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Digital competence in higher education research: A systematic literature review

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ABSTRACT

In the information and knowledge society, where technology develops rapidly and penetrates deeply into our lives, the discussion about digital competence has become a hot topic today. After the emergence of the Coronavirus (Covid-19) and with its huge impact on the education industry, the concern about digital competence has reached a new height. This systematic literature review uses Web of science and Scopus as databases to store and analyze the existing research on digital competence in higher education settings. The purpose of this review is to provide the scholar community with a current overview of digital competence research from 2015 to 2021 in the context of higher education regarding the definition of digital competence, dimensions used to evaluate digital competence, research purposes, methodologies, and results and limitations. Major findings include that the majority of publications cited both research and EU policy in describing the definition of digital competence. The review indicates that most university students and teachers have a basic level of digital competence. Besides, the institutions of higher education are encouraged to focus on the development students and teachers' digital competence, create relevant learning strategies and use appropriate tools to improve the quality of education.

1. Introduction

The rapid advance of new information and communication technologies has created new conditions for the knowledge society. Since the 1990s, many countries have gradually entered the knowledge age from the industrial times and through the information age. The acquisition, production, processing and utilization of knowledge all play increasingly important roles in boosting a country's economic growth and has gradually become essential. The knowledge society has also contributed to changes in human epistemology and structure. When we are talking about the knowledge society, digital competence is one of the most important factors that distinguish it from the information society. As the knowledge society serves to transform information into resources that enable society to take effective actions, whereas the information society only creates and disseminates raw data (Castelfranchi, 2007).

Nowadays, people are surrounded by the Internet and a series of digital technologies. The development of social structure and trends in using technology have already changed not only how we live but also how we acquire knowledge. Due to the outbreak of the Covid-19 pandemic, regular traditional teaching activities have been suspended. Many institutions and organizations are changing their teaching methods and seek to provide a convenient, safe and flexible educational environment for their students (Schleicher,

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2020). The focus on digital competence continues to grow in popularity in higher education, as college students in the 21st century are the generation that have grown up with the rapid development of computer networks, and they are the experiencers of the unprecedented development of online media represented by the Internet, virtual reality, artificial intelligence, while the Covid-19 has brought increased social attention to the need for digital skills (Iansiti & Richards, 2020). Moreover, today's future teachers are digital natives who use technology in everyday life and who would benefit greatly from implementing these applications in the teaching-learning process (Guillén-Gámez, Mayorga-Fernández, & Álvarez-García, 2018). Active-duty teachers should also develop related capacities to satisfy the newly expanded teaching requirements and make changes to adapt to the new teaching environment.

The concept of digital competence can be defined as a set of abilities to use technology to optimize our daily lives effectively (Ferrari, 2013; INTEF, 2017), understood as “the confident, critical and responsible use of the technologies from the society of information for work, entertainment and education” (European Commission, 2018, p. 9). It has been frequently mentioned by scholars and proposed in policy-related discussions, and sometimes it has been discussed along with digital literacy in the past few decades.

In the recommendation on key competences for lifelong learning that is proposed by the European Commission (2006), digital competence has been identified as one of the eight key life skills along with communication in the mother tongue, communication in foreign languages, mathematical competence and basic competences in science and technology, learning to learn, social and civic competences, sense of initiative and entrepreneurship. New policies and documents introduced in various countries demonstrate the importance attached to technology and digital-related capabilities. After the European Commission had considered digital competence as one of the eight key life skills, they developed DigComp (the European Digital Competence Framework) as a reference framework to explain what it means to be “digitally competent”, it is also available in updated versions based on developments in the community. Digcomp presents an updated list of 21 competencies and different competency levels (Carretero, Vuorikari, & Punie, 2017; Ferrari, 2013; Vuorikari, Punie, Gómez, & Van Den Brande, 2016). In addition, since 2012, the National Institute of Educational Technologies and Teacher Training (INTEF) in Spain has worked in collaboration with other agencies to develop and expand an educational initiative, and launched a document called Common Digital Competence Framework For Teachers (CDCFT) which offers a descriptive reference for relevant educational institutions, departments and educators, which can not only be used for training purposes but can also be used in evaluation, certification and accreditation processes, and this framework is built on the basis of the Digcomp (INTEF, 2013). Furthermore, according to the United Nations Educational, Scientific and Cultural Organization (UNESCO), they did not only release ICT competency standards for teachers, indicating the skills that teachers need to harness technology in the service of education, as part of the Global Alliance to Monitor Learning (GAML), but also developed a Digital Literacy Global Framework (Law, Woo, de la Torre, & Wong, 2018; UNESCO, 2008; UNESCO & UIS, 2017a; 2017b). In China, several plans and blue papers on digitalization and informatization have been released from The General Office of the Central Committee of the Chinese Communist Party and the General Office of the State Council (2017) and Ministry of Education of China (2018), covering the economy, education and other industries.

There is a close connection between digital competence and digital literacy, but sometimes they are referred together and used to underpin each other, even though they have different meanings. There are regional differences in referring those concepts that studies concerning digital competence are often conducted in European countries outside the UK, while those on digital literacy in English speaking counties (Spante, Hashemi, Lundin, & Algers, 2018). However, in some countries, for some reasons such as translation, the distinction between digital competence and digital literacy are blurred (Madsen, Thorvaldsen, & Archard, 2018). Digital competence is often used to point out the skills that people in today's society should have (Ilomäki, Paavola & Lakkala, 2016). And digital literacy is described as the integration of computer literacy, information literacy, media literacy (Paynton, 2012).

Many reviews of digital competence and digital literacy have been performed over the decades. There are reviews that focused on the concept of digital competence and discussed its relationship with digital literacy (Spante et al., 2018). Some papers explored digital competence without determining the educational settings. There are also several reviews presented their attention on specific objectives (Esteve-Mon, Llopis Nebot & Adell-Segura, 2020; Henriquez-Coronel, Gisbert Cervera, & Fernandez Fernandez, 2018; Marta-Lazo, Rodríguez, & Peñalva, 2020). The review conducted by Petterson (2018) explained how questions about digital competence have been solved over the past decade in terms of policy, organizational infrastructure, strategic leadership, and teachers and their teaching practices in different educational contexts. Sánchez-Caballé, Gisbert-Cervera, and Esteve-Mon (2020) indicated a review of university students' digital competence by identifying the most frequently used terms and students' digital competence related profile. Although these studies have provided different perspectives on knowing digital competence, it is still not easy to get a full picture of digital competence of teachers and students in the context of higher education.

