THESIS DOCTORAL

Education in the knowledge society PhD programme

University Teachers and Students' Digital Competence: A Case Study of Gansu Agricultural University in China

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Salamanca, 2022

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CAMPUS OF INTERNATIONAL EXCELLENCE

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PhD thesis

University Teachers and Students' Digital Competence: A Case Study of Gansu Agricultural University in China

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Abstract

Living today in the knowledge society allows us to be aware of the changes in the structure of society, the connections between countries and the acquisition of knowledge, as well as the ever-growing technological development and penetration into every aspect of our life. The outbreak of the new coronavirus (COVID-19) has further propelled the revolution in education. The educational model has changed and with it comes a variety of challenges. Teachers and students are required to be equipped with adequate digital competence and the ability to use information and communication technologies (ICTs) and the Internet proficiently, especially in higher education. Consequently, the gap of digital competence is widened, not only between developed and developing countries, but also within the same country due to the imbalance of economic growth, such as the huge gap between the east and west of China. It is of great necessity to enhance the digital competence to better meet the challenges, to narrow the digital gap and to adapt to this knowledge society as well as to the new learning environment.

The main purposes of this thesis are: firstly, to present the definition of digital competence in the higher education, to indicate the dimensions commonly used to assess university teachers and students' digital competence, to determine the state of research in this field, and to identify the areas for further research through a systematic literature review and a mapping study. Secondly, to carry out an empirical study on university teachers and students at Gansu Agricultural University in the west of China. For in-service university teachers, the focus was on the exploration of their digital competence, the use of ICTs and their attitudes towards the use of ICTs in education. For university students, especially for those freshmen and senior students, the emphasis was placed on students' digital competence and their attitudes towards ICTs; and their availability of technological resources, their potential for digital competence, and previous training related to ICTs and digital competence were covered as well. Moreover, the factors influencing digital competence were examined to determine its development needs.

Keywords: Digital competence; ICTs; higher education; University; university teachers; university students; China

Resumen

Vivir hoy en día en una sociedad del conocimiento nos permite ser capaces de conocer los cambios en la estructura de la sociedad, las vinculaciones entre países y la adquisición de conocimientos, así como el desarrollo y la penetración cada vez mayor de la tecnología en todos los aspectos de nuestra vida. El brote del nuevo coronavirus (COVID-19) ha impulsado aún más la revolución en educación. El modelo educativo ha cambiado y con él llegan diversos retos. Se exige a los profesores y a los estudiantes que estén dotados de la competencia digital adecuada y de capacidad para utilizar con eficiencia diversas herramientas de las tecnologías de la información y la comunicación (TIC), especialmente en educación superior. Además, la brecha de la competencia digital se amplía, no sólo entre los países desarrollados y los países en vías de desarrollo, sino también dentro de un mismo país, debido al desequilibrio del crecimiento económico, como la enorme brecha entre el este y el oeste de China. Es muy necesario mejorar la competencia digital para afrontar mejor los desafíos, reducir la brecha digital y adaptarse a esta sociedad del conocimiento, así como al nuevo entorno de aprendizaje.

Los principales objetivos de esta tesis son: en primer lugar, presentar la definición de competencia digital en educación superior, indicar las dimensiones que se utilizan habitualmente para evaluar la competencia digital de los profesores y estudiantes universitarios, determinar el estado de la investigación en este campo e identificar las áreas de investigación futura mediante una revisión sistemática de la literatura y un estudio de mapeo. En segundo lugar, realizar un estudio empírico sobre los profesores y estudiantes universitarios de la Universidad Agrícola de Gansu, situada en el oeste de China. Para los profesores universitarios en activo, la atención se centró en la exploración de su competencia digital, el uso de las TIC por parte de los profesores y sus actitudes hacia el uso de las TIC en la educación. Con respecto a los estudiantes universitarios, especialmente los de primer y último curso, se hizo énfasis en la competencia digital de los estudiantes y sus actitudes hacia las TIC; y también se incluyó su disponibilidad de recursos tecnológicos, su potencial de competencia digital y la formación previa relacionada con las TIC y la competencia digital. Además, los factores que influyen en la competencia digital para determinar sus necesidades de desarrollo han sido examinados.

Palabras clave: Competencia digital; TIC; educación superior; universidad; profesores; estudiantes; China

| Chapter 1 |

Introduction

University of Salamanca

Today's society is changing and evolving at a rapid pace, in which the convergence between telecommunications, broadcasting and information and communication technologies (ICTs) is accelerating. ICTs are generating new products and services, and new forms of organization. At the same time, as markets open up to competition, investment and foreign participation, opportunities for partnerships, businesses and professions proliferate. The world is undergoing an enormous transformation. Countries have gradually advanced from the industrial society that marked the 20th century through the information age and into the knowledge society.

In this dynamic development process, information technology and the information industry play an increasingly important role in economic and social development. The information society, based on electronic information technology and knowledge, with information resources, information service industry, digitalization and networking as basic social interaction, has come into people's sight (Isazadeh, 2004). Then, the rapid progress of new ICTs has created new conditions for the rise of today's knowledge society. This knowledge society emerged in response to social developments, so as to build a pluralistic, inclusive, cohesive and participatory view of society, and to create and apply the capacities to identify, produce, process, transform, disseminate and use information necessary for human development (Bindé, 2005). In contrast to the earlier information society, which merely creates and disseminates raw data, the role of the knowledge society is to transform information into a resource that enables society to respond effectively (Castelfranchi, 2007). The knowledge society summarizes and expresses the complexity and dynamism of the social transformations that are taking place in modern society, and serves to analyze these transformations, and it plays an important role in the current discussions in the social sciences.

Various technologies have undergone incredible development over the last decade, which have allowed ICTs to bring their gradual incorporation into different professional fields, including education (Brown & Duguid, 2017; Dellit, 2002; Varela-Ordorica & Valenzuela-González, 2020). The crossroads of history we are at is not only populated by digital immigrants who have to learn and adapt ICTs, but also by digital natives who have grown up with technology and who form a major part of education now and will become the mainstream of education in the future (Prensky, 2001, 2009). As a consequence, the digital divide or even digital inequality may appear because of the use of ICTs. Digital competence is specifically required to improve the quality of ICTs use (Ilomäki et al., 2011). Moreover, several countries and institutions have been accelerating progress towards the Sustainable Development Goal 4 (SDG), which refer to goals of quality education proposed by the United Nations (2015). Different plans and reports have been launched to develop digital education with the aim of supporting the sustainable and effective adaptation of education and training systems, reinforcing digital competence and helping to bridge the digital divide in education (European Commission, 2020a, 2020b; Gobierno de España, 2020).

