Professional Development in Digital Competence for Special Education Teachers: A Systematic Review

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Abstract: Digital competence is increasingly being recognised as a crucial factor in transforming education in the technological era. Various studies have been conducted to identify and develop digital competence improvement programs for teachers. However, there has been a lack of comprehensive synthesis regarding their impact, particularly for special education teachers. This problem is important to explore, given that special education teachers face unique pedagogical challenges when serving students with disabilities. This systematic review aims to address this gap by exploring the implementation of digital competence programs for teachers in special education settings. In particular, this study analysed the characteristics of related publications, the effectiveness of training programs, the training materials expected by teachers, and the instruments used to assess digital competence. This study followed PRISMA guidelines, and a comprehensive search was conducted of the Scopus, ScienceDirect, and ERIC databases. This review synthesised 17 studies from 127 screened articles published between 2014 and 2024. The Inclusion and exclusion criteria were based on language, document type, publication year, research type, and full-text availability. The results indicated that while the interest in teacher digital competence is growing, research specifically targeting special education contexts remains limited. Most program initiatives adopt a one-size-fits-all approach, focusing on general digital tools rather than assistive or adaptive technologies suited to learners with disabilities. Training materials tend to emphasise technical rather than pedagogical and accessibility-related aspects. These findings indicate that there is a misalignment between the content of teacher training and the realities of inclusive digital classrooms. The results of this study provide valuable insights for developing digital competence development programs tailored to the needs of special education teachers. This research contributes to digital learning practice by providing a framework for designing practical digital training customised to special education contexts. It advances the scope of virtual and digital learning by highlighting the specific needs and conditions required for inclusive digital education to thrive.

Keywords: Digital competence, Professional development, Special education, Student with disabilities, Teacher training, Technology-Enhanced education

1. Introduction

The COVID-19 pandemic had a profound impact on the global education system. Many schools were closed to control the spread of the Coronavirus (Tadesse and Muluye, 2020; Meinck, Sabine, Fraillon, Julian and Strietholt, Rolf, 2022). Traditional classroom-based instruction shifted to distance learning facilitated by digital technology (Mali and Lim, 2021; Afikah et al., 2023; Fisher et al., 2024). Online education emerged as a solution for sustaining the teaching and learning process during the pandemic (Betancourt-Odio et al., 2021; Silletti et al., 2021; Starks and Starks, 2022; Bastian, Liza and Efastri, 2023). Technology integration in the online education system also ensured that learning is not confined to a specific space and time (Murphy, Malenczak and Ghajar, 2019; Podsiadlik, 2021). The crisis accelerated digital transformation in education, establishing new norms for integrating technology into teaching and learning environments.

The increased reliance on technology brought about a shift in the perception of digital tools from optional enhancements to essential components of educational delivery. Awareness of the importance of digital technology in the learning process has increased significantly following the COVID-19 pandemic. This shift is not limited to general education but also extends to special education contexts. The integration of technology in educational activities has provided new approaches and experiences (Kaplarević-Mališić et al., 2022; Liao et al., 2022). In special education specifically, this integration promotes inclusivity for students with disabilities (Olakanmi et al., 2020; Montenegro-Rueda and Fernández-Batanero, 2022). Various digital tools, such as screen readers, augmentative and alternative communication applications, and adaptive learning platforms, are increasingly being employed to support learning activities (Moreno-Rodriguez et al., 2021; Basnayaka et al.,

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2023; Reyes, Meneses and Xavier, 2023; Nino et al., 2024). These technologies bring with them opportunities for adaptive, flexible, and personalised learning for students with disabilities (Pearson et al., 2019; Thompson and Copeland, 2020; Ohalezim, Edwards and Aderemi, 2021). Technology devices thus serve both as an instructional media and as an empowering tool that enables differentiated instruction for students with disabilities.

Digital technology supplements traditional instruction and simultaneously transforms how teaching and learning occur. These changes require teachers to have adequate digital competence to utilise digital technology-based learning effectively (Claro et al., 2024; Gómez-Puerta et al., 2024; Kiryakova and Kozhuharova, 2024; Arif, Aziz and Ma'arif, 2025). Digital competence refers to the set of skills and abilities that enable the effective use of digital tools and technologies. In the teaching context, digital competence is a professional competence practice applied by the educator in their profession to use digital technology effectively in order to improve and innovate education (Redecker, 2017; Santoianni and Ciasullo, 2023). It generally includes technological proficiency, pedagogical awareness, content knowledge, attitude toward technology adoption, cultural insights, critical approaches, and professional engagement (Skantz-Åberg et al., 2022). Teachers' digital competencies influence their self-efficacy in relation to digital teaching (Börnert-Ringleb, Casale and Hillenbrand, 2021; Peng, Razak and Halili, 2024). The level of digital competence among teachers directly influences their confidence to teach effectively in a digital environment, which in turn impacts the students' learning outcomes (Pinto-Llorente et al., 2018; Tonks, Kimmons and Mason, 2021; Obesso, Nú˜nez-Canal and P´erez-Rivero, 2023).

