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Analysis of Frameworks for Digital Skills Training for Secondary School Teachers: A Systematic Review

Wilder Banoy-Suarez [1], Ronald Andrés González-Reyes [1]

[1]Antonio Nariño University, Cl. 22 Sur #12D-81, Bogotá, Colombia

***Abstract* - To improve the quality of education, educators must be provided with updated curricular proposals, resources, and tools to optimize and develop their digital competencies regularly. This systematic literature review aims to investigate the association between frameworks, training, and diagnostic strategies used from 2017 to October 2022 to enhance the digital proficiency of secondary school educators. The PRISMA methodology guidelines were followed. From 589 documents in Scopus and after the identification, screening, eligibility and inclusion phases, an in-depth sample analysis (n=29) was performed with ATLAS.ti. The study identified DigCompEdu, DigComp and the INTEF framework as the primary sources of reference for creating of face-to-face and online training programs. Ad hoc diagnostic research and the application of established tools were predominantly led by Spain and Portugal. Three aspects stand out: a growing trend to develop digital competencies comprehensively and not only at the instrumental level; however, it is recognized that some proposals focus on the identification and improvement of specific sub-competencies. Secondly, there is a need to create permanent communication channels to update and improve the different dimensions of the digital competence of teachers through contributions, questions and experiences shared in virtual communities, not only during training. Lastly, there is the possibility of creating digital certification systems for new levels of competence with alternatives such as micro-credentials.**

***Keywords* – Teacher training, secondary education, technological education, educational research, systematic review.**

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Corresponding author: Wilder Banoy-Suarez,
Antonio Nariño University, Bogotá, Colombia
Email: wbanoy90@uan.edu.co

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1. Introduction.

Today, the educational community prioritizes addressing teaching digital competencies (TDC) [1], which has emerged as a critical issue in the scientific literature [2]. Training in TDC is vital due to the rising importance of technological mediation of education and the application of artificial intelligence in various everyday environments. Moreover, enhancing the professionalism of teachers and instilling desirable competencies is imperative to improve their performance [3]. Teachers across all academic levels must craft learning experiences that involve assessing, selecting, and utilizing fitting resources and technologies [4].

While there is no unified definition for TDC, given the fluidity of the technological landscape and the abundance of synonyms and related terms [5], it is generally understood to incorporate proficiencies across digital tools usage, technological troubleshooting, digital content generation [6], [7], online communication and collaboration, and online privacy and security [8], [9], [10], [11], [12]. Digital skills are crucial for success in life and work in today's digital society [13], [14], [15], [16], [17].

Training in digital competencies should be considered a vital aspect of a comprehensive approach to enhancing the quality of education, among other reasons, because the role of the teacher is crucial to determining the mastery of digital literacy skills in students [18]. Therefore, teachers must have ongoing support and access to current resources and tools to continuously optimize and develop their teaching practices in daily pedagogical scenarios, not just during exceptional situations like the COVID-19 pandemic.

This support should be structured according to various frameworks that allow for consolidating TDC strategies, resulting in enhanced educational practices. Diagnostic assessments and regularly updated training proposals (TP) supported by institutions responsible for teacher preparation, state education offices, school districts [19], [8], and territorial organizations are vital to achieving this [20], [21], [22], [23], [14].

Frameworks have been designed to describe the structural areas of the TDC. These frameworks have enabled the validation of instruments to assess levels of competence and enabled the development of TP for teachers. According to Cabero *et al.* [24], the European Framework for Digital Competence of Teachers DigCompEdu, ISTE Standards for Educators, UNESCO ICT Competence Framework for Teachers, the Spanish Common Framework of Digital Competence for Teachers by INTEF, the British Framework for Digital Teaching, ICT Competences for Colombian Teachers' professional development, and ICT Competences and Standards for the Chilean teaching profession are the most widely recognized frameworks [25], [26]. However, the methods employed to construct TDC in schools and universities evolve more slowly and consistently than anticipated [5]. Moreover, it is imperative to acknowledge that the degree of self-perception and reflective attitudes regarding praxis, innovation, and collaboration are fundamental to the TDC [7].

Since TDC frameworks vary in usage across training proposals at various educational levels and in the design of diagnostic assessments aimed at determining the level of TDC, it is essential to conduct a thorough literature review to discern which frameworks and corresponding TDC areas and diagnostic assessment types are best suited. While some proposals and instruments advocate for the comprehensive development of TDC competencies, others emphasize leveraging technological advances in pedagogical processes. Both ad hoc and standardized approaches have significantly influenced the design of diagnostic assessments used to identify levels of TDC. In order to understand which frameworks and respective TDC areas have had the most impact on the design of TP for active and trainee secondary education teachers between 2017 and 2022, it is essential to conduct a systematic literature review. This review will identify the types of diagnostic assessments, both ad hoc and standardized, that have been most influential. In order to accomplish this, the following research questions were posed:

- Q1. What are the frameworks and areas associated with digital competence that have the greatest influence on the design of training proposals for secondary school teachers?
- Q2. What is the relationship between frameworks, diagnostic research, and DC training proposals for secondary school teachers?

2. Methodology

In order to answer the research questions, an SLR was made that generates an approach with the existing corpus, provides a theoretical basis for the study, justifies the research proposal, and contributes to the discussion from the objective and the questions posed [27]. For this synthesis of the state of knowledge, the protocol of the PRISMA 2020 statement is used [28].

2.1. Inclusion and Exclusion Criteria

The search criterion was adjusted to Boolean operators with the words: "competence" AND "digital" AND "teacher OR teachers" AND "framework OR training". Secondary was not included because many researchers addressed all educational levels; in the second phase, the respective screening was performed (Figure 1). Inclusion focused on the primary TDC standards without limiting the results to the five mentioned in the introduction. The search criteria included the criteria applied in Scopus, considering its importance and prestige in the field of social sciences and the number of articles published on the subject.

2.2. Screening process

Two expert reviewers assessed the identification, screening, eligibility, and inclusion phases from October 2022 to January 2023. The evaluation was performed through a 329-page registration document containing the year of publication, number of citations, title, abstract, keywords, URL, and pertinent descriptions of the noteworthy aspects of the remaining 394 documents after eliminating duplicates. Figure 1 illustrates the correlation between the stages and specifics of publications eliminated through readings of titles, abstracts, methods, and conclusions (with an additional phase defined by the authors), full-text evaluation, and thorough analysis.