Moreover, the emergence and outbreak of the coronavirus disease in 2019 (COVID-19) have brought a huge impact to several industries, as well as education. Education systems are experiencing the greatest disruption and challenge in their history. The impact of the epidemic has forced the closure of many schools and other learning centres around the world. The crisis has also widened the existing education gap (UNESCO, 2020a). In response, many schools and institutions are following recommendations to transform traditional face-to-face offline education into online distance learning and use open educational applications and platforms to ensure and facilitate teaching and learning activities (UNESCO, 2020b). Teachers and students, as essential parts of education, are required to be equipped not only with pedagogical skills, but also with adequate competencies related to digital technology, so as to face these changes and challenges in the new landscape imposed by the COVID-19 pandemic.

Despite the fact that offline education is slowly coming back into the limelight as the epidemic comes to a close, the growth of online education has nonetheless become an unstoppable trend. The educational environment is becoming increasingly complex (Hatlevik & Christophersen, 2013). Today's education needs to be understood and developed through the use of new technologies, and where educational participants' digital competence is a key factor (Caena & Redecker, 2019; Carini et al., 2006). Teachers' digital competence, as a main guide in the teaching and learning process, their digital competence contributes significantly to their level of teaching expertise (Mangiri et al., 2019). Also, higher education is considered as an essential place for students in acquiring abilities for present academic and future professional contexts (Pérez-Mateo et al., 2014). University students are expected not only to accomplish their professional learning goals but also to integrate with new forms of social, political, economic and educational life organizations in view of their later entry into the professional career. Moreover, in the 21st century, today's university students represent a generation that has grown up with the dramatic development of computer networks, experienced the unprecedented development of the Internet, virtual reality (VR) and artificial intelligence (AI), and had the requirement of having their digital competence increased by the emergence of COVID-19. In general, there is a need for developing new professionals with a wide range of skill sets, with a particular focus on digital competence (Cabero et al., 2018).

In 2006, digital competence was included in the recommendation on key competences for lifelong learning that was proposed by the European Commission. Digital competence is defined as "the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: 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, p. 15). The European Commission has updated the eight key competences for lifelong learning in 2018, among which are digital competence; literacy competence; multilingual competence; mathematical competence and competence in science, technology and engineering; personal, social

and learning to learn competence; citizenship competence; entrepreneurship competence; cultural awareness and expression competence involved. The definition of digital competence involves "the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society" (European Commission, 2019, p. 10). Digital competence reflects not only the skills in using digital technologies, but also the use and understanding of the social and emotional aspects of digital devices and related technologies. Digital competence in the teaching and learning process is understood as technology-related knowledge, skills and attitudes towards the use of digital technologies to achieve educational goals and expectations (Kim et al., 2018).

Different frameworks have been proposed to evaluate and develop citizens, workers and educators' digital competence (Centeno, 2020; Ferrari, 2012; Kluzer & Priego, 2018). In the European countries, the digital competence framework (DigComp) has been widely understood and used to develop citizen's digital competence (Ferrari, 2013). It is a project carried out by the Joint Research Centre from 2010 to 2013 with the purpose of identifying the key components of digital Competence. After several phases (conceptual mapping, case studies analysis, online consultation, experts' workshop), a consolidated draft proposal for a digital competency framework was presented and a roadmap that would allow for the realization and revision of the digital competency framework was drawn (Ala-Mutka, 2011; Ferrari, 2012, 2013; Janssen & Stoyanov, 2012). Various versions of DigComp have been presented with the advancement of digital technologies and the changing situation. Several updates have been made from DigComp 1.0 to DigComp 2.2, not only in terms of vocabulary and descriptors, but also in terms of use cases in different scenarios (employment and learning) and examples of knowledge, skills and attitudes. (Carretero et al. 2017; Vuorikari et al. 2016 Vuorikari et al., 2022). This has led to a range of frameworks to contribute to the development of the digital competence of subjects in different fields, such as a framework for digitally-competent educational organizations (DigCompOrg) and the Digital Competence Framework for Consumers (DigCompConsumers) (Brečko & Ferrari, 2016; Kampylis et al., 2015).

In the educational field, distinct frameworks have been presented according to the different characteristics of teachers and students. The International Society for Technology in Education (ISTE) published National Educational Technology Standards for Teachers (NETS-T) and National Educational Technology Standards for Students (NETS-S) that offers a comprehensive roadmap for the effective use of technology in schools (ISTE, 2008, 2016). There were several proposed frameworks to analyze teachers' digital competence in particular. Two main proposals stand out in the existing literature on models for developing digital competence in teaching, which are Digital Competence Framework for Educators (DigCompEdu) (Redecker, 2017) and the Common Digital Competency Framework for Teachers (CDCFT) (INTEF, 2017). DigCompEdu, which is articulated through major proposals for international teacher frameworks, has been elaborated on previous work (DigComp and DigCompOrg) and has presented 22 educator-specific digital competences organized

in six areas (Redecker, 2017). In terms of CDCFT, it is developed in Spain within the Strategic Framework for Teacher Professional Development and the Digital Culture Plan in Schools by the National Institute of Educational Technologies and Teacher Training (INTEF) and supports educational institutions, departments and educators with a descriptive reference (INTEF, 2017). It has been divided into five competence areas comprising 21 competences that adapted from the DigComp 2.1 and DigCompEdu. Both of them have separately presented six progressive competence levels of educators. Moreover, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has proposed an ICT Competency Framework for Teachers and Media and Information Literacy Curriculum for Teachers (UNESCO, 2011, 2018). The Technology Pedagogical Content Knowledge (TPACK) framework, which describes the knowledge required for teachers to successfully integrate technology in their teaching, has been adopted by a wide variety of researchers in the field of education (Gur, 2015; Mishra & Koehler, 2006; Soler-Costa et al., 2021).

Before the pandemic, digital competence had been mentioned and discussed (Hatlevik, et al., 2015; Røkenes & Krumsvik, 2014; Salazar Gómez et al., 2018). It has been a topic of interest in the different studies carried out in the educational field, as it remains a key competence (Newland & Handley, 2016; Ilomäki et al., 2016; Sánchez-Caballé et al., 2020). In the context of the continuous development of ICTs and within a particular educational context, the interest of academics in digital competence had reached a new height (Sá & Serpa, 2020; Tejedor et al., 2020).