In this review, we will systematically explore the application of digital competence in higher education to provide an understanding of the definition of digital competence, observe the dimensions of assessing digital competence of university teachers and students, discover the main trends in the assessment of digital competence in universities, summarize the progress that research has achieved on digital competence in higher education over the past seven years, and outline the limitations of digital competence research in higher education. The aim of this review is to get an overview of the status and development of digital competence of students and teachers in higher education in a systematic way. The review will focus on the following research questions:

- 1: How is digital competence defined in terms of teachers and students in the context of higher education?
- 2: What are the dimensions commonly used to assess the digital competence of university teachers and students?
- 3: What were the major research purposes, methodologies and outcomes in the studies of digital competence in the context of higher education over the past seven years?
- 4: What kinds of limitations exist in research on digital competence in higher education?

With these research questions, the rest of this paper is structured as follows. In the next section, we will explain the methodology followed in this review and how the studies are selected. Then, we present results and answer the research questions based on the articles selected for this literature review. After pointing out possible limitations in this study, we present the conclusions and recommendations for future research on digital competence development in higher education.

2. Materials and methods

A systematic review was established to define the concept of digital competence (Spante et al., 2018). Four research questions were performed to better present research on digital competencies in higher education, with the aim of providing an impartial summarization and interpretation of the findings (Gough, Oliver, & Thomas, 2004). This review was based on the guidelines for systematic literature reviews provided by Kitchenham and Charters (2007) and García-Peñalvo (2017), and followed the other systematic review's format recently conducted on topics of educational technology (Crompton & Burke, 2018).

At the beginning of the review, the research questions should be clearly spelled out as a goal to be answered. The databases chosen for the search are then indicated, as well as the search strings, the criteria followed for the evaluation and selection of studies. Finally, we introduce the publications that were included at the end of the process. In particular, the process is organized in three main phases: selecting, identifying, and synthesizing (Gough, Oliver, & Thomas, 2017).

2.1. Search strategy

The Web of Science (WOS) and SCOPUS electronic databases were selected to conduct this systematic review of the literature. Web of Science and Scopus were selected as the main databases for international multidisciplinary academic literature (Aghaei Chadegani et al., 2013).

The selected terms were searched in the title, keywords and abstract of the paper. In this systematic review the search strings per chosen electronic database were as follows:

- WOS: TS=((("digital competence*" OR "digital abilit*" OR "digital skill*") AND ("higher education" OR "universit*" OR "college*"))
- Scopus: TITLE-ABS-KEY (("digital competence*" OR "digital abilit*" OR "digital skill*") AND ("higher education" OR "universit*" OR "college*"))

2.2. Study selection

The study selection process was an iterative and incremental process, in which it was divided into several stages with different activities carried out. The search was established to get the latest trends and research results on digital competence as digital technology evolved fast. The initial search resulted in 1410 articles.

2.2.1. Inclusion and exclusion criteria

The following inclusion and exclusion criteria (Table 1) were established to select studies that are relevant to obtaining answers to the proposed research questions (García-Peñalvo, 2017). The results obtained after applying the search strings were identified. The inclusion and exclusion criteria should be applied in each study. The inclusion and exclusion criteria were validated by a group of experts consisting of five university professionals, one expert in statistics, two experts in linguistics, and two experts in educational technology.

First of all, the 1410 papers were reviewed against the inclusion and exclusion criteria, resulting that 225 articles were duplicates

Table 1

Inclusion criteria and exclusion criteria.

Inclusion Criteria:
The research work is related to the digital competence of teachers or students in the context of higher education.
The publication includes state of the art on digital competence.
Research papers are published between 2015 and 2021.
The research papers are written in English.
The research papers have been published after being submitted to a peer review process.
The full version of the publication is available through the subscription of our institution or by the associations of which we are members.
The research follows the appropriate structure of a research according to the research method.
Exclusion Criteria:
The research work is not related to the digital competence of teachers or students in the context of higher education.
The publication does not include the state of the art on digital competence.
Research papers are not published between 2015 and 2021.
Research papers are not written in English.
Research papers have been published without a peer review process.
The full version of the publication is not available through subscription from our institution or from the associations of which we are members.
The publications do not follow the appropriate structure of a research according to the research method.

and 1185 articles needed to be removed which did not meet the inclusion criteria. Then the 80 articles were further read and reviewed with quality criteria to ensure that the selected articles met the inclusion and exclusion criteria and allowed guaranteeing the quality of the works selected to answer the research questions.

2.2.2. Quality criteria

Papers that met all the inclusion criteria and not match any of the exclusion criteria would be fully reviewed to decide if it fulfills a set of characteristics or quality criteria. In this review, the quality criteria focused on the description of the concept of digital competence, the research objectives, research design, research instrument, research sample, answers to research questions, research conclusions, research limitations, recommendations for future development of digital competence in the context of higher education and future research directions. It was validated by a group of experts consisting of five university professionals who assessed each item for clarity, pertinence and relevance, and suggested amendments. The quality criteria were presented in the form of questions with coded elements (Table 2).

Each question had three options and answers were coded as yes (1 point), no (0 point) and partial (0.5 point). Publications would be scored based on the content corresponding to the questions. Papers included in the final process must have or exceed a value of 7.5 as a cut-off point for the selection of papers.

The remaining 80 articles were evaluated by a set of quality questions as criteria. From this step, 47 articles were eliminated. In the end, 33 articles were selected to do the analysis and answer the research questions.

This data extraction procedure is represented through a PRISMA flow in Fig. 1 (Moher, Liberati, Tetzlaff, Altman, & Prisma Group, 2009).

3. Results and discussion

In this section, we provide answers to the research questions through the analysis of the selected articles. It is structured according to the questions posed, presenting the results of the systematic literature review (SLR).

3.1. How is digital competence defined in the context of higher education?

To clarify the definition of the digital competence, 21 of the 33 selected articles cited both research and EU policy in describing the definition of digital competence, seven of them defined digital competence by only referring to EU policy documents and five publications in this review defined digital competence by referring only research.

Among these selected publications, most of them defined digital competence in a general way. Ten publications explained particularly the concept of digital competence in terms of teachers and four publications indicated the digital competence developed among students in higher education.