The 29 documents analyzed comprised 18 in English (62.06%), 10 in Spanish (34.48%), and 1 in Portuguese (3.44%). Qualitative text and image procedures were employed in ATLAS.ti 22 software [29], with a coding of 20 elements distributed as follows: =TP was developed using eight frameworks in TDC. It included diagnostic research and the design of instruments supported by the frameworks above.

One standardized and one ad hoc instrument were applied, with results linked to TP.

The design and application of instruments also yielded results, as did the documents linked to TP. Overall, there were conclusions about both TP and the instruments used.

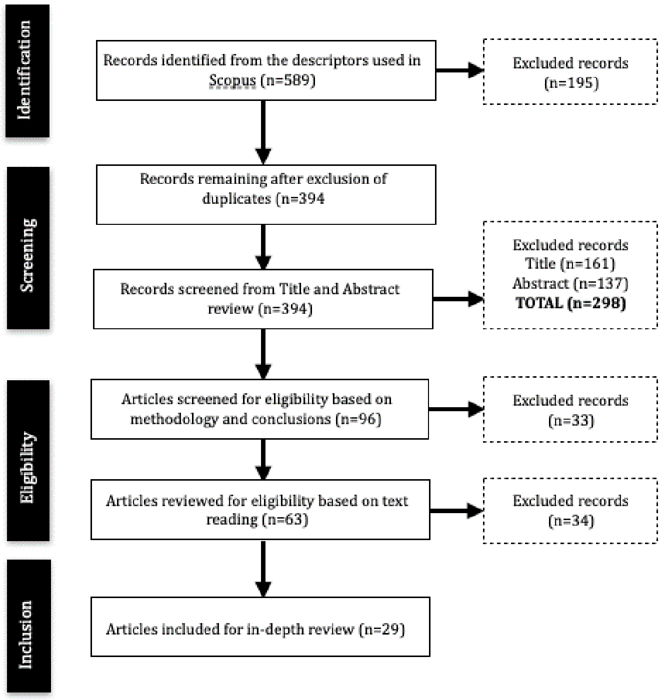

Figure 1. Phase flow diagram according to PRISMA (SRL) Source: Elaborated by the authors

Finally, a visual representation was created using VOSviewer version 1.6.19, with keywords set to appear at least five times in the export file from Scopus, which was in RIS format. Fig. 2 displays the complete graph, indicating a noticeable cluster of secondary education. This finding supports the statements made in the systematic literature review regarding geographic location, teacher involvement, and the development of teacher and student DC. Therefore, when crafting TP, like diagnostic evaluations, it is crucial to consider the views of both educators and students on their digital competence (DC) levels and the training they have received. The analysis should occur at various stages of the curriculum proposals to gauge and nurture teachers in this area. Moreover, when offering TDC training, it is essential to include ongoing reflection on professional practice during the process [30]. Contextual and personal factors also impact teachers' digital competence [31].

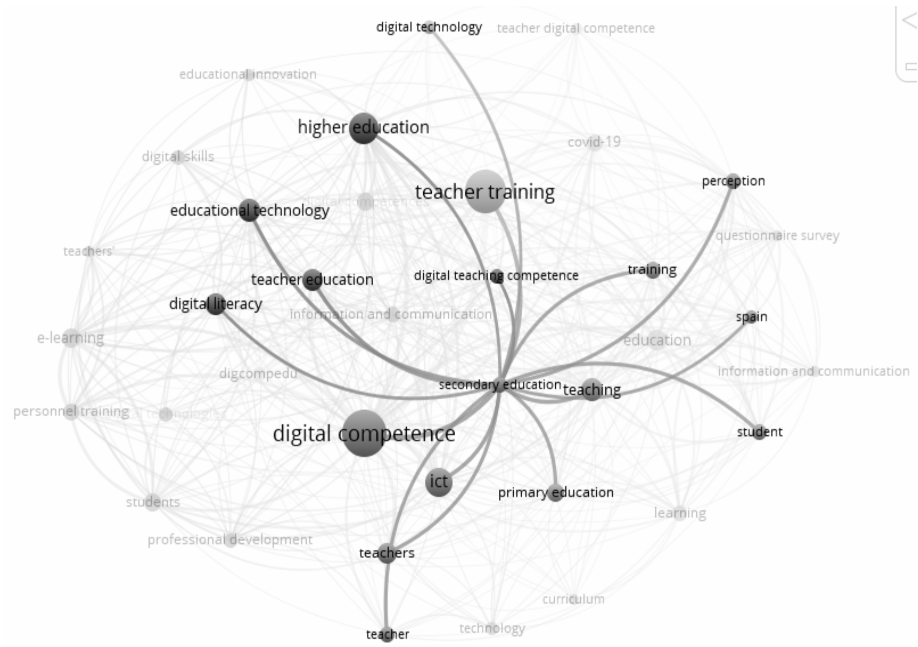

Figure 2. Secondary education cluster in the graphical analysis from VOSviewer. Source: Elaborated by the authors

3. Results

What are the frameworks and areas associated with digital competence that have the most significant influence on the design of training proposals for secondary school teachers?

Table 1 presents the four categories of training proposals observed in the sample. The first category includes TP developed and implemented using ad hoc diagnostic tools validated by prior research to assess the level of TDC. The second category comprises TP that employed valid data collection instruments but were not applied or evaluated. Two types of evaluations were conducted: those without instruments, which were applied and evaluated after the training, and those with both diagnostic and evaluative instruments that were validated and applied before and after the training (pre-test and post-test). Additionally, Clausen [32] introduced a complementary proposal for micro-credentialing systems.

Spain is the leading country in technology pedagogy (TP) research on digital competence (DC) concerning secondary school teachers in undergraduate and postgraduate training and refresher programs, followed by Portugal. The systematic literature review (SLR) also allowed for the identification that the frameworks most utilized in the design of the curricula for the mentioned proposals, both individually and in hybrid form, were created by the European Commission (DigComp and DigCompEdu) and INTEF. In this respect, the number of studies that followed the guidelines of the latter two frameworks is unexpectedly high. Please refer to Table 1 for further information.