With the changes brought about by the pandemic and the development of new technologies, as well as having pedagogical abilities, working with digital technologies have become a core part of an educators' daily work. A number of studies have investigated the impact of educators' proficiencies and pedagogical judgements in the use of ICTs on the quality of education and students' digital competence and their academic performance (Bai et al., 2016; Krumsvik, 2011; Starkey, 2020; Uerz et al., 2018). For the other protagonists of education, digital competence of students is positively related to their learning performance (Hubbard, 2020; Nyikes, 2018). Moreover, the "digital divide" and even existing social inequalities can be further deepened due to the conditions associated with digital competence (Šuminas et al., 2018). The issues of digital competence are not only a component of the digital status of participants in the educational process, but are also solutions that can help educators alleviate the problems that have arisen in today's knowledge society with the effects of the pandemic. Furthermore, the concept of digital competence is sometimes presented, compared and discussed along with issues of digital literacy (Spante et al., 2018). Teachers' proficiency in using ICTs as part of the teaching process has a strong connection to the quality of their education.

Over the past few years, the importance of exploring teachers and students' digital competence has gained attention in the field of educational research, and as a result, different studies have appeared on the subject (Rodríguez-García et al., 2019). As mentioned earlier, UNESCO has presented frameworks for teachers all over the

world (ICT Competency Framework for Teachers, Media and Information Literacy Curriculum for Teachers). Various well-developed frameworks on citizens'(DigComp), teachers' (CDCFT, DigCompEdu, NETS-T, TPACK) and students' (NETS-S) digital competence have been introduced in western countries. However, frameworks specifically designed for Eastern educational systems has yet to be fully established and developed. The characteristics of education systems in Eastern countries are found to be different from those in Western countries, as well as learners' features (Ho, 2009; Sit, 2003).

On the other side of the world from Europe, China has the largest population in the world (Baidu, 2021). There are 325 million online education users in China (China Internet Network Information Center, 2021). However, in comparison with developed Western countries, China is still in the informatization and digitalization. The information industry ecosystem in China has now been basically established, with ICTs and economic and social developments deeply integrated (General Office of the Communist Party of China, 2016). To date, there has not been a framework specifically designed for Chinese citizens to assess their digital competence. A number of reports and blue papers have been published and released to implement and promote the strategic deployment of "Digital China", which refers to embracing the digital era, activating the potential of data elements, accelerating the construction of a digital economy, digital society and digital government, and driving overall changes in production methods, lifestyles and governance with digital transformation. (Cyberspace Administration of China, 2020; Office of the Central Cyberspace Affairs Commission, 2021). However, the unevenness of China's education informatization and digital development has also come to the fore (Wei & Wang, 2016). People's digital abilities are uneven, which is reflected in the international information gap and the domestic information gap (Zhu, 2011). The differences between China and other countries in terms of theoretical guidance have been mentioned above. The domestic information gap, on the other hand, is reflected in differences between regions and populations, and is generally characterized by a "high in the south and low in the north" and a "high in the east and low in the west" distribution (Wei & Wang, 2016). Although the Internet penetration rate in China is being further improved and the urban-rural divide is being narrowed (China Internet Network Information Center, 2021), development has been slower in the remote western regions than in other regions.

In this study, we focused on university teachers and students' digital competence at Gansu Agricultural University in the west of China. Gansu Agricultural University is situated in Lanzhou, the capital of Gansu Province in western China, and is one of the key universities in the mid-west region of China on which the government concentrates its development. Teachers and students of this university have provided strong support and human resources for the economic construction and social development of the west region of China. According to the Action Plan for Revitalizing Teacher Education (2018-2022) released by China's Ministry of Education in 2018, it has mentioned the need to promote equitable development of education, to strengthen teacher training in the mid-west region, to improve the quality

of education and students' development in poverty areas and to continues promoting the deep integration of information technology and education. It is a region with a complex educational background that is an important factor in the development of China's digitalization and informatization process (Lu, 2004).

Considering the importance of digital competence in the educational process today, and the existing regional development gap in China, it is in this context that the hypothesis that provides meaning to this research study arises: The need to investigate the state of the art of teachers' and students' digital competence in order to be able to make reasoned, contrasted and structured suggestions towards the development of the digital competence in higher education.

The objectives and research questions of this thesis, as well as the structure of the document, will be presented in the following parts.

1.1 Objectives and research questions

The main objectives of this work are:

- To identify teachers' digital competence at Gansu Agricultural University.
- To determine first and fourth year students' digital competence at Gansu Agricultural University.

From these general objectives, the following specific objectives are proposed:

- To conduct a systematic literature review with mapping study on digital competence in higher education.
- To explore university teachers' digital competence, with the support of the use of ICTs and their attitudes towards the use of ICTs in education.
- To analyze whether there are significant differences between university teachers' digital competence, the use of ICTs and their attitudes towards using ICTs in education in terms of socio-demographic variables.
- To describe students' availability of technological resources, the potential for students' digital competence development and ICT and digital competence related training.
- To identify university students' digital competence and their attitudes towards ICTs.
- To find out whether there are significant differences in students' digital competence and their attitudes towards ICTs with regard to socio-demographic variables and to past training and methods of improving digital competence.

The overall purpose of this study is to understand teachers and students' digital competence in the west of China, on the example of Gansu Agricultural University, to

contribute to the future development of digital competence in this region, to point out influencing factors, to detect training needs and to determine future training directions, and to support the design of educational strategies related to the advancement of digital competence. It takes the following main research questions as an entry point for this research area:

- *What is the teachers' digital competence at Gansu Agricultural University to determine their needs?*

- *What is the first- and fourth-year students' digital competence at Gansu Agricultural University to determine their needs?*

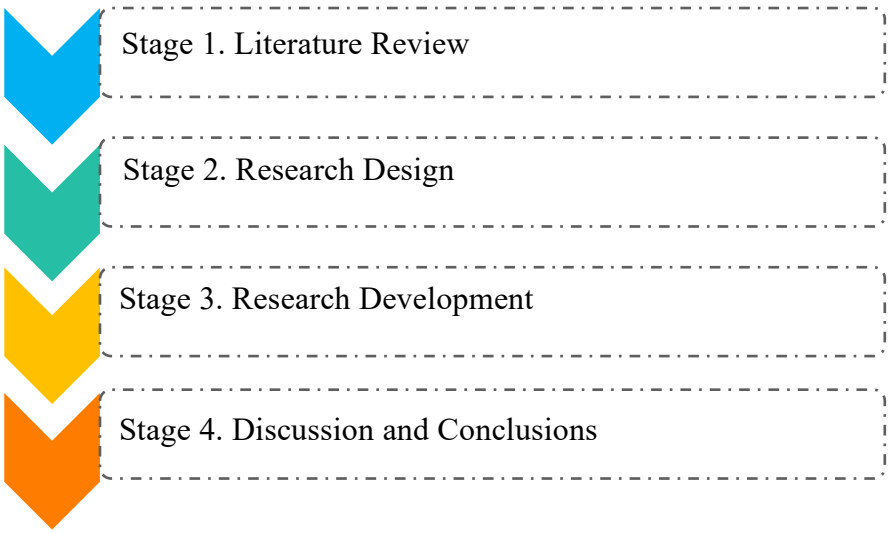
This thesis consists of a systematic literature review, one empirical study conducted with university teachers and the other one carried out with the first and the fourth-year university students in Gansu Agricultural University. In order to further analyze and gain a better understanding, these studies have their own research objectives and research questions, which will be presented in their corresponding chapters.