In this literature review, the definition of digital competence by referring to European Union or other department policy documents or reports was quite common. First of all, nine of the selected publications referred to the Key Competences for Lifelong Learning European Reference Framework presented by the European Commission. Indicating that digital competence has been identified as one of the eight key competences for lifelong learning, it defined digital competence as “the confident and critical use of information society technology for work, leisure, and communication. It is underpinned by basic skills in information and communion technology: the use of computers to retrieve, assess, store, produce, present, and exchange information; and to communicate and participate in collaborative networks via the internet” (European Commission, 2006, 2018, p. 2018).

In addition, 11 publications paid attention to a report written by Ferrari (2012, 2013) from the European Commission, which was used in describing the concept of digital competence. Ferrari’s report reiterates the importance of incorporating digital technologies into educational process, because they provide benefits for teaching and learning, since basic training in digital competence is the key to personal development in today’s society and can help reduce the digital divide. He defined digital competence as follows:

“the set of knowledge, skills, attitudes, abilities, strategies, and awareness that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure,

Table 2

Quality criteria.

Quality criteria
1. Is the concept of digital competence clearly defined?
2. Are the research objectives clearly specified?
3. Is the study designed to achieve the objectives?
4. Is the instrument clearly described and design based?
5. Is the sample and population of the study clearly described, and is its size sufficient to carry out the proposed analyses?
6. Are the research questions adequately answered?
7. Are the conclusions clearly described and based on the results?
8. Do the authors discuss the problems and limitations of the research?
9. Are there any suggestions for digital competence in higher education as seen by faculty and students?
10. Are future lines of research presented?

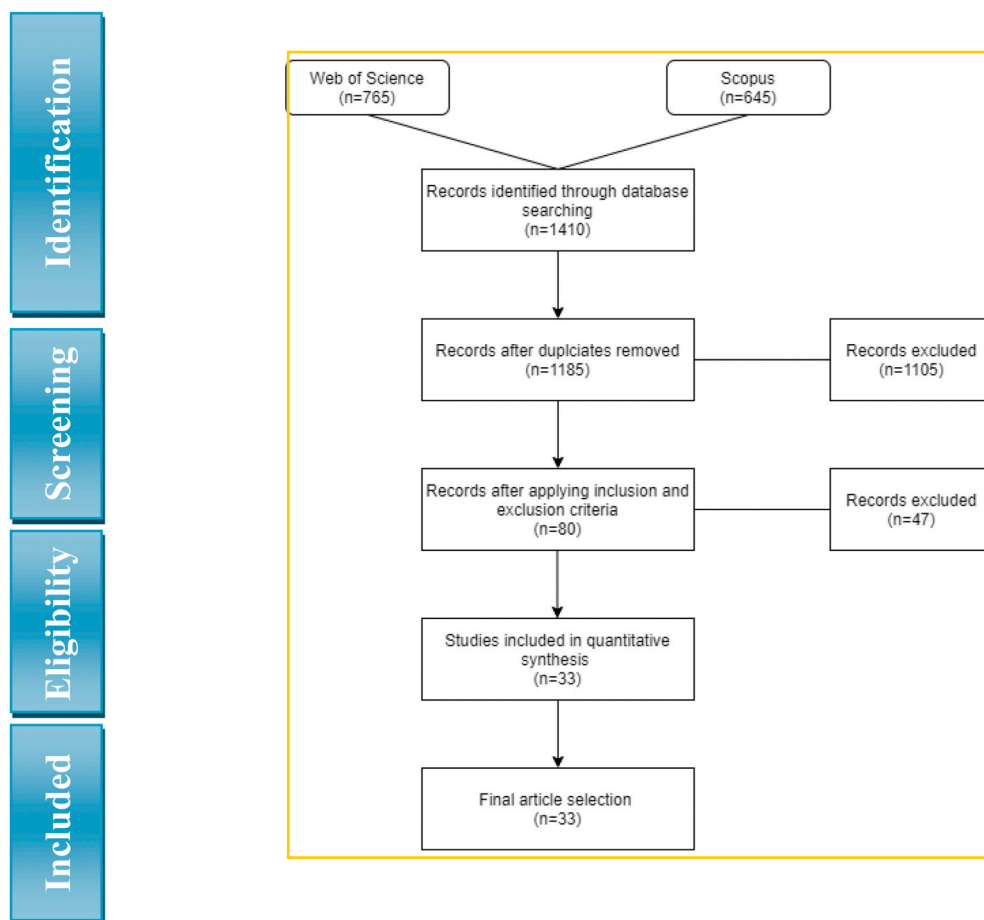


Fig. 1. PRISMA flow: data extraction procedure.

participation, learning, socializing, consuming and empowerment (p. 30)."

Furthermore, five articles referred to the European Commission's Digital Competence Framework (Digcomp) when defining and introducing digital competence. Indicating the inadequacy of the EU citizen's digital competence level, the Digcomp has been established to identify the EU citizen's digital competence and become a tool to improve and support digital competence. More importantly, five components of digital competence were presented: 1) information and data literacy; 2) communication and collaboration; 3) digital content creation; 4) safety; and 5) problem solving (Carretero et al., 2017; Vuorikari et al., 2016). This framework was updated into Digcomp 2.1 in 2017 with the same key dimensions for the development of digital competence. With these categories, the specific sub competences could be evaluated across different levels of proficiency. Gallego Arrufat, Torres-Hernández, and Pessoa (2019) noted that this framework has been consolidated and spread internationally through the European Digital Competence Framework for Educators (DigcompEdu). In the DigCompEdu project presented by the European Commission (2017), digital competence is considered as the ability of users to make a safe, critical and creative use of ICT to satisfy different objectives (Guillén-Gámez & Mayorga-Fernández, 2020a). And Redecker (2017) categorized an educator's digital competence into six areas: 1) professional engagement, 2) digital resources, 3) teaching and learning, 4) assessment, 5) empowering learners, and 6) facilitating the digital competence of the learners (Ryhtä et al., 2020). DigcompEdu established a model of digital competence for trainers (Romero-Tena, Barragán-Sánchez, Llorente-Cejudo, & Palacios-Rodríguez, 2020). And teacher digital competence (TDC) was presented by Ortega-Sánchez, Gómez-Trigueros, Trestini, and Pérez-González (2020), following the main skills of digital competence. In the work of López-Belmonte, Pozo-Sánchez, Fuentes-Cabrera, and Trujillo-Torres (2019), the Common Digital Competence Framework for Teachers indicating by National Institute of Educational Technologies and Teacher Training (INTEF), adapted from DigComp and DigCompEdu, has a high level of comprehensiveness and is also divided into 5 competence areas including 21 competencies, which are defined as the competencies that 21st century teachers need to develop in order to improve their educational practice and for continuous professional development, and a new revised version in 2017 (INTEF, 2017). With the aim to help teachers become digitally empowered learners, the theoretical works of the International Society for Technology in Education (ISTE) has been set as standards for educators (Romero-Tena et al., 2020).