Table 1. Groups for analysis of training proposals (FP) and DC areas for secondary school teachers

Tipology	*Authors and year*	*TDC Framework*	*Research Country*	*Training type and duration*	*Research approach*
Diagnostic evaluation with TP applied	Sánchez *et al.* (2021)	INTEF	Spain	Virtual / LMS (No specific time)	Quantitative
	Martínez *et al*. (2022)	DigCompEdu	Spain	Virtual. T-MOOC (No specific time)	Quantitative
Diagnostic evaluation with TP design (not applied)	Cabero *et al.* (2020)	DigCompEdu	Spain	Virtual. T-MOOC (No specific time)	Qualitative
TP applied with subsequent evaluation	Reisoğlu, İ., Çebi, A (2020)	DigComp y DigCompEdu	Spain	Face-to-face One week (70 hours)	Qualitative
	Gordillo *et al.* (2021)	DIGCOMP INTEF	Spain	Virtual. MOOC simulated social network	Quantitative
	Marta *et al.* (2019)	European Commission	France, Germany, Italy, The Netherlands, Spain, Portugal, United Kingdom.	Virtual S-MOOC (one month)	Mixed
	Romero *et al.* (2020a)	INTEF	Spain	Virtual. (12 Synchronous Sessions in virtual classroom - LMS). One semester	Quantitative
Diagnostic assessment with applied TP design and evaluation (pre- and post-test)	Lucas *et al.* (2021a)	DigCompEdu	Portugal	Face-to-face. (Three three-hour sessions, plus independent work)	Quantitative
	Romero *et al.* (2020b)	INTEF	Spain	Virtual. (15 Synchronous Sessions in virtual classroom - LMS). One semester	Quantitative
	Çebi *et al.* (2022)	DigComp TPACK	Turkey	Face-to-face. Six consecutive days. 51 hours	Mixed
Alternative proposal for TDC training	Clausen, J.M. (2021)	ISTE	United States	Virtual From specialized platforms	Qualitative Field Report

Source: Elaborated by the authors

Notably, the TP and instruments created, validated, and utilized, concentrated on the TDC's five areas: information and information literacy, communication and collaboration, digital content creation, security, and problem-solving [17], [15], [33], [8], [34]. In contrast, one researched solely on security, particularly the accountable usage of technology [22]. Others authors focused on professional engagement, digital resources, assessment and feedback, student empowerment, and the development of student digital competence [21], [24], [13]. Just as they were utilized the two sets of digital competency areas mentioned [14]. The guidelines for each area and their corresponding sub-skills were crucial inputs in designing the TPs.

Now, regarding virtual teacher professional development, there is a focus on establishing virtual communities and groups on social media platforms and establishing direct communication channels between trainers and trainees. These methods are utilized not only during the training but also afterward. These channels enable perpetual updating through academic peers' contributions, questions, and shared experiences in virtual learning communities. These communities supplement TDC training and adhere to the communication and collaboration guidelines of frameworks like DigCompEdu and INTEF [13], [17], [22].

The social MOOC (S-MOOC) proposal highlights the inter-creativity, or the ability of individuals to create original and productive elements in a virtual environment, of learners to collaboratively design tasks and resources for creating online courses [34]. The authors utilized the concept of RICT - Relationship, Communication, and Information Technologies - rather than the traditional concept of ICT to carry out this inter-creativity. This aspect could be crucial in designing future TP to facilitate continuous iteration in technology-mediated reflective pedagogical practices.

Additionally, the micro-credentialing systems constitute an innovative alternative that supplements TP in TDC according to the guidelines of the ISTE framework. Based on two principles, this work posits that conventional university degrees may fail to demonstrate educator competencies and knowledge and that a single course may not grant apprentices and teachers enough understanding of how to integrate technology into their pedagogical approaches effectively [32]. As a result, four micro-credentials were developed to cover the range of skill levels associated with each of the seven ISTE standards. This system could serve as an alternative for certifying the ongoing education of teachers in DC and as an excellent supplement to the partial progress of various training programs.

The presented frameworks and areas have aided in the design of TP and in the development, validation, and application of diagnostic research instruments. These instruments rely on participant perceptions and competence levels and facilitate the identification of teacher training needs in DC [22], [34], [14], [15]. This highlights the significance of the SLR's second research question.

What is the relationship between frameworks, diagnostic research, and DC training proposals for secondary school teachers?

This section presents six diagnostic research instruments designed based on the TDC frameworks and validated for elaborating the TP presented in the previous section. They were applied to identify the DC level of secondary school teachers. The instruments were evaluated using two types of evaluations: pre-test and post-test. Table 2 provides the details.

Table 2 presents 14 studies utilizing data collection tools associated with the TDC level. The authors developed, validated, or applied these instruments. Additionally, ten studies employed six pre-existing designs. Regarding the latter, the DigCompEdu Check-In tool is the most widely used [13], [21], [35], [36]. The instrument validated by Touron *et al.* [37], which is also cited in this SLR, plays a crucial role in the research of Romero *et al.* [33] and Prieto *et al.* [38]. Other notable tools include the TPACK deep scale and the DCQ questionnaire [8]. The article discusses the use of the SPTKTT Inventory survey in the Croatian educational system [20], and the COMDID-A instrument, which was applied by Rodriguez et al. (2021) and based on the previously validated COMDID-C [39], also cited within this work. Additionally utilized two instruments related to the categories above [21].

Table 2. Groups for DC diagnostic research analysis for secondary school teachers

Type of diagnostic investigation	*Authors*	*Instrument(s) ad hoc / pre-validation*	*Validated instrument and/or applied*	*Trainee / active teachers*	*TDC Frame work*	*Comments*
Pre-test and pos-test	Romero *et al.* (2020b)	Prior validation	Applied	Spain In training (postgraduate)	INTEF	Validated by Touron; 5 frame areas; 5-item Likert-type scale.
	Lucas *et al.* (2021a)	Prior validation	Applied	Portugal In formation (undergraduate)	DigCompEdu	DigCompEdu Check-In tool (Self-assessment tool). Validated by the European Commission.
	Çebi *et al.* (2022)	Prior validation	Applied (2 tests)	Turkey In training (undergraduate)	DigComp TPACK	Two tools: DC Questionnaire (DCQ); based on DigComp. TPACK deep scale, to determine the level of TPACK competence.
Pre-test	Sánchez *et al.* (2021)	Ad hoc.	Validated and applied	Spain Active teachers.	INTEF	ACDC Tool (Analysis of Common Digital Competencies). For active teachers at all levels.
	Martínez *et al.* (2022)	Ad hoc (1) Prior validation (2)	Validated and applied (1) Applied (2)	Spain In training (postgraduate)	DigCompEdu	Two tools: Content Questionnaire: Digital Resources and Digital Pedagogy (ad hoc) and Digital Teaching Competencies Questionnaire (DigCompEdu Check-In).
	Lucas *et al.* (2021b)	Ad hoc	Validated and applied	Portugal Active teachers	DigCompEdu	All DigCompEdu areas.
	Gallego *et al.* (2019)	Ad hoc	Validated and applied	Spain and Portugal In training (undergraduate)	DigCompEdu INTEF ISTE	The article and the instruments focus on the area of digital security.
	Cabero *et al.* (2020).	Ad hoc	Validated and applied	Spain In training (undergraduate)	DigComp ISTE	Digital Competence Questionnaire for Future Teachers. Complex analysis of results.
	Touron *et al.* (2018)	Ad hoc	Validated and applied	Spain Active teachers	INTEF	Tool mentioned by other authors. 5 INTEF dimensions
	Moreno *et al.* (2020)	Prior validation	Applied	Spain In training (postgraduate)	INTEF	The instrument focuses on the area of information and information literacy.
	Barišić *et al.* (2019)	Validates previously created instrument	Validated and applied	Croatia In Training (Undergraduate)	TPACK	SPTKTT survey, to measure TPACK (on prospective teachers' knowledge of teaching and technology).
	Jiménez *et al.* (2020)	Ad hoc	Applied	Spain In Training (undergraduate start)	DigComp	Reliability is explained, but there are no details about validation.