1.2 Methodology

To achieve the proposed objectives, the following research phases were followed (Figure 1).

Figure 1

Research phases



In the first stage, a review of the literature was carried out to better comprehend the definition of digital competence, to identify the state of current research, and to determine which dimensions might be the most used and considered to assess

university teachers and university students' digital competence, as well as the research limitations that might appear in studies related to digital competence in the context of higher education. A systematic literature review (SLR) and a mapping study were conducted, following the guidelines indicated by García-Peñalvo (2017), García-Holgado and García-Peñalvo (2021), Kitchenham and Charters (2007), and Kitchenham et al. (2011), which presented an understanding of digital competence's definition, provided an observation of the dimensions used to assess the digital competence of university teachers and students, identified the main research trends, described the current state of digital competence in higher education, and outlined the limitations of digital competence research in higher education settings.

In the second stage, an empirical study for university teachers and the other one for university students were planned, designed and prepared in accordance with the instructions presented by Buendía et al. (1998). Considering Gansu Agricultural University as an example, population and sample were confirmed for each study. Quantitative research methodologies were followed. After designing each questionnaire as a research instrument, the validation process was carried out by a group of experts in the fields of research methodology, education and linguistics.

In the third stage, after validating the instrument and revising the questionnaire according to the experts' feedback, the empirical study was carried out, with the purpose of investigating digital competence among a sample of teachers and students at a university in the west of China. With the consideration of the cognitive change, it was conducted with students, especially with the first- and fourth-year students of Gansu Agricultural University. Data were collected, organized, coded and treated statistically. Descriptive analyses and inferential analyses were applied (Van Dalen & Meyer, 1981). And the results were obtained and analyzed.

Finally in the fourth stage, a synthesis of the results obtained in these empirical studies conducted with university teachers and university students was carried out. The most important research findings based on the analysis and results were summarized and presented.

1.3 Thesis structure

This doctoral thesis has been elaborated as a collection of articles that cover the majority of the research work carried out. However, not all the chapters included in this thesis have already been published, some of them being original contributions.

This thesis is divided into three parts. The first part refers to the theoretical aspects and includes Chapter 2; the second part focuses on the empirical research and includes Chapters 3 and 4; and the third part consists of Chapter 5, which presents the conclusions, the research limitations encountered and the prospects for future research directions.

In the second chapter, the state of the art is provided through a systematic literature review (SLR) and a mapping study. The research on digital competence from 2015 to 2021 in the context of higher education were examined and analyzed. This systematic literature review has been published in *Computer & Education* and its full text is attached in Appendix A.

The empirical part begins in Chapter 3. It identifies university teachers' digital competence, taking teachers working at Gansu Agricultural University as a case study. The design and development of the study is also described in this chapter. Most results of this research have been published in the journal *Sustainability* with the full text included in Appendix B.

Chapter 4 introduces the empirical study exploring university students' digital competence, which, as in the previous chapter, is developed through a research stay in China as part of the research process of this thesis. Samples for the study came from students at Gansu Agricultural University located in the west China. As mentioned earlier, the freshmen and senior students were chosen in consideration of the grade level. The majority results of this research have been published in the journal *Sustainability* and the full content is provided in Appendix C.

Finally, the fifth chapter presents the most relevant conclusions derived from the different research studies, as well as the existing research limitations and possible future research directions arising from this thesis.

Moreover, it is necessarily noted that an extended abstract in Spanish is presented in Appendix D.

| Chapter 2 |

State of the art

In recent years, digital competence has become a crucial concept when discussing the skills and understandings that people should have in a knowledge society (Ilomäki et al., 2016). However, it is not a standardized concept and it remains unclear how to define the concept (Spante et al., 2018). Digital competence is an evolving concept, which is often associated with the advancement of digital technology, as well as political goals to be achieved and the expectations of citizenship.

Several terms have been introduced to describe skills and competencies in the use of digital technology. The concept of digital competence and digital literacy has been frequently discussed. A close connection exists between digital competence and digital literacy. Although they have different meanings, sometimes they are mentioned as synonymous and used to support each other (Iordache et al., 2017; Martin & Grudziecki, 2006). There are regional variations in the citation of these concepts: Research on digital competence is usually carried out in European countries apart from the UK, while those on digital literacy are conducted in English-speaking countries (Spante et al., 2018). Digital competence is understood as follows: "to explore and face new technological situations in a flexible way, to analyze, select and critically evaluate data and information, to exploit technological potentials to represent and solve problems and build shared and collaborative knowledge, while fostering awareness of one's own personal responsibilities and respect of reciprocal rights/obligations" (Calvani et al., 2009, p. 186). In other words, this concept points out what today's people should have in a knowledge society (Ilomäki et al., 2016). Digital literacy has longer tradition than digital competence. It is a representation of one's ability to perform tasks effectively in a digital environment (Jones-Kavalier & Flannigan, 2008). It is also considered as the combination of computer literacy, information literacy and media literacy (Paynton, 2012). However, in some countries, the differentiation between digital competence and digital literacy has become blurred for reasons such as translation (Madsen, et al., 2018).

There have been many reviews of digital competence and digital literacy over the last decades (Coronel et al., 2018; Esteve-Mon et al., 2020; Marta-Lazo et al., 2020; Pettersson, 2018; Sánchez-Caballé et al., 2020; Spante et al., 2018). While these studies have provided different perspectives on understanding digital competence, it is still not easy to uniformly understand teachers and students' digital competence in the context of higher education.

For an overview of the present status and development of students and teachers' digital competence in higher education, a systematic literature review (SLR) and a mapping study were carried out in this doctoral thesis to analyze the state of the art (García-Peñalvo, 2017; Kitchenham, 2004; Kitchenham & Charters, 2007; Kitchenham et al., 2011;).

This systematic literature review collects and critically analyzes multiple studies or research papers through a systematic process. Together with the mapping study, it provides a comprehensive review of the literature and helps to present a conceptual framework that contextualizes the students and digital age teachers' digital

competence in higher education. These review methodologies gather information that responds to the research questions proposed by the authors, evaluate and interpret the work of researchers, academics and practitioners, and identify trends and gaps in the literature in the chosen field (Fink, 2019).

In addition, mapping techniques in the literature review complements the SLR, which are useful at the beginning of the SLR, and serve as a brainstorming and contextualization tool (CASCADE Project, 2012, as cited in García-Peñalvo, 2017), thus facilitating to provide an overview of the earlier research conducted on a topic, and helping to identify the most explored areas, the most relevant authors or developments of the researcher's interest.