The growing demand for digital integration in education emphasises the need for educators to adapt and improve their skills. Strengthening digital competence has become a significant area of study in educational practice and a primary goal of teachers' professional development (Alarcón, Jiménez and Vicente-Yagüe, 2020). Improving teachers' digital competence through professional development programs is critical for transforming education and preparing students for the future (Assainova et al., 2023; Baxter and Reeves, 2023). Such program opportunities include workshops, mentoring, online courses, and collaborative communities. The effectiveness of these programs is characterised by their relevance to the teachers' needs, sustained duration, active learning approaches, and opportunities for feedback and reflection.

Various studies have explored the topic of improving teachers' digital competence, highlighting both successes and challenges (Börnert-Ringleb, Casale and Hillenbrand, 2021; Tonks, Kimmons and Mason, 2021; Obesso, Nú˜nez-Canal and P´erez-Rivero, 2023; Peng, Razak and Halili, 2024). However, most of the existing research has focused on teachers in general education settings, with limited attention given to special education teachers (Carter and Rice, 2016; Almenara et al., 2023). This imbalance is concerning because teaching students with disabilities involves distinct pedagogical, technological, and contextual considerations (Hsieh, 2024). Students with disabilities may require tailored technological solutions such as assistive software, adaptive input devices, and accessible learning management systems that go beyond standard educational tools. For this reason, teachers in special education settings require digital skills that encompass understanding technological aspects and how technology can be effectively applied to teach students with disabilities (Gonçalves and Ferreira, 2021; Acuña-Gamboa, Mérida-Martínez and Pons-Bonals, 2023; Acuña-Gamboa and Pons-Bonals, 2024).

Despite the increasing recognition of the importance of digital competence in inclusive education, a systematic synthesis that evaluates the nature, design, and effectiveness of professional development programs tailored to special education contexts remains lacking. Previous studies have primarily examined general education teachers and focused on broader technology integration, leaving the specific professional learning needs of special education teachers underexplored. To address this gap, the present study conducts a systematic review of empirical research on the development of digital competence among special education teachers. Specifically, it analyses how professional development initiatives have contributed to enhancing the digital competence of special education teachers and identifies the instruments, content, and outcomes reported in previous studies. To achieve the objective, this study examines four research questions:

RQ1. What are the characteristics of publications in the field of digital competence among special education teachers?

RQ2. How effective is digital competence training on the abilities of special education teachers regarding technology-based learning for students with disabilities?

RQ3. What material do special education teachers expect from training related to technology-based learning for students with disabilities?

RQ4. What instruments are used to measure the digital competence of special education teachers?

Understanding how digital competence related to professional development programs impacts special education teachers is essential for improving training strategies. This understanding can inform policymakers, teacher educators, and school administrators in making evidence-based decisions to support inclusive digital education.

2. Literature Review

2.1 Conceptualising Teachers' Digital Competence

Digital competence is one of the fundamental teacher competencies that must be included in teacher education curricula. Recent frameworks such as the European DigCompEdu (Redecker, 2017) and the UNESCO ICT Competence Framework for Teachers (UNESCO, 2018) emphasise that digital competence extends beyond operational capabilities to encompass pedagogical design. However, there is no agreement on how teachers' digital competencies are defined and implemented (Claro et al., 2024).

Some studies emphasise the technical mastery of digital devices and access to infrastructure (Zhang, Sazalli and Nadjwa, 2024), while others focus on the pedagogical and contextual adaptations of technology use in the classroom (Aindriú et al., 2023; Kiryakova and Kozhuharova, 2024). This narrow focus can limit the understanding of how digital skills contribute to inclusive teaching, particularly in special education contexts where technology serves as a tool and instructional support.

2.2 Professional Development for Digital Competence

The ability to competently use digital technology in the teaching process has become a primary goal of teacher professional development (Alarcón, Jiménez and Vicente-Yagüe, 2020; Gurgenidze et al., 2022). Professional development is effective when it is ongoing, collaborative, subject-specific, utilises external expertise, is supported by teachers, has a content focus, and considers the role of context (Avci, O'Dwyer and Lawson, 2020; Sims and Fletcher-Wood, 2021).

However, a comparison of previous studies reveals substantial variability in training outcomes. Some studies have reported increased teachers' confidence and self-efficacy (Pérez and Delgado, 2019; Benigno et al., 2023), whereas others indicate the limited transfer of digital skills into classroom practice due to inadequate contextualisation (Fernández-Batanero, Montenegro-Rueda and Fernández-Cerero, 2022). These results demonstrate the importance of aligning professional development with the teachers' specific contexts and ensuring relevant content and materials.