	Rodríguez *et al.* (2021)	Validates previously created instrument	Applied to be validated.	Spain In Training (undergraduate)	DigCompEdu	Validation of the COMDID tool, created in 2017.
	Boudet (2017)	Ad hoc	Validated and applied	Spain Active teachers.	INTEF	The validation of the instrument is not described in depth. Validation through pilot testing and approval of final version by experts.
	Dias & Ferreira (2020)	Previously created	Validated and applied for Portugal	Portugal Active Teachers	DigCompEdu	DigCompEdu Check-in tool. 6 areas of competence. Active teachers from different areas and levels.
	Dias *et al.* (2021)	Previously created	Applied	Portugal Active Teachers	DigCompEdu	DigCompEdu Check-in tool. 6 areas of competence.
	Orosco *et al.* (2021)	Ad hoc	Validated and applied	Peru Active Teachers	INTEF	DC questionnaire based on INTEF with one additional competency from the research team (curriculum integration), for a total of 22. Active teachers from a province.
	Prieto *et al*. (2021)	Previously created and validated.	Validation	Spain Active teachers.	INTEF	The original design was enriched with open-ended questions on the effect of confinement on teachers' work (Covid-19). It was sent to school principals for distribution. Created and validated previously by Touron.
	Rodríguez *et al.* (2022b)	Ad hoc	Validated and applied	Spain In training (undergraduate)	ISTE UNESCO DigComp DigCompEdu INTEF	Instrument based on a single area: Content Creation. Took into account several frameworks. The validation process is unclear.
	Fernández *et al.* (2018)	Ad hoc	Validated and applied	Spain Active teachers.	UNESCO	UNESCO's tool with 5 sub-dimensions for teacher training in ICT. 3 levels.
Pos-test	Marta *et al*. (2019)	Ad hoc (Validated by experts)	Validated	In 7 European countries. Active teachers"	European Commission (both frameworks)	Tool to evaluate the results of an S-MOOC. Active teachers from different areas in France, Germany, Italy, the Netherlands, Spain, Portugal and the United Kingdom.
	Fraile *et al.* (2018)	Ad hoc	Applied	Spain In training (postgraduate)	INTEF	Tool with 5 INTEF areas. Evaluation of the TDC level.
	Cantabrana *et al.* (2019)	Ad hoc	Validated and applied	Spain In Training (undergraduate)	DigCompEdu	COMDID-C tool. 88 items (two parallel forms of 44 items) for 4 dimensions of the TDC. Based on a previous test called COMDID-A.
	Gordillo *et al.* (2021)	Ad hoc	Reliability and applied	Spain Active teachers.	DigComp INTEF	Anonymous ad hoc questionnaire.
Can be used as a pre-test or post-test.	Cattaneo *et al*. (2022)	Ad hoc	Validated and applied	Spain Active teachers.	DigCompEdu	Tool: Digital Competence Scale for VET. The Digital Competence Scale for VET comprises 10 subscales reflecting the 22 digital competences of DigCompEdu 2.0.

Source: Elaborated by the authors

The findings indicate that the three European frameworks are favored by researchers in designing diagnostic assessments using pre-test and post-test formats to assess TDC levels (Figure 3). Notably, the DigCompEdu and INTEF Frameworks exceed the utilization of the ISTE, UNESCO, and TPACK guidelines by a factor of five [40], [41]. Researchers will likely prefer the former option due to variations in competency levels, domains, and supporting organizational structures.

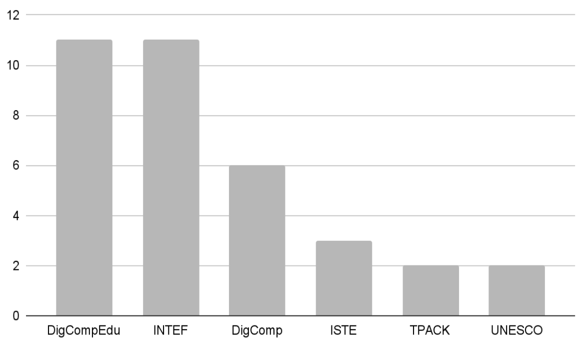

Figure 3. TDC frames of reference used in diagnostic assessment instruments. Source: Elaborated by the authors

Although training frameworks for teachers' digital competencies have defined specific areas as the basis for developing diagnostic evaluations, some studies have focused solely on one area to identify specific training needs. In this context, four studies are notable [42], which is centered around information and information literacy in the INTEF area. Gordillo [22] assessed teacher advancement in the safe and responsible use of technology area using the DigComp and INTEF frameworks. Gallego *et al.* [43] concentrated on digital safety, applying hybrid perspectives from the DigCompEdu, INTEF, and ISTE frameworks. Lastly, Rodríguez *et al.* [44] study focused on using ICT in content creation, with precise objective and objective assessments. Of the 24 proposals, only this study utilized more than three DC frameworks. Notably, for the development of the last two instruments, which were based on only one area, more reference frameworks were taken into account than for the others.

An essential aspect of the findings pertains to the tests' purpose and their timing of implementation. The designs associated with entry or identification diagnostic assessments are nearly five times more prevalent than those intended for exit tests (post-training) or pre-test and post-test evaluations. The researchers focus more on studying the TDC entry level than on the results or effectiveness of the few existing TP designed for secondary school teachers, as described in the previous section. It should be noted that only one instrument was designed and validated for both input and output [19].

