Established TDC models should enable the development of tests or task-based criteria to evaluate TDC in HE for certification purposes and, in particular, for designing teachers initial and ongoing training proposals (Duran et al., 2016; Fernández-Batanero et al., 2020; Palacios et al., 2020; Starkey, 2020).

HE institutions need to be able to respond to the new demands of digital education, particularly as we move towards post-pandemic realities characterised by hybrid and blended models. In this sense, it is essential to increase TDC research across disciplines, subject matter and geographic realities (Perdomo et al., 2020; Pettersson, 2018; Zhao et al., 2021). TDC in HE research should be reoriented due to a lack of robust research that goes beyond descriptive research based on students or teacher self-perceptions. Increasing sample sizes and the use of qualitative or mixed methods (i.e., case-studies, ethnographies, or in-depth studies) are needed, including exploring the possibility of using meta-analysis techniques (Esteve-Mon et

al., 2020; Perdomo et al., 2020; Zhao et al., 2021). Moreover, systematic reviews should be repeated regularly, and results applied to advance theory and practice (Pettersson, 2018).

Finally, it is important to analyse the role that universities play in DC development to enhance links between policy, organisational infrastructures, strategic leadership and teachers and teaching practices (Pettersson, 2018). In this sense, it is necessary to consider the connection between teaching competence and pedagogical leadership for educational innovation and the importance of digital teacher training for the development of student and institutional competencies (Fernández-Batanero et al., 2020).

In relation to RQ3, a broad variability was observed when assessing methodological quality, organised into low, medium and high-quality clusters. Similar to results from Polanin et al. (2017), one of the most concerning findings from the current study is the quality reporting of the reviews, both in terms of methodological reporting and reporting of the included primary studies. There were omissions across a range of criteria, as reported in the results. These findings can again be explained by the broader consensus in the literature about methodological quality and relevance of EdTech research more generally (Bulfin et al., 2020; Castañeda et al., 2018; Hew et al., 2019) as well as a lack of clear guidelines for systematic reviews in educational research, where much of the methodological literature comes from the health sciences (Aromataris et al., 2015; Pollock et al., 2021). There may be several factors explaining these results, including discipline, as critical appraisal is primarily carried out in the health sciences, pragmatic concerns such as time constraints or the fear that many studies will be excluded, or the lack of familiarity with guidelines for conducting systematic reviews.

Implications for practice

There are two lines of implications for the current study. The first deals with TDC development as a shared and widespread concern among a range of stakeholders in the HE context. The impact of TDC development in HE is felt far beyond institutional contexts as a motor for broader societal change considering that teacher training and teacher professional development is a fundamental setting for research in this area, influencing DC development in K-12 education and TDC encompasses the enabling of student DC and, therefore, the training of future professionals across a range of disciplines is directly affected by teacher competence in this area.

Many of the implications for practice have focused on either TDC training or evaluation programs as solutions; however, institutions need to strategically enable TDC development through an integrated and ecological perspective, understanding that training proposals are only one piece of a larger systems-based approach. Although developing DC awareness during initial teacher training is essential, there is a range of interconnected components which relate to TDC development beyond training which need to be considered, such as developing an institutional culture which strategically identifies TDC as a priority. Developing such a culture involves building goals and visions which are formulated in policy-related documents on multiple levels of both institutions and the educational system more broadly. It also includes providing optimal working conditions and opportunities for teachers to develop this important competency autonomously and collaboratively with colleagues and students. Further, it is critical to recognise the link between teaching competence and pedagogical leadership, curricular development and renewal, technological and institutional infrastructure, governance and academic leadership and the links and interactions between them, all of which affect teachers and their teaching practices.

The second line of implications concerns methodological considerations at both the systematic review and primary study level. Firstly, if critical appraisal continues to be overlooked when conducting systematic reviews, it will be difficult to assess the quality of work, with limitations in terms of rigour and quality. A booming research industry in TDC shows no signs of slowing down and systematic reviews will likely continue to emerge to synthesise the most recent evidence and allow researchers to keep up to date in a fast-moving field. Methodological guidelines from both education research (Polanin et al., 2017; Zawacki-Richter et al., 2020) and the health sciences (Aromataris et al., 2015; Pollock et al., 2021) should be followed for overview procedures, ensuring the highest standard of work possible.

Study limitations

Although clear methodological guidelines were followed, some limitations need to be examined. By using only three databases, some existing systematic reviews may not have been considered. By searching other languages, we may have been able to synthesise and assess other cultural approaches to TDC development in HE. Finally, we may have been able to gain greater insight from the evidence by carrying out more innovative analytical techniques during data extraction and analysis, such as co-citation mapping or overlap analysis.