2.3 Digital Competence in Special Education Context

Research focusing on digital competence among special education teachers remains relatively scarce. Most available studies examine the general education context, with few addressing the unique pedagogical and technological challenges faced by special education teachers (Fernández-Cerero and Montenegro-Rueda, 2023). A comparative analysis across studies reveals a persistent gap including a lack of training in the application of technology in learning to support students with disabilities (Pérez and Delgado, 2019; Graván and Cerero, 2022), a standardised or "one-size-fits-all" training approach (Starks and Reich, 2023), and unequal access to training for teachers (Acuña-Gamboa, Mérida-Martínez and Pons-Bonals, 2023). The use of digital technology in inclusive education can be utilised for training and repetition, to assist learning, and to expand learning opportunities (Drushlyak et al., 2023). To overcome these issues, there is a growing need for targeted professional development that provides teachers working with students with disabilities with appropriate content and experience (Olivencia et al., 2025). The contrast between what is needed (accessibility-oriented assistive competencies) and what is typically provided (general digital skills) reflects a critical research gap that justifies this systematic review.

2.4 Research Gap and Rationale for the Present Study

Although the research on professional development for digital competence has been extensive, several gaps remain:

- First, the literature remains fragmented as studies tend to examine digital competence development in isolation, lacking cumulative evidence.
- Second, there is limited analytical synthesis comparing digital competence development models across contexts and populations.

- Third, limited attention has been given to special education teachers' digital competence, particularly in terms of program design, learning expectations, and assessment instruments.

To fill these gaps, this review systematically analyses empirical studies published between 2014 and 2024 that focus on digital competence development programs among special education teachers. This review expands the existing knowledge by identifying trends and evaluating their effectiveness and contextual relevance.

3. Method

3.1 Research Design

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. The PRISMA framework was chosen because it offers a structured and transparent method that enables authors to conduct systematic and comprehensive analyses. Following this protocol helps to maintain the flow of evidence and enhances the reproducibility and credibility of the review process. As outlined by Page (2021) and Sarkis-Onofre (2021), the PRISMA consists of four phases: identification, screening, eligibility, and inclusion, which were carefully applied throughout this study to ensure methodological integrity.

3.2 Systematic Searching Strategies

Systematic searches were conducted across three major academic databases: Scopus, ScienceDirect, and ERIC databases. These sources were selected because they provide up-to-date, high-quality literature and encompass a range of multidisciplinary perspectives that support a comprehensive analysis. By using multiple databases, this review aimed to ensure comprehensive coverage of relevant studies and the capturing of diverse disciplinary perspectives on the topic.

3.2.1 Identification

In the first step of the PRISMA approach, three main keywords were identified: Digital Competence, Teacher Training, and Special Education. These terms were expanded using related synonyms and combined through Boolean operators (AND, OR). The search strategy accounted for both singular and plural forms of key terms (e.g., “digital competence” and “digital competences”) to capture variations in terminology. Wildcard and truncation operators (e.g., “competenc*”) were applied when supported by the database’s syntax. This step helped minimise the potential omission of studies that used slightly different phrasing. The formulas used in the three databases are listed in Table 1.

Table 1: Keywords of the search strings used in the databases.

Keywords	Database			Total
	Scopus	ScienceDirect	ERIC	
("digital competence" OR "digital skill" OR "technology competence" OR "technology skill")	9822	8743	3475	22040
("digital competence" OR "digital skill" OR "technology competence" OR "technology skill") AND ("teacher training" OR "teacher professional development")	692	646	205	1543
("digital competence" OR "digital skill" OR "technology competence" OR "technology skill") AND ("teacher training" OR "teacher professional development") AND ("special education" OR "inclusive education" OR "student with disabilities")	19	99	9	127

The first search using the keyword “digital competence” and its synonyms yielded 22040 publications. The search was then combined with the second keyword, “teacher training,” resulting in 1543 papers. The last search, utilising Boolean operators, combined the three keywords with their synonyms and yielded 19 papers on Scopus, 99 papers on ScienceDirect, and nine publications on ERIC. A total of 127 search results were included in the screening stage.

3.2.2 Screening

The second stage in the PRISMA protocol was screening. In this phase, several criteria were applied. Articles were selected from 2014 to 2024, and only included papers written in English were included, as English is used as the publication standard. For credibility and relevance, the selected articles had to be journal articles or

conference papers. Non-empirical studies that did not align with the review's focus on evidence-based findings were not included. The selected articles had to have full-text access to ensure comprehensive analysis. The inclusion and exclusion criteria are listed in Table 2.

Table 2: Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Language	English paper	Non-English article
Document type	Article journal, conference paper	Book chapter, review, report, dissertation
Research type	Empirical studies	Literature review
Text access	Full text	Did not have full text
Timeline	2014-2024	Earlier than 2014

Based on the criteria in Table 2, eight articles were excluded because they were not written in English, 22 articles as they were not journal articles or conference proceedings, and five because they were non-empirical studies. Additionally, the authors did not have access to the full text of 33 articles, and 13 articles were written outside the specified time frame. Thus, a total of 46 articles met the eligibility criteria and were included in the subsequent processes.