Except for the European Commission policy and reports, Cote and Milliner (2017) referred to The United States Department (1996), which defined digital competence as having computer skills and abilities to use computers and other technology to improve learning,

productivity and performance. Then Bond, Marín, Dolch, Bedenlier, and Zawacki-Richter (2018), based on the Organization for Economic Cooperation and Development's (OECD) work (2015, 2018), emphasized the growing awareness of the importance of developing information and communications technology (ICT) skills and digital related competence and the digitization of higher education institutions.

21 publications described the definition of digital competence by using both policy documents and research. Articles presented by Calvani have gained attentions as a means to define digital competence (Byungura, Hansson, Muparasi, & Ruhinda, 2018; He & Zhu, 2017; He, Zhu, & Questier, 2018). Calvani, Cartelli, Fini, and Ranieri (2009) summarized digital competence as a combination of concrete and unquantifiable skills. Then they divided it into three dimensions and established a framework, emphasizing the co-existence of dimensions characterized both on the technological, cognitive and ethical levels dimensions and the integration of the relevant skills within these dimensions (Calvani, Fini, Ranieri, & Picci, 2012). Three of the selected publications referred Janssen et al. (2013) that defined digital competence as cognitive, attitudinal, and technical skills that help to mitigate numerous problems and challenges in the knowledge society and has a characteristic of dynamic and transversal (Gallego Arrufat et al., 2019; Guillén-Gámez et al., 2018; He & Li, 2019). Similar understanding was obtained Guillén-Gámez and Mayorga-Fernández (2020a) by referring Lazaro-Cantabrana, Usart- Rodríguez and Gisbert- Cervera (2019) and From (2017). Esteve-Mon, Adell-Segura, Nebot, Novella, and Aparicio (2019) referred to the frame presented by Larraz (2013) that digital competence has four dimensions (informational, technological, multimedia and communicative). He et al. (2018) indicated that digital competence is related to digital literacy, media literacy, ICT literacy, Information literacy and Internet literacy. They also defined digital competence with reference to Venkatesh, Morris, Davis, and Davis (2003) and Hatlevik and Christophersen (2013), regarding digital competence as students' ability in using technology or ICT self-efficacy, and they believed that digital competence could show how students produce and communicate information with digital technology. Byungura et al. (2018) mentioned that "The overall consideration of these concepts is related to values, knowledge, and skills that determine an individual's experience or proficiency in a particular technology (p.32)." Sales, Cuevas-Cerveró, and Gómez-Hernández (2020) referred to the update provided by Cilip (2018) to emphasize the informational dimension.

There are five publications in this review defined digital competence by referring only to research as a basis. Blayone, Mykhailenk, Kavtaradze, Kokhan, Oostveen and Barber (2018) as well as Kim, Hong, and Song (2019) considered the concept of digital competence in academic work as a set of technologies related to knowledge, skills and attitudes, which support a purposeful and effective use in technology (Ala-Mutka, 2011). Other publications defined digital competence as a description or identification of capacities and abilities (He et al., 2018; Gutiérrez Porlán & Serrano Sánchez, 2016). Gutiérrez Porlán and Serrano Sánchez (2016) referring to the work of Cebrián and Junyent (2015), indicated the complexity of the concept of competence, and then used the term competence to define digital competence (Muñoz, 2008). Guillén-Gámez and Mayorga-Fernández (2020b) understood digital competence as pedagogical digital competence that has three dimensions: attitudes towards ICT, knowledge and educative use of said technologies by referring the work of Ananiadou and Claro (2009) and Navarro, Zervas, Gesa, and Sampson (2016).

3.2. What are the dimensions commonly used to assess the digital competence of university teachers and students?

Various instruments with different dimensions were used among these 33 selected publications. Before presenting the results that refer to the dimensions often used to assess the digital competence of university teachers and students, the type of sample is counted in the following Fig. 2 and corresponding articles can be found in appendix.

There are 24 selected publications where their participants were students, six publications focused on teachers, and meanwhile

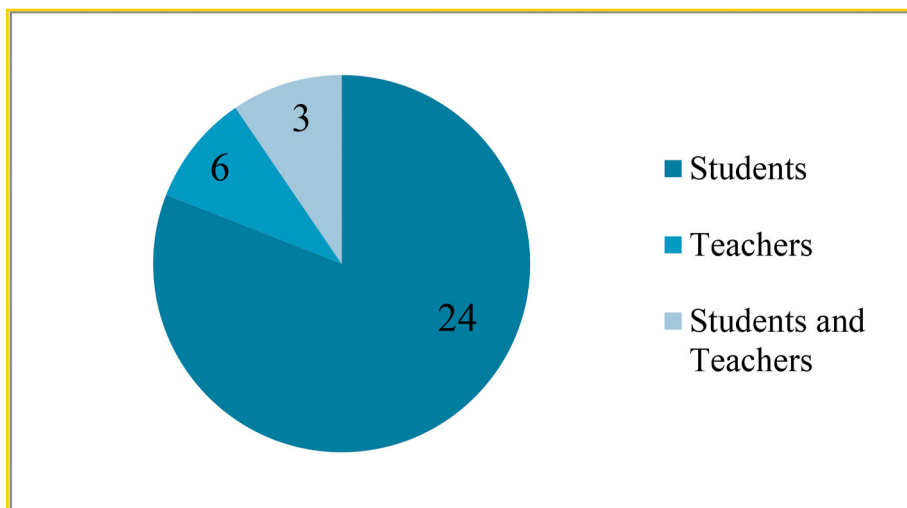


Fig. 2. Results of the category of participants.

there are three publications studied both teachers and students.