Figure 4 recognizes the leadership of Spain and Portugal in diagnostic research. This situation may be linked to the majority use of European reference frameworks described in the first research question. In addition, there are no instruments available in Latin America that were designed, validated, and applied using the most commonly referenced TDC frameworks. These are discussed further in the following sections.

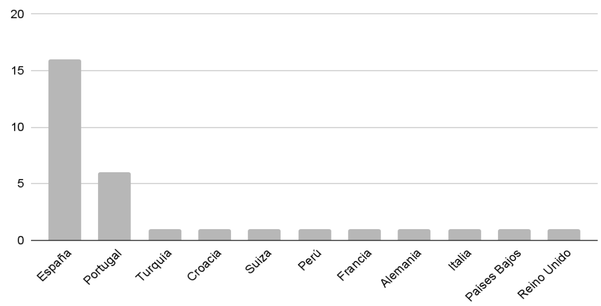

Figure 4. Relationship between countries and TDC diagnostic assessment tools. Source: Elaborated by the authors

Concerning the intended readership, Table 2 illustrates that the diagnostic evaluation was designed, validated, and applied among three primary groups. The first group includes 11 proposals for secondary school teachers who are either active or practicing. The second group encompasses eight instruments for teachers in undergraduate training, and the final group comprises five works destined for teachers in postgraduate training. Researchers are likely to be equally interested in active teachers who require regular updates on their digital skills and universities' temporary proposals for standardized undergraduate and graduate training.

A significant finding pertains to the most prevalent techniques for instrument reliability, validation, and data analysis [17], [31], [43], [24], [37]. Regarding reliability, Cronbach's alpha was identified as the primary measure [42], [23], [30], [45], [49]. Secondly, regarding validation, the experts' method was the most widely used [17], [43], [30], [53], [39]. It should be noted that in addition to the processes mentioned above and statistical analysis, the sample investigations employed several techniques.

These include McDonald's Omega, Composite Reliability (CR), Average Variance Extracted (AVE), Maximum Shared Variance (MSV), ANOVA test, Pearson Correlation, Pilot tests, Convergent and Discriminant Construct Validity, Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA), as well as the Varimax Method with Kaiser Normalization, Confirmatory factor analysis (CFA), dimensional and external validation, Kaiser-Meyer-Olkin Sample Appropriateness Index (KMO), and Bartlett's Test of Sphericity.

After examining the connection between diagnostic assessment and TP, we identified three ad hoc designs with pre-tests in the previous section [17], [21], [24]. Additionally, one of the designs utilized a test that had previously been validated by the European Commission [21]. Six studies were conducted on the European TDC frameworks, with three using ad hoc post-tests [14], [22], [34] and three employing pre-test and post-test instruments validated by other authors [33], [13], the latter using an additional instrument, the TPACK deep scale [8].

4. Discussion

According to the findings, Spain and Portugal lead in designing TP and diagnostic assessment in DC for secondary school teachers. European frameworks are the most used to support their structure. This coincides with the research by Cabero *et al.* [24], in which it is stated that the most suitable and valued framework for designing a virtual proposal in T-MOOC format is DigCompEdu, followed by INTEF. It is necessary to highlight the importance of the areas, levels, and sub-competences of these frameworks, proposals, and instruments in emerging training designs in Ibero-America because they are not only focused on the instrumental use of technologies in the classroom but on the comprehensive development of the TDC [17]. Hence, Viñoles *et al.* [51] state that the TDC goes beyond the technical use of technologies; it is necessary to place greater emphasis on the creation of learning objects and foster collaboration and learning communities.

From there, the level of detail in the characterization of competency levels proposed by the most commonly used frameworks (six levels in the European frameworks) explains, in part, the preference for their use by researchers [19], [36], [10], [22], [31], by allowing to formulate more consistently the equivalences between the instruments [34], [21], [42], [45], [38], and the expected results in the studies and to see their cognitive evolution from the novice to the pioneer level [30], [33], [17], [37], [50]. Only some studies are cited here, the entirety can be seen in the list of references.

On the flip side, it is worth mentioning that the virtual format was utilized for nearly 70% of the PTs via LMS or MOOC courses (T-MOOC or S-MOOC). Wannapiroon *et al.* [52] posit that the high percentage of online instruction usage can be attributed to three reasons: first, the advantageous use of the Internet in instruction; second, the medium's role as a fundamental pillar of sustainable development, making online instruction safer and more economical; and finally, the ability to enable communication between instructors and students through applications and chats. The remaining instructional sessions were conducted face-to-face, with a maximum duration of one week and high intensity. Virtual training may continue to grow, driven by the need to enhance TDC proficiency in the current technological environment. This is facilitated by technological advancements and the use of ICT, LKT, and RICT tools [34], supplemented by online platforms employing augmented and virtual realities with varying levels of immersion and real-time communication. Such platforms are also utilized in social MOOCs or S-MOOCs [34]. There may be a discrepancy in designing face-to-face teaching for digital competence in contexts that need more technological requirements of connectivity and equipment. This situation impacts many educational institutions in Latin America, especially those in the official, rural, and provincial sectors [45]. Therefore, virtual instruction offers a viable alternative.

Both in the TP and in the design of diagnostic assessment instruments, the frameworks were used in their entirety, in a hybrid form (use of several frameworks), or in a partial manner. In other words, research was found to focus not on all the frameworks but on specific areas [22], [42], [43], [44], who supported their research from the areas of Digital Security and Content Creation. The above allows for identifying a need to train teachers in the protection of devices, personal data and privacy, health and well-being, and the impact of technologies on the environment (components of the security area of DigComp 2.2). This point is significant since TDC training in these areas should empower students in their own learning process when developing their DC (areas 5 and 6 of DigCompEdu).

Another aspect is that although the design, validation, or application of diagnostic instruments was directed in similar proportions to active teachers and trainees, it is very likely that a growing trend is being generated in the interest of knowing the DC level of future teachers and graduate students by noting that the highest percentage of the diagnostic evaluation focused on this type of population and sample in 2020, 2021 and 2022. It is inferred that faculties of education in Latin America should generate and periodically update their cross-curricular plans to improve the digital competencies of future teachers and graduate students [33]. This objective is likely to be realized if local, regional, and national research is done beforehand to expose in detail the link between TDC frameworks, competency areas, instruments, and techniques being used in universities [43], [35], [14]. It is clear that active teachers also need constant updating of their digital competencies, hence the importance of proposals based on INTEF guidelines and a micro-credentialing system, certifies teachers periodically in their pedagogical work [32].