3.2.3 Eligibility

In the eligibility stage, the authors manually analysed the remaining articles by reading each article's title, abstract, and content to confirm their eligibility. Three articles were excluded as duplicate studies. The content analysis excluded another 31 articles that did not fit the research context, either because they did not focus on the study of teacher training for special education teachers or because they did not focus on teacher training in the field of digital competence.

3.2.4 Inclusion

After conducting three previous processes, at the final PRISMA stage, 17 papers were included in this systematic review. All studies discussed improving the digital competence among teachers of students with disabilities. The complete process of identification, screening, eligibility assessment, and final inclusion is illustrated in Figure 1.

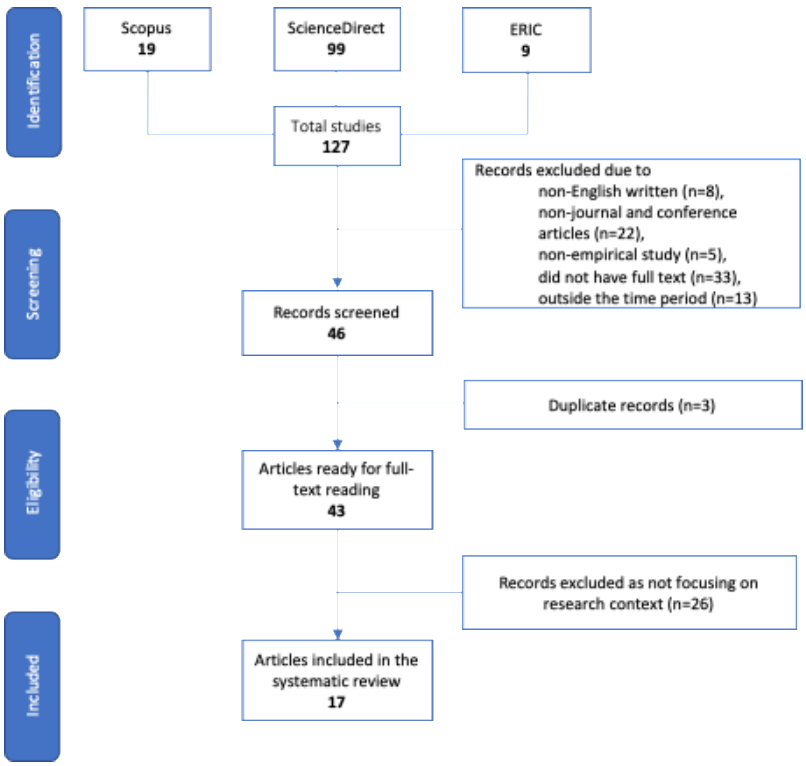

Figure 1: PRISMA flow diagram

3.3 Data Analysis and Extraction

A structured procedure was used for the data extraction and analysis to ensure clarity and transparency. A spreadsheet template was designed to record essential details from each of the 17 included studies. The extracted information covered the study title, year, authors, country, participant characteristics, research objectives, methodological approach, digital competence dimensions addressed, technologies used, and key findings related to teacher training and digital competence development. The lead author carried out the initial data extraction, after which the co-authors cross-checked all entries to ensure accuracy and completeness. Any disagreements were discussed and resolved through consensus, with reference to the original publications as needed. This collaborative checking process enhanced the reliability and transparency of the analytical process. For the content analysis, both quantitative and qualitative techniques were applied. These two approaches were chosen to allow a comprehensive understanding in the literature. The quantitative analysis involved generating various graphical representations to provide a comprehensive overview of the topic's general aspects. For the qualitative component, the VOSviewer tool was used to identify and categorise the primary themes of the study. A table containing all pertinent information from the articles included in the review was also compiled to facilitate the data extraction process (Table 3).

Table 3: Description of the research articles included in the review

Journal Indexing	Journal name	Methodology	Sample	Citation	Reference
Scopus Q1	Education and Information Technologies	Mixed method	114 university teachers and ICT professionals	1	(Román-Graván et al., 2024)
	European Journal of Special Needs Education	Quantitative	21 experts in technology and disability	9	(Montenegro-Rueda and Fernández-Batanero, 2024)
	Education and Information Technologies	Qualitative	13 special education teacher candidates	0	(Kurt and Erden, 2024)
	Heliyon	Quantitative	310 K-12 teachers	5	(Montes, Fuentes and Cara, 2023)
	Computer and Education	Qualitative	20 K-12 teachers	21	(Starks and Reich, 2023)
	Education and Information Technologies	Quantitative	2072 university teachers	16	(Fernández-Batanero et al., 2022)
	Research and Practice in Technology Enhanced Learning	Mixed method	1500 K-12 teachers	25	(Fernández-Batanero, Montenegro-Rueda and Fernández-Cerero, 2022)
	Literacy Research and Instruction	Qualitative	3 K-12 teachers	25	(Ciampa, 2017)
Scopus Q2	Journal of Education and e-Learning Research	Quantitative	130 K-12 teachers	0	(Aldousari and Yuan, 2024)
	Societies	Qualitative	62 K-12 teachers	1	(Montenegro-Rueda and Fernández-Cerero, 2023)
	Education Sciences	Quantitative	25 K-12 teachers	1	(Aindriú et al., 2023)
	International Journal of Educational Research and Innovation	Qualitative	10 experts in technology and disability	4	(Graván and Cerero, 2022)
	Journal of Special Education Technology	Qualitative	3 K-12 special education teachers	8	(Carter and Rice, 2016)