Compared to the traditional literature review, the SLR has orderly, explicit and reproducible features. Sánchez- Prieto (2018) indicates that: "it allows the analysis of large amounts of documents in a structured way. Likewise, it also facilitates the extraction of the necessary information to answer the research questions following established methodological lines that allow the recording of each step taken in the review" (p. 23).

In order to carry out this literature review, research steps proposed by García-Peñalvo (2017) and Kitchenham and Charters (2007) were followed, and the present chapter was constructed accordingly.

In the first section, we present the methodology followed for the literature review. In the second section, we collect and present the results of the mapping study and the SLR and answer the research questions. In the third section, we indicate the limitations that arise in this review. In the final part of the chapter, we indicate the most relevant conclusions obtained from the review. This systematic literature review has been published in the international journal *Computer & Education* (Zhao, et al., 2021), and is included in Appendix A.

2.1 Methodology

This section presents the methodology employed to search for and select the studies in this systematic literature review. We followed the guidelines of García-Peñalvo (2017) and Kitchenham and Charters (2007).

The following are the details of the research questions posed. At the beginning of the review, the research questions should be clearly spelled out as an objective to be answered. Then we indicate criteria established for the selection and the evaluation of the studies, and the databases chosen for the search, as well as the search strings. After reviewing the articles and assessing their quality, we introduce the publications that were included at the end of the process and present the corresponding results. Figure 2 shows the protocol of the review (García-Peñalvo, 2017).

Figure 2

Systematic literature review protocol

2.1.1 Research questions

When starting the systematic literature review, it is necessary to decide upon and to specify the research questions. In this doctoral work, two different sets of questions were formulated for the mapping study and the SLR.

When formulating the mapping questions, the objective was to obtain an overview of the status and development of teachers and students' digital competence in higher education. In order to get recent and relevant results, the years of searching for publications have been limited. The following mapping questions were formulated:

MQ1: How has the amount of research related to digital competence in higher education evolved from 2015 to 2021?

MQ2: Who are the most prolific authors in this field of study?

MQ3: What types of publications are the most frequent in this field of study?

MQ4: Which countries have developed the most research on digital competence in higher education?

MQ5: What are the most frequently used keywords in publications related to digital competence in the context of higher education?

MQ6: Who are the main research sample subjects?

On the other hand, the SLR questions further deepen the analyses on the chosen topic by turning them into much more specific and refined questions. The following paragraph contains the questions formulated for the SLR:

RQ1: How is digital competence defined in terms of teachers and students in the context of higher education?

RQ2: What are the dimensions commonly used to assess the digital competence of university teachers and students?

RQ3: What were the major research purposes, methodologies and outcomes in the studies on digital competence in the context of higher education over the past seven years?

RQ4: What kinds of limitations exist in research on digital competence in higher education?

Both mapping and SLR questions clarify the problem areas, with which we can propose an appropriate route, identify knowledge gaps and present research needs to be addressed in the future.

2.1.2 Criteria selection

The following criteria were then established to select the studies that are relevant for obtaining answers to the proposed research questions.

First of all, the inclusion criteria:

- The research work is related to teachers or students' digital competence 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.

Second, exclusion criteria:

- The research work is not related to teachers or students' digital competence 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.

In order to ensure the quality of the selected studies, we have set up quality criteria, under which the studies that passed the inclusion and exclusion criteria were assessed. They are:

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 population and sample 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 teachers and students?
10. Are future lines of research presented?

In total, there are ten questions that made up the quality criteria, and these questions have three options to answer them: yes (1 point), no (0 point) and partial (0.5 point). The publications score points due to the content corresponding to the questions. The papers were to be included in the final process must have or exceed the value 7.5 as a cut-off point for the selection of papers.

2.1.3 Database selection

After defining the research selection criteria, the databases to be searched were selected.

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

These databases meet the necessary requirements mentioned by Sánchez-Prieto (2018) in the SLR process:

> The database allows the use of logical expressions to perform the search process. The database allows searches in the whole text of the papers or in specific fields. The database allows access to articles through institutional accounts or personal subscriptions. The database is relevant and includes only papers of proven quality. (p. 27)

2.1.4 Search string

Based on the different research questions and the inclusion criteria indicated above, search strings were formulated and used in the search engines. The following search string was used in WOS:

WOS: TS= ((“digital competence*” OR “digital abilit*” OR “digital skill*”) AND (“higher education” OR “universit*” OR “college*”))

The same terms were applied in Scopus to adapt the Boolean operator to the characteristics of the database search system, and finally the search string was followed:

Scopus: TITLE-ABS-KEY ((“digital competence*” OR “digital abilit*” OR “digital skill*”) AND (“higher education” OR “universit*OR “college*”))

Search terms were applied in titles, abstracts and keywords in the databases as our deliberate search strategy to increase the accuracy of the information search (Guo & Huang, 2011; Spante, et al., 2018; Savolainen, 2016). In order to have all publications related to the topic of interest, in the search string we tried to use all terms that are related to digital competence and higher education, so not only singular but also plural terms were included.

2.1.5 Selection process

The selection process for the study was an iterative and gradual one, consisting of several phases in which different activities were carried out.

In the first phase, the search results of the two databases were summarized and compiled in an EXCEL spreadsheet to record the entire selection process. A total of 1410 documents were obtained (765 in WOS and 645 in Scopus). After recording all the obtained publications, 225 duplicate studies were screened and removed before applying the inclusion and exclusion criteria. There were 1185 articles left to proceed to the next phase.