For teacher training and updating programs, micro-credentials, nano-titles, or badges can demonstrate teachers' learning and development of specific DC [32], not only in traditional classrooms but also in ubiquitous spaces mediated by ICT. These allow sharing with the academic and working community the mastery or mastery of particular topics and practices validated by international accreditation organizations such as Open Badges, Canvas Badges, or Open Badges Passport, aligned with reference frameworks. The importance of this system lies in the fact that each teacher identifies his or her weaknesses and strengths when updating his or her performance and, secondly, generates his or her virtual portfolio of updated certifications [32]. It is recommended that this aspect be an essential part of future research.

However, two key factors regarding the location of diagnostic assessment of DC in secondary school teachers are noteworthy. First, the significant leadership of Spain and Portugal may impact the majority use of European reference frameworks, as noted in this study. Second, only a few instruments are designed, validated, and implemented in Latin America based on the most referenced TDC frameworks. Of the 24 studies in the sample that developed or utilized diagnostic assessment, only Orosco *et al.* [45] work in a province of Peru dealt with establishing the reliability and validity of an ad hoc tool utilizing the INTEF proposal. Furthermore, this was the only tool in the sample administered on paper, while the rest were conducted digitally. Insufficient access to digital technologies in educational centers and a lack of connectivity, coupled with inadequate monitoring and evaluation of digital technology's impact on education, may contribute to this situation in the region. These conditions are observed in the Colombian context and could be conditioning factors in developing teachers' and students' digital competencies [46].

In this context, it is vital to note that several Latin American frameworks, including Colombia's, rely on Unesco's (2011) approaches but have not been revised since 2013 [47]. As a result, it is advisable to consider the TDC levels, areas, and guidelines from recently updated major global frameworks when developing new TPs [24]. Therefore, further research should evaluate in detail the three levels and five competencies of the Colombian framework compared with proposals from the European Commission, INTEF, ISTE, and the latest versions of the UNESCO framework [24].

Future TDC studies are likely to be linked to previously validated instruments such as the DigCompEdu Check-In components, the validation [37], the TPACK deep scale, the SPTKTT Inventory, and the COMDID-A instrument for diagnostic research purposes. These instruments are chosen due to their high diffusion and the level of detail of their reagents. Identifying the TDC frameworks, levels, and areas outlined thus far, along with any forthcoming updated versions after 2023, is crucial. This will enable recognition and understanding of the core components necessary for diagnoses within a local investigation's context. In order to guarantee reliability and validation for the specific population, it is recommended to integrate processes. The results of the second research question mentioned some of the most accepted processes in the publications of the SLR sample.

In conclusion, teacher training in digital competencies is complex due to the variety of dimensions and levels and the impact of the structural conditions of educational contexts and the learning practices of participating teachers [48]. As such, these factors must be considered fundamental when conducting future research to assess, develop, and evaluate these competencies.

5. Conclusion

The findings of this study on teacher training proposals for secondary school teachers reveal the leadership of Spain and Europe in research associated with the subject. Curriculum designs on this topic are mainly designed by DigComp, DigCompEdu, and INTEF guidelines, which aim to develop teachers' effective use of digital skills and make a meaningful contribution to empowering the digital competences of their students. This is achieved through teacher training on professional engagement, optimal use of digital resources, technology-mediated teaching, and assessment strategies.

Moreover, face-to-face proposals for teacher training in digital competence must be adjusted to the particularities of educational communities. In contrast, virtual ones like S-MOOCs should focus on practical and assertive communication for virtuality. The collaborative design of tasks and resources based on concepts such as inter-creativity is essential. This points to the dialogic construction of knowledge among teachers from the pedagogical and critical reflection in this type of space.

To ensure that teachers learn meaningfully, creative training proposals, micro-credentialing, and certification of teachers' digital competence are necessary sources of extrinsic motivation. In-depth research in the different faculties of education must promote the design of transversal training proposals for future teachers.

The study highlights the need for qualitative and quantitative reliability and validity processes for the diagnostic evaluation of teachers.

The Latin American context shows a slow updating of official training proposals and few diagnostic evaluation results based on the development of ad hoc and statistically validated instruments to identify the level of self-perception of teachers' digital competence. Prospective regional policies must be established on this point, and the universities' faculties of education must provide teacher development in this regard.

Finally, teacher training in digital competencies is complex and requires thorough research to diagnose, develop, and evaluate this type of competency. Therefore, it is essential to consider the different dimensions and levels, the structural conditioning factors of educational contexts, and the participating teachers' learning practices.

References:

[1]. Artacho, E. G., Martínez, T. S., Ortega Martín, J. L., Marín Marín, J. A., & García, G. G. (2020). Teacher training in lifelong learning-the importance of digital competence in the encouragement of teaching innovation. *Sustainability (Switzerland), 12*(7). Doi:10.3390/su12072852

[2]. Esteve-Mon, F. M., Llopis-Nebot, M. A., & Adell-Segura, J. (2020). Digital teaching competence of university teachers: A systematic review of the literature. *Revista Iberoamericana De Tecnologías Del Aprendizaje, 15*(4), 399-406. Doi:10.1109/RITA.2020.3033225

[3]. Fernández-Batanero, J. M., Montenegro-Rueda, M., Fernández-Cerero, J., & García-Martínez, I. (2022). Digital competences for teacher professional development. systematic review. *European Journal of Teacher Education, 45*(4), 513-531. Doi:10.1080/02619768.2020.1827389

[4]. Kimm, C. H., Kim, J., Baek, E.-O., & Chen, P. (2020). Pre-service Teachers' Confidence in their ISTE Technology-Competency. *Journal of Digital Learning in Teacher Education, 36*(2), 96–110. Doi:10.1080/21532974.2020.1716896

[5]. Mezentceva, D. A., Dzhavlakh, E. S., Eliseeva, O. V., & Bagautdinova, A. Sh. (2020). On the question of pedagogical digital competence. *Vysshee Obrazovanie v Rossii, 29*(11), 88–97. Doi:10.31992/0869-3617-2020-29-11-88-97

[6]. Bocconi, S., Panesi, S., & Kampylis, P. (2020). Fostering the Digital Competence of Schools: Piloting SELFIE in the Italian Education Context. *Revista Iberoamericana de Tecnologías Del Aprendizaje, 15*(4), 417–425. Doi:10.1109/RITA.2020.3033228

[7]. Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (Digcompedu). *European Journal of Education, 54*(3), 356–369. Doi:10.1111/ejed.12345