Several aspects and different points of view to evaluate the digital competence of students and teachers were showed (In Appendices Table 1). Most of the selected publications used survey as their research instrument. By examining and comparing the dimensions they have in the instruments, we find that nine publications followed and established on the basis of the dimensions presented by Digcomp which includes five dimensions developed from information, communication, digital content creation, security and problem solving to information and informal literacy, communication and collaboration, digital content creation, security and problem solving. Then six publications used and varied their instruments' dimensions based on technological, cognitive and ethical dimensions (Calvani et al., 2012; Janssen et al., 2013), while other publications established their instrument with other theoretical frameworks from different aspects. The most common dimensions used in the rest of the publications are the use and the knowledge of ICT tools, Internet and ICT related capacities, digital related experience and attitudes towards digital technologies.

3.3. What were the major research purposes, methodologies and outcomes in the studies of digital competence in the context of higher education over the past seven years?)

Firstly, the research concretized the concept of digital competence and offered us an understanding from different aspects and subdivides digital competence. Furthermore, it presented us with several precise instruments under different theoretical frameworks to carry out educational assessment in higher education.

To clarify the progress that has been made in the research on digital competence in higher education over the past seven years, we examined research purposes, research methods and research outcomes to gather the related information.

3.3.1. Research purposes

By examining and analyzing the research purposes of the selected publications, we grouped them into the following categories: 1) Investigating and evaluating the participants' perceptions and level of digital competence in higher education. Articles in this category assessed and evaluated participants' perception or the level of digital competence in the context of higher education. 2) Investigating factors that could influence digital competence. Publications in this category explored the factors that influenced and made differences in digital competence. 3) Investigating the impact of digital competence on participants' achievement where here particularly referring to students. Articles in this category evaluated the effect of digital competence on students' achievement. 4) Investigating the pedagogical approaches involved in digital competence. Articles in this category presented the pedagogical approaches involved in developing digital competence. 5) Investigating the validation of the digital competence-related instrument. Articles in the category measure the reliability and validity of the questionnaire. The results of the five categories are presented in Fig. 3.

Research purpose in investigating the participants' perception and their level of digital competence was the most often represented with 61% (n = 20) of selected publications in this category. Students' perceptions were evaluated from multiple perspectives. For example, some articles investigated participants' general perceptions and status of digital competence. Other publications paid their attention to specific types of perception, for instance, Finnish social and healthcare educators' perception of competence in digital pedagogy was explored (Ryhtä et al., 2020). López-Belmonte et al. (2019) investigated teachers' level of digital competence in the area of information and information literacy. Llorent-Vaquero, Tallón-Rosales, and de las Heras Monastero (2020) analyzed the competence in communication and collaboration of university students in Spain and Italy. Gallego Arrufat et al. (2019) determined pre-service teachers' level of digital competency in security area. Esteve-Mon et al. (2019) explored the potential of an intervention through educational robotics and combining computational thinking with the future teachers' perception of digital competence. While McGuinness and Fulton (2019) explored students' perceptions of digital competence via their use of e-tutorials, Guillén-Gámez et al. (2018) investigated future teachers' perception of digital competence by using 2.0 tools. Cabezas González, Casillas Martín, Sanches-Ferreira, and Teixeira Diogo (2017) investigated the students' perception of digital competence considering the genders differences. Sales et al. (2020) explored perspectives on the information and digital competence of students and faculty before and

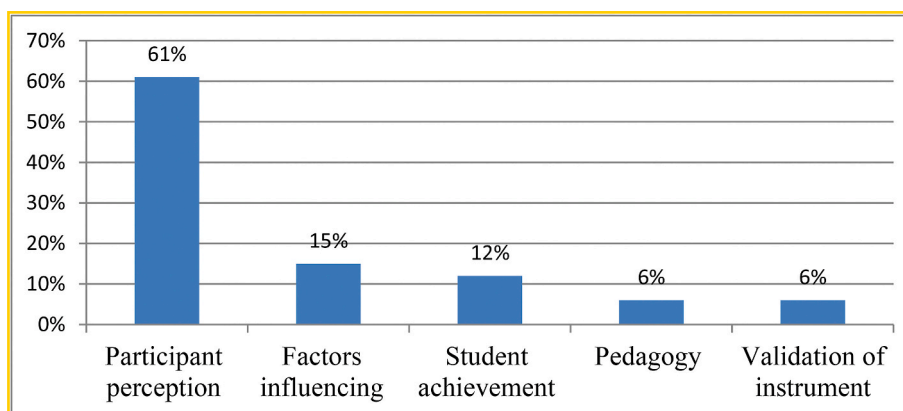


Fig. 3. Results of the category of the research purposes.

during lockdown due to Covid-19.

Factors that could influence digital competence also were investigated by 15% ($n = 5$) of selected publications. For example, Guillén-Gámez and Mayorga-Fernández (2020b) and explored the factors that could influence digital competence. Kim, Hong, and Song (2018) examined the impact of college students' prior digital experiences, particularly the influence of family, on their digital competence during college. García-Esteban (2017) analyzed the impact of video as a learning object on the development of teachers' and students' digital competence, in order to assess whether video could be beneficial to the development of this specific key competence in higher education. Grande-de-Prado, Canón, García-Martín, and Cantón (2020) identify the relationship between gender and students' digital competence. And Romero-Tena et al. (2020) investigated whether training received by the students was a key element to improve self-perception of digital competence.

Then four of publications evaluated the effectiveness of digital competence on students' achievement which is the second highest research purpose. He and Zhu (2017), He et al. (2018) as well as He and Li (2019) investigated the effects of digital competence and how they interacted on digital informal learning (DIL). Kim et al. (2019) examined university students' digital competence and digital readiness within the university context of an e-learning environment for their academic achievement.

Two of the selected publications investigated the pedagogical approaches involved in digital competence. Jiménez-Cortés, Vico-Bosch, and Rebollo-Catalán (2017) looked into the strategies used by female college students to develop digital competence and how this could influence their level of digital competence. Romero-García, Buzón-García, and de Paz-Lugo (2020) analyzed the implementation of an active methodology supported by technological tools in a virtual classroom contributes to students' digital development.