Journal Indexing	Journal name	Methodology	Sample	Citation	Reference
Scopus Q3	Journal of Learning for Development	Mixed method	44 student teachers	1	(Drushlyak et al., 2023)
	Journal of E-Learning and Knowledge Society	Mixed method	91 K-12 teachers	10	(Cappuccio, Compagno and Pedone, 2016)
Other international indexing	The Journal of Continuing Higher Education	Qualitative	64 university teachers	1	(Fernández-Cerero and Montenegro-Rueda, 2023)
	Journal of Online Learning Research	Mixed method	20 K-12 teachers	2	(Du, 2022)

4. Results and Discussion

4.1 What are the Characteristics of the Selected Publications About the Digital Competence of Special Education Teachers?

The first search using the keyword “digital competence” resulted in numerous publications. Likewise, searches related to teacher professional development programs and digital competence yielded numerous publications. However, this number decreased when filtered for the field of special education. Only 17 publications have been published on this topic over the last decade. This phenomenon highlights that digital competence development, particularly for teachers working with students with disabilities, remains poorly studied. Figure 2 shows the number of publications per year. Most publications were published in 2023 (n=6). This surge coincides with the post-pandemic period, during which the integration of digital tools into inclusive education has become more prominent.

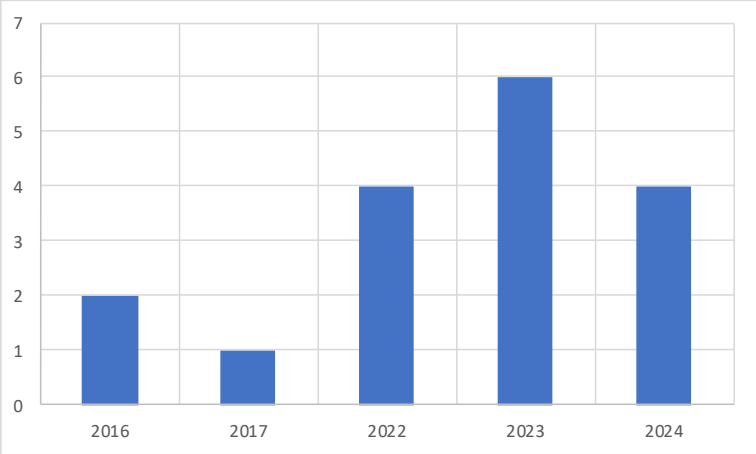

Figure 2: Study representation by year

Figure 3 illustrates the research methods used in the selected studies. Of the 17 articles, seven were qualitative, five were quantitative, and five were mixed methods. The variety of research methods utilised indicates that the topic can be investigated using multiple approaches. However, each method has a different purpose. Quantitative methods allow researchers to collect more data on the teachers' digital competence levels and training. Meanwhile, qualitative approaches enable a detailed and in-depth exploration of how teachers perceive the digital competence training they receive and what they need. At the same time, mixed-method designs collect data using both approaches to obtain comprehensive and in-depth results.

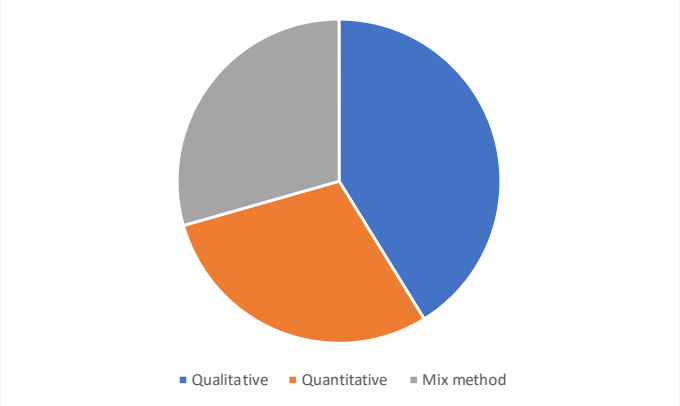

Figure 3: Distribution of the methodology utilised by the selected studies

Figure 4 shows the distribution of studies by country, grouped by first-author affiliation. Most studies were conducted in Europe. The dominance of European studies suggests that digital competence is conceptualised within EU policy frameworks (e.g., DigCompEdu).