[8]. Çebi, A., Bahçekapılı Özdemir, T., Reisoğlu, İ., & Çolak, C. (2022). From digital competences to technology integration: Re-formation of pre-service teachers' knowledge and understanding. *International Journal of Educational Research, 113*. Doi:10.1016/j.ijer.2022.101965

[9]. de Araújo, A. C., de Carvalho, M. E. P., Ovens, A. P., & Knijnik, J. (2021). Digital competencies, curriculum and physical education teacher Education. *Revista Brasileira de Ciências Do Esporte, 43.* Doi:10.1590/rbce.43.e002521

[10]. Fraile, M. N., Peñalva-Vélez, A., & Lacambra, A. M. M. (2018). Development of digital competence in secondary education teachers' training. *Education Sciences, 8*(3). Doi:10.3390/educsci8030104

[11]. Janssen, J., Stoyanov, S., Ferrari, A., Punie, Y., Pannekeet, K., & Sloep, P. (2013). Experts' views on digital competence: Commonalities and differences. *Computers and Education, 68,* 473–481. Doi:10.1016/j.compedu.2013.06.008

[12]. Kullaslahti, J., Ruhalahti, S., & Brauer, S. (2019). Professional development of digital competences: Standardised frameworks supporting evolving digital badging practices. *Journal of Siberian Federal University - Humanities and Social Sciences, 12*(2), 175–186. Doi:10.17516/1997-1370-0387

[13]. Lucas, M., Dorotea, N., & Piedade, J. (2021a). Developing Teachers' Digital Competence: Results from a Pilot in Portugal. *Revista Iberoamericana de Tecnologías Del Aprendizaje, 16*(1), 84–92. Doi:10.1109/RITA.2021.3052654

[14]. Reisoğlu, İ., & Çebi, A. (2020). How can the digital competences of pre-service teachers be developed? Examining a case study through the lens of DigComp and DigCompEdu. *Computers and Education, 156.* Doi:10.1016/j.compedu.2020.103940

[15]. Romero-García, C., Sacristán, M., Buzón-García, O., & Asencio, E. N. (2020a). Evaluation of a program for the improvement of learning and digital competence in future teachers utilizing active methodologies. *Estudios Sobre Educación, 39,* 179-205. Doi:10.15581/004.39.179-205

[16]. Rodríguez-García, A.-M., Cardoso-Pulido, M.-J., de la Cruz-Campos, J.-C., & Martínez-Heredia, N. (2022a). Communicating and Collaborating with Others through Digital Competence: A Self-Perception Study Based on Teacher Trainees' Gender. *Education Sciences, 12*(8). Doi:10.3390/educsci12080534

[17]. Sánchez-Cruzado, C., Santiago Campión, R., & Sánchez-Compaña, M. T. (2021). Teacher digital literacy: The indisputable challenge after covid-19. *Sustainability (Switzerland), 13*(4), 1–29. Doi:10.3390/su13041858

[18]. Arono., Arsyad, S., Syahriman., Nadrah., & Villia, A. S. (2022). Exploring the effect of digital literacy skill and learning style of students on their meta-cognitive strategies in listening. *International Journal of Instruction, 15*(1), 527-546. Doi:10.29333/iji.2022.15130a

[19]. Cattaneo, A. A. P., Antonietti, C., & Rauseo, M. (2022). How digitalised are vocational teachers? Assessing digital competence in vocational education and looking at its underlying factors. *Computers and Education, 176*. Doi:10.1016/j.compedu.2021.104358

[20]. Barišić, K. D., Divjak, B., & Kirinić, V. (2019). Education systems as contextual factors in the technological pedagogical content knowledge framework. *Journal of Information and Organizational Sciences, 43*(2), 163-183. Doi:10.31341/jios.43.2.3

[21]. Martínez-Pérez, S., Cabero-Almenara, J., Barroso-Osuna, J., & Palacios-Rodríguez, A. (2022). T-MOOC for Initial Teacher Training in Digital Competences: Technology and Educational Innovation. *Frontiers in Education, 7*. Doi:10.3389/feduc.2022.846998

[22]. Gordillo, A., Barra, E., Garaizar, P., & López-Pernas, S. (2021). Use of a Simulated Social Network as an Educational Tool to Enhance Teacher Digital Competence. *Revista Iberoamericana de Tecnologías Del Aprendizaje, 16*(1), 107–114. Doi:10.1109/RITA.2021.3052686

[23]. Jiménez-Hernández, D., González-Calatayud, V., Torres-Soto, A., Mayoral, A. M., & Morales, J. (2020). Digital competence of future secondary school teachers: Differences according to gender, age, and branch of knowledge. *Sustainability (Switzerland), 12*(22), 1–16. Doi:10.3390/su12229473

[24]. Cabero-Almenara, J., Romero-Tena, R., & Palacios-Rodríguez, A. (2020). Evaluation of teacher digital competence frameworks through expert judgement: The use of the expert competence coefficient. *Journal of New Approaches in Educational Research, 9*(2), 275–283. Doi:10.7821/naer.2020.7.578

[25]. Cabero-Almenara, J., Romero-Tena, R. (2020). Diseño de un t-MOOC para la formación en competencias digitales docentes: estudio en desarrollo (Proyecto DIPROMOOC). *Innoeduca. International Journal of Technology and Educational Innovation 6*(1), 4-17. Doi:10.24310/innoeduca.2020.v6i1.7507

[26]. Cabero-Almenara, J., Gutiérrez-Castillo, J. J., Palacios-Rodríguez, A., & Barroso-Osuna, J. (2021). Comparative European digcompedu framework (JRC) and common framework for teaching digital competence (INTEF) through expert judgment. *Texto Livre, 14*(1). Doi:10.35699/1983-3652.2021.25740

[27]. Paré, G., Trudel, M.-C., Jaana, M., & Kitsiou, S. (2015). Synthesizing information systems knowledge: A typology of literature reviews. *Information Management, 52*(2), 183–199. Doi:10.1016/J.IM.2014.08.008

[28]. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Whiting, P., & Moher, D. (2022). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *American Journal of Public Health, 46*. Doi:10.26633/RPSP.2022.112

[29]. Choe, Y., Lee, J., & Lee, G. (2022). Exploring Values via the Innovative Application of Social Media with Parks Amid COVID-19: A Qualitative Content Analysis of Text and Images Using ATLAS.ti. *Sustainability (Switzerland), 14*(20). Doi:10.3390/su142013026