Finally, there were two selected articles validated the digital competence-related instrument. Cabero-Almenara, Gutiérrez-Castillo, Palacios-Rodríguez, and Barroso-Osuna (2020) measured the reliability and validity of the questionnaire DigCompEdu Check-In with the participation. Mengual-Andrés, Roig-Vila, and Mira (2016) built and validate a questionnaire about digital competences in higher education on the basis of their investigation results.

3.3.2. Research methods

Research methods used in these selected publications were examined, in Table 3 which presents the findings about research methods.

In general, authors from selected publications used seven types of research methods to develop their investigations. It is important to note that 24 of them used quantitative methodology to investigate digital competence related content, and the collection of data was performed through a questionnaire. Then four articles applied partial least squares structural equation modeling (PLS-SEM) to maximize the explained variance of dependent variables, while examining the impact of digital competence on DIL is a new research topic, and it matched the exploratory nature of PLS-SEM (He et al., 2018).

3.3.3. Research outcomes

In this review, 33 selected publications were analyzed. The research outcomes would be also presented by classification according to the research purpose.

Among articles investigating the perceptions and evaluating the level of digital competence of students and teachers, their research outcomes were analyzed. First of all, five of these articles reported that participants' digital competence was maintained at a basic level and they could feel limiting capacities when operating technological tools in some areas. As for students, they rated their competence quite well in the general and most basic aspects, but it decreased when the level of complexity increased (Cabezas González et al., 2017; Gutiérrez Porlán & Serrano Sánchez, 2016). For example, in the areas of the development of information literacy, digital content creation, digital identity management and digital research skills (Martzoukou, Fulton, Kostagiolas, & Lavranos, 2020). For educators, some of them were still unsure of how to integrate digital technology into their teaching activities (Rvhta et al., 2020). Then, a special mention should be made regarding the area of safety, which students were less aware of (Gutiérrez Porlán & Serrano Sánchez, 2016). In the work of Gallego-Arrufat & Torres-Hernández & Pessoa (2019), the digital competence in the area of digital security among future teachers was also especially investigated, confirming a need for in-depth development on security in the digital environment as most of the participants did not have previous training in this area and only a third of them had reached a medium level of competence. In addition, there were four articles presented, stating that students and teachers had an intermediate digital competence level and could be considered as digital competent in some aspects (Esteve-Mon et al., 2019; López-Belmonte et al., 2019; Llorent-Vaquero et al., 2020; Guillen-Gamez, Mayorga-Fernández & Del Moral, 2020a). In the work of Sales et al. (2020), the majority of faculty participants in the sample felt they had a good command on digital competence. Similar results were obtained from students that they received positive perception of digital competence (Ortega-Sánchez et al., 2020).

Table 3

Research methodology.

Research methods	Number of studies
Quantitative methodology	24
PLS-SEM	4
Qualitative methodology	2
Mixed methods	2
Delphi study	1

Furthermore, five studies focused on analyzing the factors that influence real digital skills. Among these five studies, factors such as gender, previous digital experience, received training, number of research and innovation projects participated in, teaching experience and the use of technology (Videos) have been listed. For example, Grande-de-Prado et al. (2020) indicated that men considered themselves more competent than women in the use of ICTs, reporting better information management and online collaboration skills, and also reported that women used technologies for social purposes while men used them more for technical or training purposes considering their different perception of digital competence. Concerning previous digital experience, students' previous positive digital experience would significantly influence their perceived digital competence and their attitude towards digital technologies (Kim et al., 2018). Romero-Tena et al. (2020) showed students' low-level self-perception of digital competence and pointed out the importance of training received in the improving digital competence process. As for teachers, Guillén-Gámez and Mayorga-Fernández (2020b) indicated that the number of participating research and educational projects correlated positively, while teaching experience correlated negatively with the level of digital competence. Then, the outcomes of the García-Esteban's study (2017) indicated that working with video learning objects could have a high positive impact on the attainment of the digital competence of the participants. Besides, gathering all information about influencing factors of digital competence from selected researches, the following factors that could affect digital competence were: age, attitude and technological and cognitive skills (Cabezas González et al., 2017; He et al., 2018; Madsen et al., 2018).

Among the four articles which explored the impact of digital competence on students' achievement, three of them highlighted the essential role of digital competence in DIL. They confirmed the positive association between the university students' digital competence and students' DIL, by concluding that students with higher level of digital competence tended to more get involved in DIL (He & Li, 2019; He & Zhu, 2017; He et al., 2018). Kim et al. (2019) indicated that digital competence and digital readiness had positive and significant effects on academic engagement.

About pedagogical approaches involved in digital competence, autonomous learning strategies in ICT could promote digital self-inclusion, and pedagogical strategies based on independent and collaborative learning were suggested to be incorporated into university teaching (Jiménez-Cortés et al., 2017). Moreover, future teachers could improve their digital competence by studying a module

Table 4

Type of limitations of the selected investigations.

Investigation	Type of limitations
Gutiérrez Porlán and Serrano Sánchez (2016)	Formulation of the aims and objectives of the research, self-reported data.
Jiménez-Cortés, Vico-Bosch & Rebollo-Catalán (2016)	Not mentioned
Mengual-Andrés et al. (2016)	Implementation of the data collection method, sample size.
Cote and Milliner (2017).	Implementation of the data collection method, sample size.
Cabezas González et al. (2017)	Not mentioned
García-Esteban (2017)	Not mentioned
Guzmán-Simón, García-Jiménez, and López-Cobo (2017)	Implementation of the data collection method, sample size.
He and Zhu (2017)	Implementation of the data collection method, sample size.
Blayone, Mykhailenko, Kavtaradze, Kokhan, and Barber (2018)	Implementation of the data collection method, lack of data, formulation of the aims and objectives of the research, self-reported data.
Byungura et al. (2018)	Implementation of the data collection method, research time.
Bond et al. (2018)	Sample size.
Guillén-Gámez, Mayorga-Fernández & Álvarez-García (2018)	Lack of data, sample size, formulation of the aims and objectives of the research.
He et al. (2018)	Implementation of the data collection method, Lack of data.
Kim et al. (2018)	Lack of data, sample size, self-reported data, lack of previous research studies on the subject.
Madsen et al. (2018)	Implementation of the data collection method, lack of previous research studies on the subject.
Esteve-Mon et al. (2019)	Sample size.
Gallego Arrufat et al. (2019)	Implementation of the data collection method, sample size.
He and Li (2019)	Implementation of the data collection method, lack of data, formulation of the aims and objectives of the research.
Kim et al. (2019)	Lack of data.
López-Belmonte et al. (2019)	Lack of data.
McGuinness and Fulton (2019)	Not mentioned
Cabero-Almenara et al. (2020)	Not mentioned.
Guillén-Gámez and Mayorga-Fernández (2020a)	Self-reported data.
Guillén-Gámez and Mayorga-Fernández (2020b)	Not mentioned.
Guillén-Gámez, Mayorga-Fernández, and Del Moral (2020).	Sample size.
Grande-de-Prado et al. (2020)	Implementation of the data collection method, self-reported data
Romero-Tena et al. (2020)	Sample size.
Llorent-Vaquero et al. (2020)	Not mentioned.
Martoukou et al. (2020)	Self-reported data; sample size.
Ortega-Sánchez et al. (2020)	Implementation of the data collection method.
Romero-García et al. (2020)	Not mentioned.
Ryhtä et al. (2020)	Implementation of the data collection method, research time, lack of data.
Sales et al. (2020).	Implementation of the data collection method.