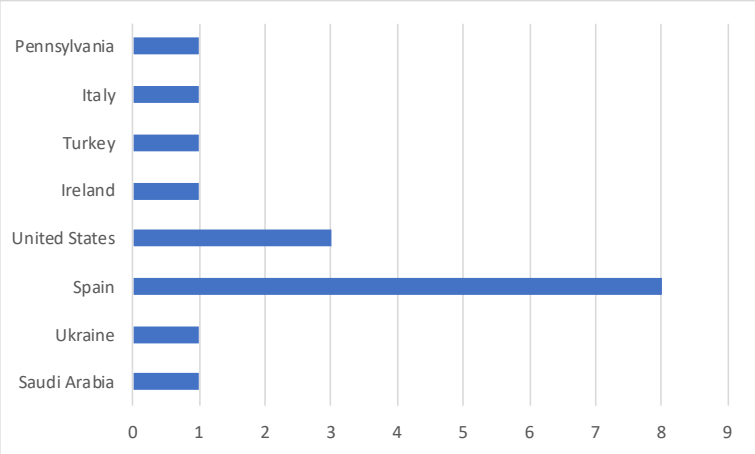

Figure 4: Studies representation by country

From the analysed references, keyword co-occurrence was examined using the VOSviewer software. Keyword co-occurrence analysis enables researchers to identify how two or more terms are interrelated and to reveal the critical points of a particular research area. Figure 5 shows the combined word network or keyword co-occurrence for this study.

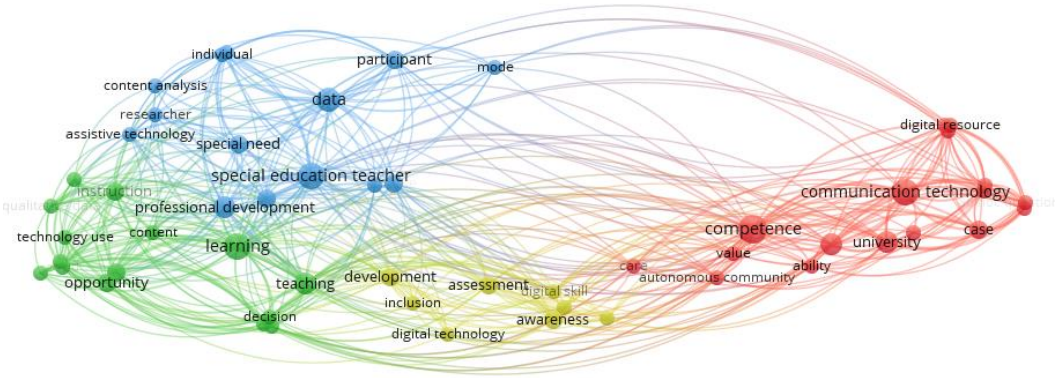

Figure 5: Co-occurrence map

From the 17 studies selected over the past decade, the researchers identified 58 keywords. As illustrated in Figure 5, these keywords were categorised into four distinct clusters based on their similarities, representing the primary research areas in this field. Cluster 1 (green) focuses on professional development, teacher training, and digital technology integration. This cluster emphasises the role of ongoing training programs and

institutional support in enhancing teachers' digital competence. Cluster 2 (blue) centres on special education, inclusive education, participants, and learning needs. This cluster highlights the pedagogical and contextual aspects of implementing digital tools for learners with disabilities. Cluster 3 (red) is associated with communication technology, competence, online learning, and autonomous learning. These keywords point to the intersection between the teachers' digital competence and their ability to facilitate remote or technology-mediated instruction. Cluster 4 (yellow) connects digital literacy, resources, and educational tools, reflecting studies that address the teachers' access to and use of digital resources as an enabling factor for competence development. The importance of each descriptor is depicted by the size of its corresponding circle or node, while the connections or spacing between nodes indicate their relationships to one another.

4.2 How Effective is Digital Competence Training on the Abilities of Special Education Teachers Regarding Technology-Based Learning for Students with Disabilities?

The analysis of the selected studies revealed that professional development programs in digital competence produced a limited impact on special education teachers. While there are studies show that special education teachers have a positive attitude toward technology (Pérez and Delgado, 2019; Dalbudak and Yiğit, 2021), their competence remains low according to their own perceptions, that of the school management, and the students (Klapproth et al., 2020; Uromova et al., 2020; Fernández-Cerero and Román-Graván, 2023). The main findings of this systematic review revealed two major problems in digital competence training for teachers. These issues collectively demonstrate why current training initiatives fail to achieve measurable improvements in the teachers' digital competence. The first concerns the low level of digital competence training for special education teachers (Román-Graván et al., 2024). Training is the first step for teachers to implement technology in their teaching (Romero-García, Buzón-García and de Paz-Lugo, 2020). Unfortunately, there are very few training workshops available to them. This low level of training is caused by the unequal access to training (Starks and Reich, 2023) and limited training available for special education teachers (Montes, Fuentes and Cara, 2023; Kurt and Erden, 2024).