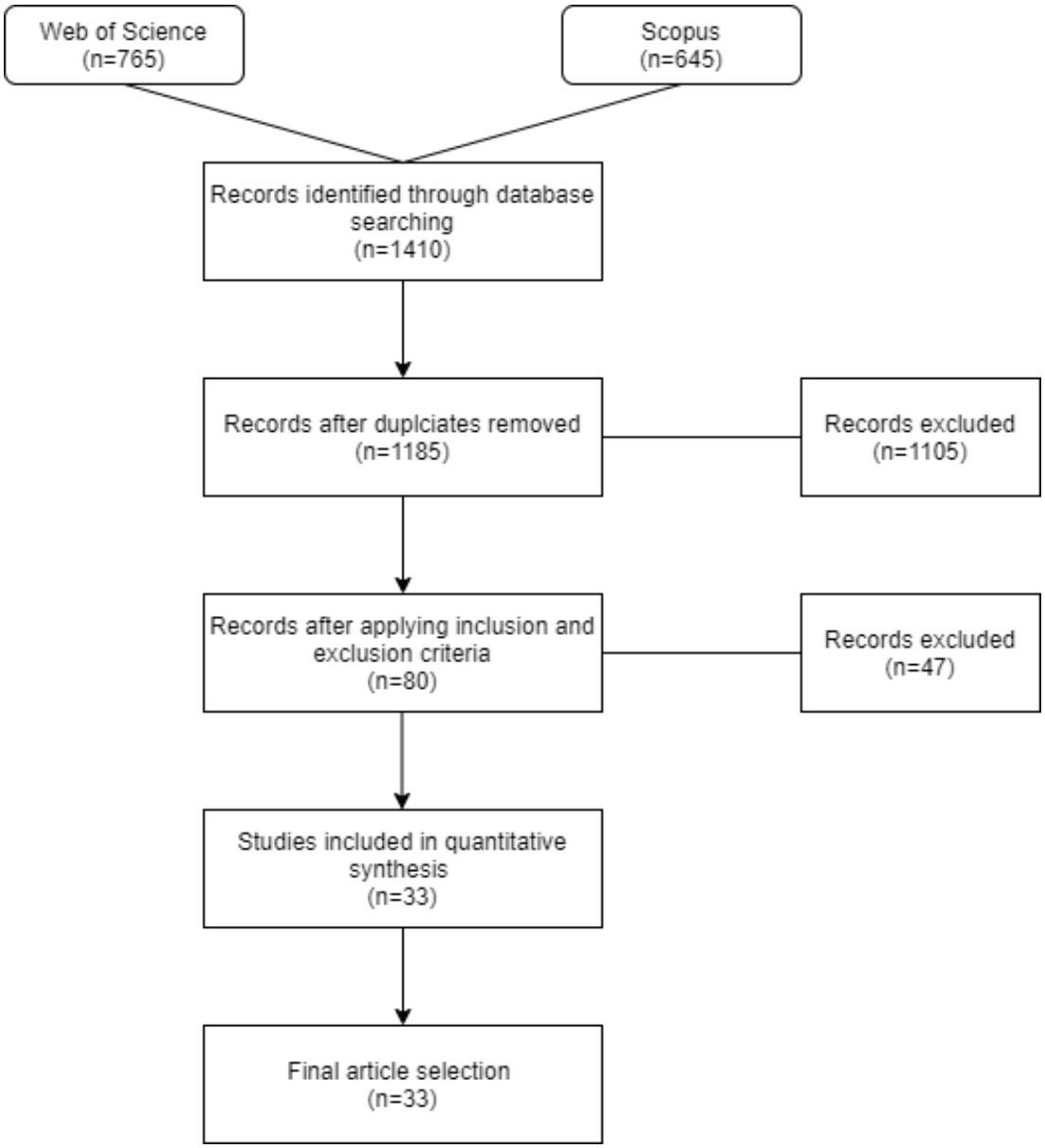
In the second phase, inclusion and exclusion criteria were then applied by reading the title, keywords and abstract of the publications. Those publications that could not be decided with these resources were left to the next phase, where we reviewed the full text of the publication and deepen the content by applying new quality criteria. In this phase, the number of documents was reduced to 80.

Finally, the criteria were applied together with the quality questions, so that publications scoring 7.5 or above were selected and publications scoring below 7.5 were removed. In the end, there were 33 publications selected to answer the research questions.

A PRISMA flow was used to show the steps of selecting the documents in Figure 3 (Pati & Lorusso, 2018).

Figure 3

Document selection process



2.2 Results

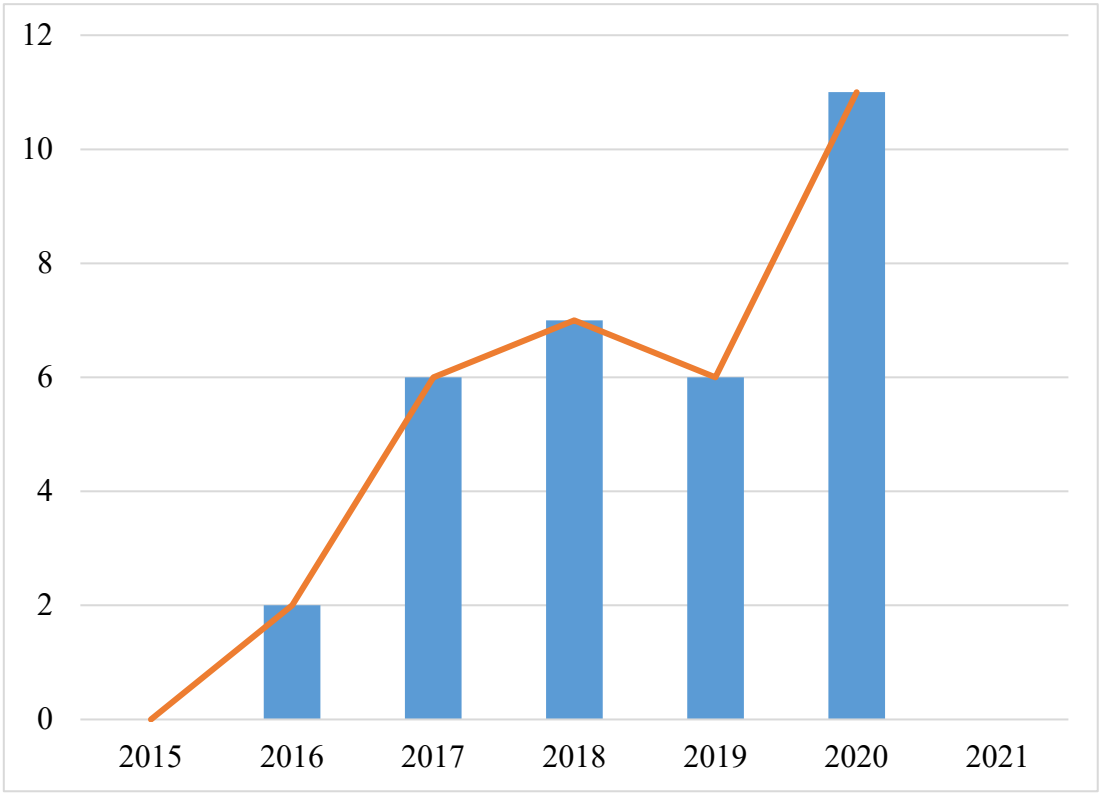
In this section, the research questions are answered through the analysis of the 33 selected research studies. This part is formulated by the questions posed, in which the results of mapping study are presented first and then the results of the SLR.

2.2.1 Results of the mapping study

In order to answer the first question of the mapping study, which refers to the evolution of the number of research studies on digital competence, the year of publication of the studies was analyzed (Figure 4).