which implements a pedagogical proposal based on active methodologies supported by digital tools (Romero-García et al., 2020).

In regard to the validation of the digital competence-related competence, the questionnaire built by Mengual-Andrés et al. (2016) was presented as a good tool for undertaking future national and international studies on digital competence in higher education. The questionnaire DigCompEdu Check-In is an instrument with high levels of reliability and validity (Cabero-Almenara et al., 2020).

3.4. What kinds of limitations exist in research on digital competence in higher education?

Table 4 shows the type of limitations of the investigations. It was observed that the implementation of the data collection method was the most frequent limitation in the 33 selected researches ($n = 14$). Then the size of the sample presented to be a research limitation that usually had in the articles ($n = 12$), and the lack of available and reliable data also couldn't be ignored in the researches ($n = 7$). There were 17 articles that had more than one research limitations while eight selected articles did not indicate their research limitation.

4. Limitations

This systematic literature review provides a state of art through validate studies. It is a description of researches that are included in two data bases called Web of Science and Scopus over the past seven years (2015–2021). First, this review only studied the publications from these two selected data bases, and therefore not all the existing publications on the subject were included. Second, it should be mentioned that we have limited the years from 2015 to 2021 when looking for publications to highlight the results in recent years. In addition, we focused on the publications written in English, articles published in other languages about digital competence in higher education were not represented. It's also recommended that having at least two individuals use the evaluation criteria to review papers in the future systematic literature reviews.

5. Conclusions

This systematic review introduces how the concept of digital competence is defined and used in higher education and provides an overview of current research on digital competence in the higher education settings regarding research purpose, methodologies, instrument, outcomes and limitations. It describes the progress and trends in research related to digital competence in higher education over the past seven years. In this review, a total of 33 publications were analyzed. First of all, a general finding about the definition of digital competence is that the reviewed publications defined digital competence in a general way by referring to policy documents and related research while it can be present from different perspectives. The framework presented in Europe has gained worldwide attention. Only a few publications have further developed these concepts for different research audiences.

We explored the dimensions commonly used to assess the digital competence of teachers and students in universities. We examined the objects of studies first, and then realized that authors in the selected publications preferred investigating students rather than teachers as students made up the majority of the higher education population. Since the outbreak of Covid-19 pandemic and the emergence of new models of teaching–learning processes, students that have potential to be future teachers should be required to acquire and develop digital competences and skills (Ortega-Sánchez & Gómez-Trigueros, 2017). After reviewing the dimensions used in various research instruments of digital competence, we highlighted that 27% of publications applied the assessment of digital competence in higher education based on DigComp. However, other frameworks for digital competence have received attention in articles published in recent years (Ortega-Sánchez et al., 2020; Ryhti et al., 2020).

Based on the answers to the questions posed, it is clear that there is a growing interest in issues related to digital competence in higher education settings. The research purpose of 33 selected publications were reviewed and analyzed. It is deduced that research on digital competence in the context of higher education mainly focused on the real status of teachers and students' digital competence, since 61% of publications indicated the research purpose as investigating and evaluating the participants' perceptions and level of digital competence. The exploration and the investigation of digital competence is still in the initial stage, with only 15% publications exploring the factors that could influence digital competence and 12% evaluating the effect of digital competence on students' achievement. In particular, they mentioned mentioning the close relationship between digital competence and students' achievement in digital informal learning. According to the results obtained, more attention should be paid to appropriate pedagogical approaches involved in digital competence which is a key for universities to adapt to the current educational model and social environment. Moreover, the validation studies of digital competence related tools have showed the aspects of other theoretical frameworks for the interpretation of digital competence and can reflect the different needs that digital competence needs to meet at different times. In terms of research methods, quantitative research methodology using questionnaires as research instrument was applied by 73% of the selected publications.

We also analyzed the research outcomes as they introduced the progress that has been made over the past seven years. In general, the digital competence of college teachers and students is at a basic or medium level. Some of them may think they have a good level of performance in a certain area such as communication and collaboration, but most of them can still feel shortcomings in their ability when they encounter complex problems. As we live in an era of big data, the security part needs special attention, which is a weakness of students and future teachers according to the obtained results. Several factors that could influence digital competence were presented, in conjunction with the positive relationship between digital competence and student achievement, considering the appropriate pedagogical approach applied in digital competence, these studies have provided us with a more refined observation of digital competence in higher education. With these instruments validated by studies, university teachers and students' digital competence

could be measured from different dimensions timely.

Among these selected publications, the most common limitations were the implementation of data collection methods and sample size. Future studies should avoid the use of a single research method and take into account the sample size of the participants in the experiment.

This review is useful for scholars to gain a comprehensive understanding of the definition and application of digital competence in higher education, to understand the remaining gaps in the literature.

6. Identified gaps and future research

This systematic review identified gaps in the research and provided research opportunities in the area of digital competence in the context of higher education. First, the majority of the selected articles explored the perception and level of digital competence. However, most of them evaluated it by self-reported data which may not show the real level of their digital competence. Applying a practical test of digital tasks may provide a better understanding of participants' digital competence. Furthermore, sub digital competence areas cannot be ignored and it is worth being investigated in more detail.