The second problem lies in the design of the training received by special education teachers. Teachers report that the training they receive is the same for all, a concept known as the one-size-fits-all approach (Starks and Reich, 2023). This concept assumes that all teachers have the same needs. In reality, teachers have different demands, especially in the field of special education. This uniform approach makes the training the teachers receive less relevant to their needs. Therefore, the main goal of improving digital competence is often not achieved. This observation aligns with previous claims that professional development programs rarely account for contextual teaching differences, particularly within inclusive classrooms. Both of these problems reflect the lack of attention paid to the development of training specifically designed for special education teachers (Graván and Cerero, 2022). The lack of focus on training that meets their needs indicates a gap in supporting teachers looking to meet the challenges of inclusive education in the digital age. There is a need for more targeted training strategies and professional development efforts for teachers to use technology with students with disabilities (Fernández-Batanero et al., 2022; Fernández-Batanero, Montenegro-Rueda and Fernández-Cerero, 2022).

4.3 What Material do Special Education Teachers Expect From Training Workshops Related to Technology-Based Learning for Students with Disabilities?

The literature review revealed a lack of studies specifically related to the development of digital teaching competence training materials for special education teachers. Meanwhile, it is paramount to have relevant and contextualised training for the special education context, as special education teachers face distinct challenges when applying technology to support the learning process of students with disabilities.

Most of the selected studies indicated that the training received by special education teachers employed a generalised approach (Román-Graván et al., 2024), wherein the materials were not specific to using technology to assist students with disabilities. This approach disregards the fact that each teacher operates within a unique teaching context, particularly when implementing digital technology to support students with disabilities (Yıldız et al., 2022).

However, several studies have identified the learning material requirements of teachers in the field of special education. The learning materials required by special education teachers to enhance digital competence include didactic strategies to implement curricular adaptation supported by technology for students with disabilities; specific technological tools, devices, and software for students with disabilities; websites with educational resources for students with special educational needs; practical knowledge of digital tools that enhance accessibility, and guidelines for inclusive practices utilising technology (Fernández-Batanero, Montenegro-Rueda

and Fernández-Cerero, 2022; Montenegro-Rueda and Fernández-Cerero, 2023). Additional research has also identified the need for materials related to Understanding by Design (UbD), Universal Design for Learning (UDL), and assistive technology-infused curriculum (Alsolami, 2022; Du, 2022; Aindriú et al., 2023; Schladant et al., 2023). Several studies provided concrete examples of the types of digital tools and assistive technologies that special education teachers expect to be integrated into professional development programs. These include screen readers such as JAWS and NVDA for students with visual impairments; augmentative and alternative communication (AAC) applications like Speech Generating Devices (SGDs) for learners with communication difficulties; interactive whiteboard software, and voice recognition tools (Hilzensauer, Pecher and Angeloni, 2022; Montes, Fuentes and Cara, 2023).

Digital competence training should not only focus on the technical aspects of technology but should also encompass pedagogical aspects by examining how technology can be implemented and prove beneficial for teaching students with disabilities. Professional development for special education teachers requires alignment with frameworks such as UDL and TPACK but with the explicit integration of accessibility and assistive technology layers. This conceptual expansion could form the basis for a new model of 'Inclusive Digital Competence' that bridges pedagogical, technological, and accessibility dimensions.

4.4 What Instruments are Used to Measure the Digital Competence of Special Education Teachers?

An analysis of the empirical research reveals that several instruments can be employed to evaluate the digital competence of special education teachers. One notable reference is DigCompEdu, developed in Europe to assess educators' digital skills in various teaching contexts. The framework comprises 22 competencies from six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. DigCompEdu has become widely used to measure the teacher's level of digital competence (Fernández et al., 2022; Betancur-Chicué and Muñoz-Repiso, 2023; Moreira, Nunes and Casanova, 2023). However, researchers have begun to adapt the framework to the specific needs of teachers in special education. These adaptations ensure that the assessment measures particular skills related to inclusive teaching, such as the use of assistive technology and the design of an accessible digital environment.

Recent studies have highlighted the importance of using instrument tools that reflect the specific digital skills of special education teachers. Montenegro-Rueda and Fernández-Batanero (2024) developed an instrument to assess the digital competencies of special education teachers. This instrument comprises 44 items to evaluate teachers' digital skills across seven areas of disability: visual, hearing, physical, intellectual, autism spectrum disorder, severe behavioural disorder, and attention deficit hyperactivity disorder. The need to adopt the assessment instruments to measure the competence of special education teachers aligns with adjusting the learning materials and training.

The growing diversity of instruments highlights a critical issue: while existing frameworks such as DigCompEdu offer a solid foundation for assessing educators' digital competence, contextual adaptation remains essential. Future studies could focus on validating and refining these instruments across educational contexts. This will ensure that the resulting assessments more accurately reflect the teachers' ability to design digital inclusive learning environments for diverse learners.