Figure 4

Number of publications per year



Despite having limited the search from 2015 to 2021, it was not until 2016 that the first publications on digital competence in the context of higher education were collected. No publications were shown in the year 2021, as there were no articles that met the selection criteria before the search expiry date (January 2021). According to the results of the 33 selected articles, up to 2018, interest in the topic of digital competence continued to increase, from 2015 with zero articles registered to 2018 with a total of fifteen articles registered. However, the number of publications decreased to six in 2019. Then the number of relevant publications reached 11 in 2020. In general, research on digital competence in the context of higher education has received increasing attention over the past few years.

The second mapping question focuses on the most relevant authors of the published research papers (Table 1). After reviewing the names of the authors of the publications, we found that authors with the most publications were Francisco David Guillén-Gámez and María José Mayorga-Fernández, with four publications focusing

on digital competence in higher education. In addition, Tao He, who has three publications, has given attention to digital informal learning. On the other hand, there were four authors who published two articles. These authors were Ah Jeong Hong, Hye Jeong Kim, Hae-Deok Song and Chang Zhu. A total of 102 different authors were involved in the 33 works analyzed.

Table 1

Number of publications per author

Author (Ranking in random order)	**Number of publications**
Guillén-Gámez, F.D.; Mayorga-Fernández, M. J.	4
He, T.	3
Hong, A.J; Kim, H.J; Song, H. D.; Zhu, C.	2
McGuinness, C.; Fulton, C.; Li, S.; Gallego-Arrufat, M. J.; Torres-Hernández, N.; Pessoa, T.; Bond, M.; Marín, V. I.; Dolch, C.; Bedenlier, S.; Zawacki-Richter, O.; Blayone, T. J. B.; Mykhailenko, O.; Kavtaradze, M.; Kokhan, M.; vanOostveen, R.; Barber, W.; Questier, F.; Byungura, J. C.; Hansson, H.; Muparasi, M.; Ruhinda, B.; Álvarez-García, F.J.; Madsen, S.S.; Thorvaldsen, S.; Archard, S.; Jiménez-Cortés, R.; Vico-Bosch, A.; Rebollo-Catalán, A.; Cote, T. J.; Milliner, B.; Guzmán-Simón, F.; García-Jiménez, E.; López-Cobo, I.; Mengual-Andrés, S.; Roig-Vila, R.; Mira, J.B.; López-Belmonte, J; Pozo-Sanchez, S; Fuentes-Cabrera, A; Trujillo-Torres, JM.; Gonzalez, M. C; Martín, S. C; Sanches-Ferreira, M; Diogo, F. L. T.; Esteban, S. G.; Porlan, I. G.; Sanchez, J. L. S.; Ortega-Sánchez D.; Gómez-Trigueros I.M.; Trestini M.; Pérez-González C.; Grande-De-prado M.; Cañón R.; García-Martín S.; Cantón I.; Romero-García C.; Buzón-García O.; de Paz-Lugo P.; Ryhtä I.; Elonen I.; Saaranen T.; Sormunen M.; Mikkonen K.; Kääriäinen M.; Koskinen C.; Koskinen M.; Koivula M.; Koskimäki M.; Lähteenmäki M.-L.; Wallin O.; Sjögren T.; Salminen L; Cabero-Almenara J.; Gutiérrez-Castillo J.-J.; Palacios-Rodríguez A.; Barroso-Osuna J; Martzoukou K.; Fulton C.; Kostagiolas P.; Lavranos C.; Romero-Tena R.; Barragán-Sánchez R.; Llorente-Cejudo C.; Palacios-Rodríguez A.; Llorent-Vaquero M.; Tallón-Rosales S.; Monastero B.H.; Del Moral M.T.; Sales D.; Cuevas-Cerveró A.; Gómez-Hernández J.-A; Esteve-Mon F.M.; Adell-Segura J.; Nebot M.A.L.; Novella G.V.; Aparicio J.P.	1

In relation to the question MQ3, which is the most common types of publications in the research field, it stands out that all publications were published in research

journals (33). The following table (Table 2) shows not only the name of the journals, their SJR index according to SCIMAGO and their impact factors (IF) calculated by Clarivate, but also the number of articles published. The journals in which the studies were published are different. Most selected articles (n=6) have been published in the *International Journal of Educational Technology in Higher Education*, followed with *Sustainability*, in which five of them were published.

Table 2

Source of publications

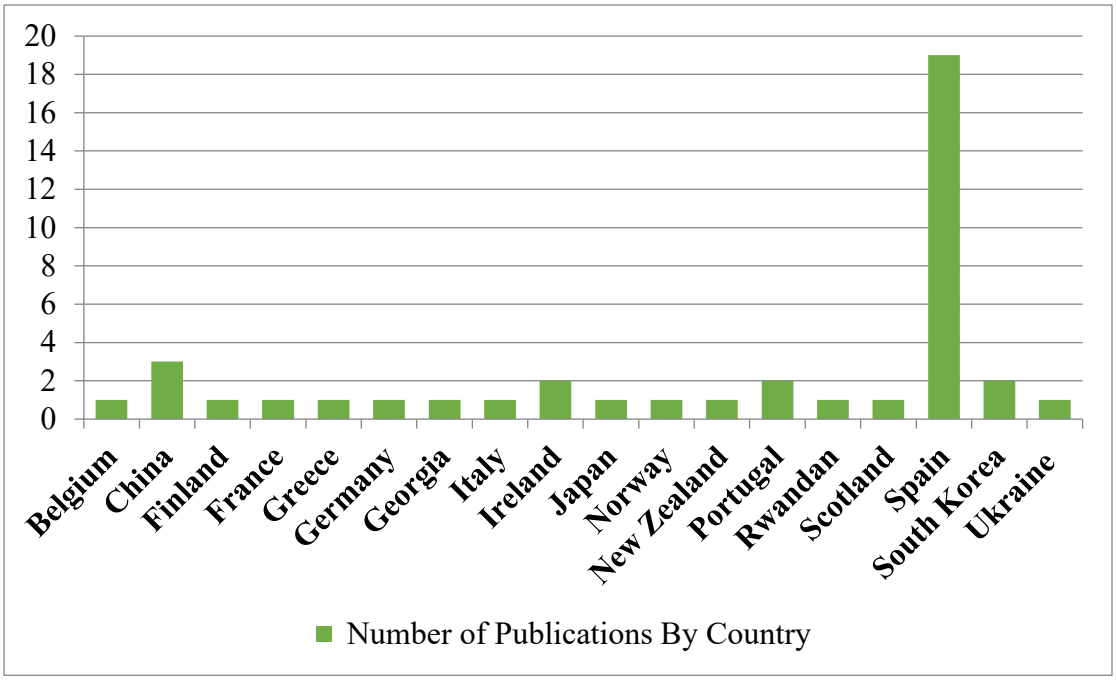
Journal	**SJR (2020)**	**IF (2020)**	**Number of publications**
Asia Pacific Education Review	0.554	1.573	1
British Journal of Educational Technology	1.79	4.929	1
Comunicar	1.217	6.013	1
Computers in Human Behavior	2.108	6.829	1
Education Sciences	0.453	Not found	2
Electronic Journal of e-Learning	0.574	Not found	1
Education and Information Technologies	0.919	2.917	1
Future Internet	0.434	Not found	1
Fonseca-Journal of Communication	Not found	Not found	1
Journal of Information Technology Education: Innovations in Practice	0.579	Not found	2
International Journal of Educational Technology in Higher Education	1.642	4.944	6
Jalt Call Journal	0.355	Not found	1
Journal of New Approaches in Educational Research	0.822	Not found	1
Journal of E-Learning and Knowledge Society	0.342	Not found	1
Multimodal Technologies and Interaction	0.433	Not found	1
Nurse Education Today	1.4	3.442	1
Nordic Journal of Digital Literacy	0.465	Not found	1
Journal of Documentation	0.675	1.819	1
Profesional de la Información	0.698	2.253	1
Rael-Revista Electronica de Linguistica Aplicada	Not found	Not found	1
Sustainability	0.612	3.251	5
Technology, Knowledge and Learning	0.969	Not found	1