[30]. Rodríguez, M. U., Cantabrana, J. L. L., & Cervera, M. G. (2021). Validation of a tool for self-evaluating teacher digital competence. *Educación XX1, 24*(1), 353–373. Doi:10.5944/educXX1.27080

[31]. Lucas, M., Bem-Haja, P., Siddiq, F., Moreira, A., & Redecker, C. (2021b). The relation between in-service teachers' digital competence and personal and contextual factors: What matters most? *Computers and Education, 160.* Doi:10.1016/j.compedu.2020.104052

[32]. Clausen, J. M. (2021). Learning to fly: Development and design of a micro-credentialing system for an educator preparation program in the absence of a required educational technology course. *TechTrends, 66*(2), 276-286. Doi:10.1007/s11528-021-00673-x

[33]. Romero-García, C., Buzón-García, O., & de Paz-Lugo, P. (2020b). Improving future teachers' digital competence using active methodologies. *Sustainability (Switzerland), 12(*18). Doi:10.3390/SU12187798

[34]. Marta-Lazo, C., Frau-Meigs, D., & Osuna-Acedo, S. (2019). A collaborative digital pedagogy experience in the tMOOC "Step by Step." *Australasian Journal of Educational Technology, 35*(5), 111–127. Doi:10.14742/ajet.4215

[35]. Dias-Trindade, S., & Ferreira, A. G. (2020). Digital teaching skills: Digcompedu checkin as an evolution process from literacy to digital fluency. *Icono14, 18*(2), 162–187. Doi:10.7195/RI14.V18I2.1519

[36]. Dias-Trindade, S., Moreira, J. A., & Ferreira, A. G. (2021). Evaluation of the teachers' digital competences in primary and secondary education in Portugal with digcompedu checkin in pandemic times. *Acta Scientiarum - Technology, 43*. Doi:10.4025/actascitechnol.v43i1.56383

[37]. Touron, J., Martin, D., Navarro Asencio, E., Pradas, S., & Inigo, V. (2018). Construct validation of a questionnaire to measure teachers' digital competence (TDC). *Revista Española de Pedagogía, 76*(269), 25–54. Doi:10.22550/REP76-1-2018-02

[38]. Prieto-Ballester, J.-M., Revuelta-Domínguez, F.-I., & Pedrera-Rodríguez, M.-I. (2021). Secondary school teachers self-perception of digital teaching competence in spain following covid-19 confinement. *Education Sciences, 11*(8). Doi:10.3390/educsci11080407

[39]. Cantabrana, J. L. L., Rodríguez, M. U., & Cervera, M. G. (2019). Assessing teacher digital competence: The construction of an instrument for measuring the knowledge of pre-service teachers. *Journal of New Approaches in Educational Research, 8*(1), 73–78. Doi:10.7821/naer.2019.1.370

[40]. Koehler, M (2012). *Technological Pedagogical Content Knowledge (TPACK) explained*. Tpack. Retrieved from: https://matt-koehler.com/tpack2/tpack-explained/ [accessed: 12 October 2023].

[41]. Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. Doi:10.1111/j.1467-9620.2006.00684.x

[42]. Moreno-Guerrero, A.-J., Miaja-Chippirraz, N., Bueno-Pedrero, A., & Borrego-Otero, L. (2020). The information and information literacy area of the digital teaching competence. *Revista Electrónica Educare, 24*(3). Doi:10.15359/REE.24-3.25

[43]. Gallego-Arrufat, M.-J., Torres-Hernández, N., & Pessoa, T. (2019). Competence of future teachers in the digital security area. *Comunicar, 27*(61), 53–62. Doi:10.3916/C61-2019-05

[44]. Rodríguez, N. C., Lorenzo-Rial, M.-A., & Rodríguez, U. P. (2022b). Digital competence of teachers in terms of content creation: self-perception of teachers in educational scientific training in Galicia (Spain). *Educacao e Pesquisa, 48*. Doi:10.1590/S1678-4634202248243510

[45]. Orosco-Fabian, J. R., Pomasunco-Huaytalla, R., Gómez-Galindo, W., Salgado-Samaniego, E., & Colachagua-Calderón, D. A. (2021). Digital competences in secondary education teachers in a province of central Peru. *Revista Electronica Educare, 25*(3). Doi:10.15359/ree.25-3.34

[46]. DNP. CONPES 3988 de 2020. (Departamento Nacional de Planeación de Colombia). *Tecnologías para aprender: Política nacional para impulsar la innovación en las prácticas educativas a través de las tecnologías digitales.* Colaboracion. Retrieved from: https://colaboracion.dnp.gov.co/CDT/Conpes/Econ%C3%B3micos/3988.pdf [accessed: 19 October 2023].

[47]. MEN (Ministerio de Educación Nacional de Colombia) (2013). *Competencias TIC para el Desarrollo Profesional Docente.* Mineducacion. Retrieved from: https://www.mineducacion.gov.co/1759/articles-339097_archivo_pdf_competencias_tic.pdf [accessed: 25 October 2023].

[48]. Bastida-Bastida, D. (2019). Adaptación del modelo 5E con el uso de herramientas digitales para la educación: propuesta para el docente de ciencias. *Revista Científica, 34*(1), 73-80. Doi:10.14483/23448350.13520

[49]. Fernández Cruz, F. J., Fernández Díaz, M. J., & Rodríguez Mantilla, J. M. (2018). The integration process and pedagogical use of ICTs in Madrid schools. *Educación XX1, 21*(2), 395-416. Doi:10.5944/educXX1.17907

[50]. Punie, Y., editor(s), Redecker, C., (2020). *European Framework for the Digital Competence of Educators: DigCompEdu*. Publications Office of the European Union, Luxembourg. Doi:10.2760/178382

[51]. Viñoles-Cosentino, V., Sánchez-Caballé, A., & Esteve-Mon, F. M. (2022). Desarrollo de la Competencia Digital Docente en Contextos Universitarios. Una Revisión Sistemática. REICE. *Revista Iberoamericana Sobre Calidad, Eficacia Y Cambio En Educación, 20*(2). Doi:10.15366/reice2022.20.2.001

[52]. Wannapiroon, P., Nilsook, P., Jitsupa, J., & Chaiyarak, S. (2022). Digital competences of vocational instructors with synchronous online learning in next normal education. *International Journal of Instruction, 15*(1), 293-310. Doi:10.29333/iji.2022.15117a

[53]. Boudet, J. M. F. (2017). Assessment of digital competence in teachers in the autonomous community of Aragon. *Revista Electrónica de Investigación Educativa, 19*(4), 73–83. Doi:10.24320/redie.2017.19.4.1359