4.5 Discussion

This review examined how digital competence among special education teachers has been conceptualised, developed, and assessed in previous research. A review of 17 studies shows the growing interest in this topic. However, most of the research remains concentrated in Europe—particularly in Spain—where the European DigCompEdu framework serves as the primary reference. This dominance suggests that the European policy context shapes the prevailing understandings of teachers' digital competence. This perspective may not be fully applicable to different educational systems with different infrastructure and policies. These findings point to the importance of government efforts to support the improvement of teachers' digital competence through policy, education, training, and ongoing support. The lack of policies on implementing digital learning for students with disabilities is one factor contributing to the under-implementation of technology in education. This aligns with the research findings (Courduff and Moktari, 2022; Hata et al., 2023) which emphasise the need for comprehensive regulations and guidance for implementing technology-based learning in educational institutions for students with disabilities.

The selected publications yielded relatively similar results regarding the effectiveness of teacher training. Most of the selected studies indicate that professional development programs have produced a limited impact on special education teachers. This limited effectiveness can be traced to two interconnected structural problems:

the restricted access to training opportunities and the prevalence of uniform one-size-fits-all" program designs. The limited availability of digital training programs for teachers indicates the need for more accessible and continuous professional development initiatives for all teachers. Policymakers and educational institutions must collaborate to design sustainable digital competence programs supported by adequate infrastructure that considers needs-based training. Training providers have to examine effective training models and identify barriers to special education teachers' participation in digital learning. Additionally, the educational institute can provide guides and self-study materials that teachers can use outside of training sessions, at any time and from anywhere.

A further issue concerns the content of the learning materials used in professional development. The reviewed studies show that existing professional development programs rarely incorporate pedagogical frameworks such as Universal Design for Learning (UDL), Understanding by Design (UbD), or assistive technology–infused curricula. The materials are often generic, lacking context-specific examples, case-based learning, or simulations that mirror real inclusive classroom challenges. Most training initiatives focus on general tools such as Google Classroom rather than assistive and adaptive technologies. For example, very few programs provide hands-on experience with tools such as screen readers, text-to-speech software, or communication boards. This suggests an imbalance in the design of professional development programs, often prioritising the technological aspect of digital competence over its pedagogical and accessibility dimensions. The results highlight the need for teachers to receive pedagogical, technological, and content training to improve their digital skills (Blasco-Serrano, González and Coma-Roselló, 2022). Future training programs should integrate practical case studies, simulated classroom scenarios, and co-designed modules developed in collaboration with special education teachers to increase their relevance and transferability.

Regarding the fourth research question related to teacher digital competence instruments, numerous options are available for utilisation. The DigCompEdu framework has become foundational, even though researchers still need to adapt these instruments by tailoring them to the specific needs of each field. Recent work by Montenegro-Rueda and Fernández-Batanero (2024) proposes a more specialised tool that includes domains such as assistive technology and digital adaptation for particular types of disability. The alignment of measurement tools, training design, and policy priorities will be essential to ensuring the coherence and effectiveness of the professional development system.

From a theoretical perspective, this review broadens the concept of digital competence by emphasising an adaptive dimension. On a practical level, it highlights the need to shift from generic training models to approaches that are grounded in the context of the participants. Integrating accessibility, pedagogy, and technology in this way positions digital competence not only as a technical skill but also as a pedagogical and ethical commitment to inclusion.

This review shows that efforts to develop digital competence among special education teachers remain fragmented and lack a theoretical foundation. To move the field forward, future research should examine diverse cultural and policy contexts, validate inclusive frameworks through empirical studies, and investigate the long-term effects of adaptive, collaboratively designed training programs. Addressing these aspects will help to transform digital competence from a set of technical skills into a meaningful driver of equitable and accessible learning for all students.

5. Conclusion

This review examined 17 studies on the development of digital competence among special education teachers. It has discussed the effectiveness of professional development programs, the training content, and the materials needed to support students with disabilities. This is in addition to instruments used for measuring teachers' digital competence. Overall, the findings highlight that while special education teachers demonstrate openness and positive attitudes toward technology, the opportunities available to them to enhance their digital skills are often limited by the generic nature of the training model. Future programs require embedding accessibility and inclusivity principles into both their content and delivery. Universal Design Learning (UDL) and Technological Pedagogical Content Knowledge (TPACK) framework can be referred to meet this need. Future assessment tools should integrate elements of assistive technology literacy and inclusive digital pedagogy. This would enable a more accurate evaluation of teacher readiness to implement technology in diverse learning environments.

From a practical perspective, these findings underscore the urgent need for contextualised professional development that combines technical training with pedagogical adaptations to different disability categories (visual, auditory, or neurodevelopmental). Such programs should be co-designed with special education experts

and practitioners to ensure relevance and sustainability. From a theoretical perspective, the review calls for expanding the existing digital competence frameworks to include explicit indicators of inclusivity and accessibility, bridging the gap between mainstream educational technology and special needs pedagogy.

Nevertheless, several limitations affected this review. First, the review was limited to three database sources. This makes it possible to have missed other studies. Second, the review did not address digital competence building for teachers to support students' learning in relation to one specific learning barrier. It is essential to research digital competence improvement programs that utilise tailored approaches for special education teachers. Further research is recommended on designing digital competence improvement programs for special education teachers who are teaching students with specific learning barriers.

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