Future lines of research

Given the current state of evidence synthesised in this review, we present several recommendations for future research. The first is a general need to reorient away from basic forms of research, driven by teacher and student self-perceptions, to more robust forms previously discussed. Future research could explore TDC through an educational design research approach, in line with Reeves and Lin (2020), who have shown promise in developing iterative solutions to complex educational problems while also engaging with and advancing theory. In agreement with Pettersson (2018), we encourage research which focuses on theorisation and operationalisation of the pedagogical aspects of TDC development in HE through an integrated perspective of micro, meso and macro level analysis, including “developing links between policy, organisational infrastructures, strategic leadership and teachers and teaching practices” (p. 1017). Finally, as the vast majority of research in this area originates from faculties of education in the field of EdTech, it would be beneficial to broaden the field by including multidisciplinary perspectives on TDC across a range of subjects outside of the social sciences, in order to see how disciplinary and paradigmatic differences may impact development in this area. Disciplinary plurality in research on TDC may bring interesting new ideas, including theoretical and methodological approaches that are emerging outside the usual purview of EdTech.

Conclusions

The current overview presents the key characteristics and features of TDC research in HE by systematically synthesising the current evidence base. The objective was to offer an integrated assessment of research in this area. Although there are many recent systematic reviews from a range of perspectives, geographic settings and levels of analysis, such reviews often show one piece of the larger DC in the HE puzzle. The results have several implications for TDC development, with a special view toward building an integrated perspective across a range of stakeholders and dimensions at the micro, meso and macro level. We hoped to deepen our understanding of the relationship between TDC training proposals, student DC development, criteria for DC evaluation, pedagogical quality and leadership, HE policy, technological infrastructures as well as academic leadership and governance. We have been able to offer some possibilities for reorienting the field by (a) strategically enabling TDC development through an integrated and ecological perspective, (b) moving away from basic forms of inquiry and incorporating multidisciplinary perspectives outside of educational sciences in order to advance theory and practice and (c) conducting and reporting research in line with methodological guidelines to ensure the highest possible standards at both the primary study and systematic review levels.

Compliance with ethical standards

The authors wish to report there is no conflict of interest associated with the current study, nor does the research involve human participants requiring informed consent.

Availability of data and materials

The data sets generated and analysed during the current study are available on the Figshare repository at <https://doi.org/10.6084/m9.figshare.15156258.v1>.

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Appendices

Appendix A

Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist (Tricco et al. (2018, pp. 467–473)

Section	Item	PRISMA-ScR checklist item	Reported on page #
Title			
Title	1	Identify the report as a systematic review.	Page 1
Abstract			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results and conclusions that relate to the review questions and objectives.	N/A
Introduction			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Page 2–3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts and context) or other relevant key elements used to conceptualise the review questions and/or objectives.	Page 3
Methods			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Not applicable
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language and publication status), and provide a rationale.	4
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Page 4
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the review.	Pages 3–4
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	4–5
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Pages 8–9, 12
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Page 6
Synthesis of results	13	Describe the methods of handling and summarising the data that were charted.	Page 6
Results			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 5–6

Section	Item	PRISMA-ScR checklist item	Reported on page #
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	6–7
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Page 11
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Pages 8–11
Synthesis of results	18	Summarise and/or present the charting results as they relate to the review questions and objectives.	Pages 5–11
Discussion			
Summary of evidence	19	Summarise the main results (including an overview of concepts, themes and types of evidence available), link to the review questions and objectives and consider the relevance to key groups.	Pages 12–13
Limitations	20	Discuss the limitations of the scoping review process.	Page 14
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 14
Funding			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Page 15

Note. JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

Appendix B

JBI critical appraisal checklist for systematic reviews and research syntheses

Critical Appraisal Item	Yes	No	Unclear
1. Is the review question clearly and explicitly stated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Were the inclusion criteria appropriate for the review question?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Was the search strategy appropriate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Were the sources and resources used to search for studies adequate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Were the criteria for appraising studies appropriate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Was critical appraisal conducted by two or more reviewers independently?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Were there methods to minimise errors in data extraction?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Were the methods used to combine studies appropriate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Were recommendations for policy and/or practice supported by the reported data?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Were the specific directives for new research appropriate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Note. The table contains all of the JBI items (p. 3) except for whether the likelihood of publication bias was assessed, which is not relevant for the purposes of the current systematic review in the field of educational technology.