Second, the findings of this systematic review reveal that the pedagogy involved in digital competence and the validation of the digital competence related instruments accounted only for 6% each of a total of 33 studies. How digital competence can be used and immersed for teaching and learning and the building and the validation of an instrument related to digital competence need to be further explored.

Third, according to the results from this systematic literature review, many articles used only one research method. A quantitative data approach, combining with a qualitative data approach may offer more comprehensive results about digital competence in higher education.

Finally, the findings of this systematic review show that undergraduate students are a common group studied in digital competence research, especially first year students. Although undergraduates make up the largest percentage of higher education students, it would be pertinent to conduct more in-depth studies related to digital competence on graduate students and on teaching faculty. And sample size should be noted by future researchers, as these could influence whether the results are representative or not.

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Declaration of competing interest

None.

Appendix

Table 1

Participants and dimensions mentioned of digital competence in the selected investigations.

Investigation	Participants	Dimensions mentioned
Gutiérrez Porlán and Serrano Sánchez (2016)	Students	Information; communication; creation of contents; safety and problem solving.
Jiménez-Cortés, Vico-Bosch & Rebollo-Catalán (2016)	Students	Sociodemographic variables and use of technologies; learning strategies scale; Internet digital skills scale
Mengual-Andrés et al. (2016)	Teachers and students	Technological literacy; information access and use; communication and collaboration; digital citizenship; and creativity and innovation.
Cote and Milliner (2017).	Students	

(continued on next page)

Table 1 (continued)

Investigation	Participants	Dimensions mentioned
Cabezas González et al. (2017)	Students	Use of various applications; ability to complete the digital tasks; ability to fulfill the following Internet-related tasks; general computer knowledge.
Guzmán-Simón et al. (2017)	Students	Identification; possession of the ICT devices; knowledge related to ICT; management of the digital tools; attitude to ICT.
García-Esteban (2017)	Students	Information literacy and ICT literacy.
He and Zhu (2017)	Students	Information and data Literacy; communication and collaboration; digital content creation; safety; problem solving.
Blayone et al. (2018)	Students	Technological dimension: 1. visual literacy (VL); 2. understanding Technological Concepts (UTC); 3. trouble Shooting (TS); cognitive dimension: 1. organizing and connecting textual and visual data (OCTV); 2. organizing structured data (OSD); 3. Information Search (IS); ethical dimension: 1. staying safe online (SSO) refers to personal privacy; 2. respect for others (RO). Attitude to DIL; personal innovativeness.
Byungura et al. (2018)	Students	Socio-demographic and device-usage items; technical dimension, and communicational dimension, informational dimension and computational dimensions of use.
Bond et al. (2018)	Teachers and Students	Participants' demographic information; ownership, access and use of computing tools and the Internet; and the level of confidence with technology and previous computer-based training to acquire digital skills.
Guillén-Gámez, Mayorga-Fernández & Álvarez-García (2018)	Students	Teachers: The use and perceived usefulness of digital tools for teaching. Frequency of using the digital tools.
He et al. (2018)	Students	Students: Frequency of use and perceived usefulness of digital tools and services.
Kim et al. (2018)	Students	Sociodemographic characteristics; use of electronic devices in teaching practice; the use of 2.0 tools; use of Learning Management System; the use of other 2.0 resources.
Madsen et al. (2018)	Teachers	Technological skills; cognitive skills and ethical knowledge.
Esteve-Mon et al. (2019)	Students	Attitude toward digital technologies; Learning Agility; Prior Digital Experience with Family; Student Engagement; Personal effort to learn ICT; Perceived digital competence.
Gallego Arrufat et al. (2019)	Students	Digital Competence; professional attitude; professional applications of tools.
He and Li (2019)	Students	Informational literacy, technological literacy, multimedia literacy and communicative literacy.
Kim et al. (2019)	Students	Interaction through technologies; information sharing and digital contents; netiquette; digital identity management; personal data protection; protection of health; cyber bullying on social and smart phone technology.
López-Belmonte et al. (2019)	Teachers	Digital competence: ISK, ASK, ASE; digital informal learning; Technology expectancy.
McGuinness and Fulton (2019)	students	Academic engagement; E-learning adoption; E-learning attitude; Digital readiness; Academic achievement
Cabero-Almenara et al. (2020)	Teachers	Social; Navigation, search and filtering; Evaluation; Storage and recovery; Massive data processing.
Guillén-Gámez and Mayorga-Fernández (2020a)	Students and teachers	Sociodemographic characteristic; perception of digital literacy and experience on-line learning; perception of E-tutorial and usability; perception of learning supported by e-tutorial; perceived challenges; perception of on-line learning.
Guillén-Gámez and Mayorga-Fernández (2020b)	Teachers	Professional engagement; digital resources; teaching and learning; assessment; empowering learners; facilitating learners' digital competence.
Guillén-Gámez et al. (2020).	Students	Attitude; knowledge; the use of digital technologies.
Grande-de-Prado, Caño, García-Martín & Cantón (2020)	Students	knowledge and use in 2.0 tools for teaching, evaluation and research.
Romero-Tena et al. (2020)	Students	Attitude; knowledge; the use of digital technologies.
Llorent-Vaquero et al. (2020)	Students	Information and data Literacy; communication and collaboration; digital content creation; safety; problem solving.
Martoukou et al. (2020)	Students	Technological literacy; search and treatment of information; critical thinking; communication and collaboration; digital citizenship; creativity and innovation.
Ortega-Sánchez et al. (2020)	Students	Competence in the knowledge and use of ICTs for social; communication and collaborative learning; competence in the use of ICTs for searching and processing
Romero-García et al. (2020)	Students	Information; interpersonal competence in the use of ICTs in a university context.
Ryhtä et al. (2020)	Teachers	Everyday participation as a Digital Citizen; ICT proficiency with completing different tasks; ICT productivity; information identification in different contexts; information literacy skills; digital creation skills; digital research skills; digital communication skills; digital innovation; digital learning and development; digital identity management; digital wellbeing.
Sales et al. (2020)	Teachers	Teaching skills and future teachers' TDC; university teachers' TDC.
		Technological literacy; search and treatment of information; critical thinking; communication and collaboration; digital citizenship; creativity and innovation.
		Educator competence; recent changes in requirements concerning educator competence; future educator competence; continuing education and professional development for educators; the educators' use of digital technology.
		The use and value of information; agents responsible for information competence at the university; self-conception of information competence as a teacher.

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