In terms of the countries in which most of the research was carried out (MQ4), it is observed that the country with the most selected publications was Spain (Figure 5).

China followed with three publications concentrating on the digital informal learning contexts, while other countries such as Ireland, Portugal and South Korea each were recorded with two publications. The other countries included in Figure 5 had only one publication selected. In general, European countries have demonstrated the highest level of interest in exploring digital competence. Of the 33 chosen studies, seven of them included samples from more than one country.

Figure 5

Number of publications by country



With reference to the keywords commonly used in the study on digital competence in higher education (MQ5), after reviewing the 33 selected publications, the keywords with the highest frequency were “Digital Competence” (n=19), “Higher Education” (n=13), “ICTs” (n=10), and “Digital literacy” (n=4). The rest of the keywords appearing in the selected publications can be found in Table 3.

Table 3

The frequency of concurrence of keywords

Keywords	**Frequency of occurrence**
Digital competence	19
Higher education	13
ICTs	10
Digital literacy	4
Educational technology; Information literacy.	3
Online learning; Internet; Initial training; Digital informal learning; PLS structural equation modeling; Future teacher; Gender; University students; Students; Teachers; E-learning; Spain; University; Teacher training; Digital tools; Digital technologies.	2
Digital learning environments; Academic engagement; Academic performance; Blended learning; E-tutorials; Online tutorials; Teacher education; Privacy; Cyber security; Student engagement; Learning agility; University professors; Germany; Student perceptions; Teacher perceptions; Digital media usage; Digitalization; Social constructivist; Ukraine; Georgia; DTPB; Familiarity with technology; Net generation; Tertiary education; Digital skills; First-year students; New methodologies; New technologies; Educational innovation; Learning strategies; University students; Women's studies; Study abroad; Japanese university; Academic literacy; Questionnaire; Standards; Big data; Data management; Age; Virtual objects; Video; student teachers; CLIL; Digital; Digcomp; Universidad.; Digital pedagogy; competence; Education; Educator; Social and healthcare; Everyday life; Lifelong learning; Student transitions; Empirical research; Students Profile; Educational Modality; Questionnaires; Validation; Pre-service professors; DigCompEdu; Pedagogical digital competence; Technological resources; ITC; Professors; Measurement; Regression; Educational research methods; Media education; Digital teaching competence; University teaching staff; Graduates; Computational thinking; Educational robotics; Student teachers; Teacher digital competence; Self-perception; Information competence; Curriculum; Social Sciences student body; Social Sciences faculty; Motivation for learning; Teaching and learning strategies; Spanish universities; COVID-19; Coronavirus; Pandemics; Distance learning; Italy; Communication; Collaboration; Early childhood education; Active methodologies; Information and communication technology.	1

In addition, these keywords are presented visually by a word cloud in Figure 6.

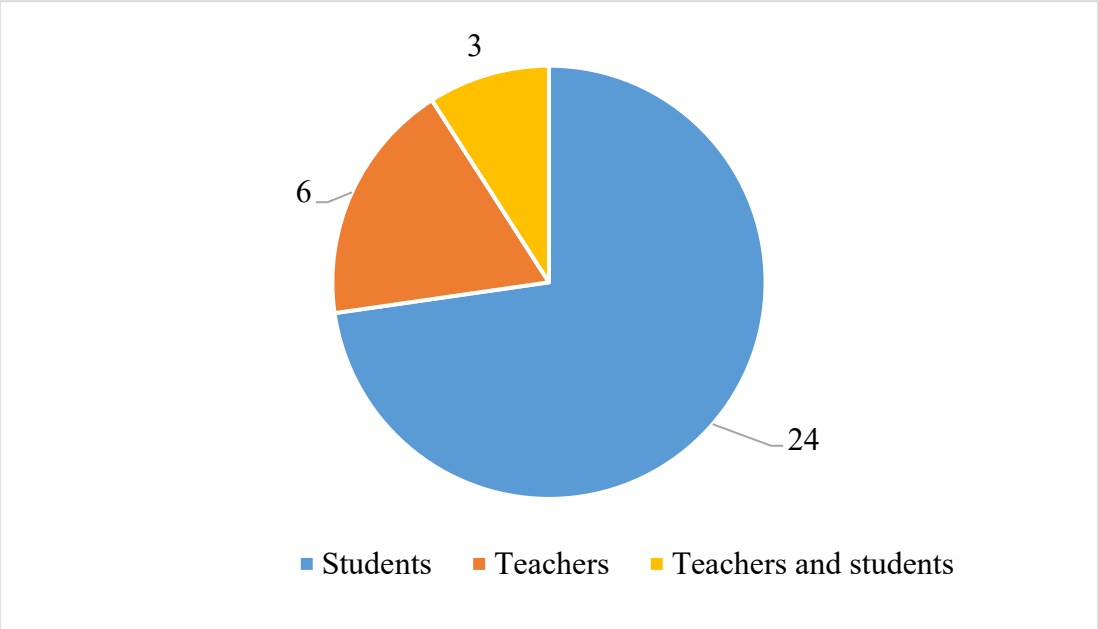
Figure 6

Word cloud of keywords in publications related to digital competence in higher education

The question MQ6 refers to the most frequently analyzed research sample subjects (Figure 7). Among the 33 selected studies, most studies focused on university teachers, while there were six publications where their participants were teachers. And there were three publications, which investigated not only teachers but also students.

Figure 7

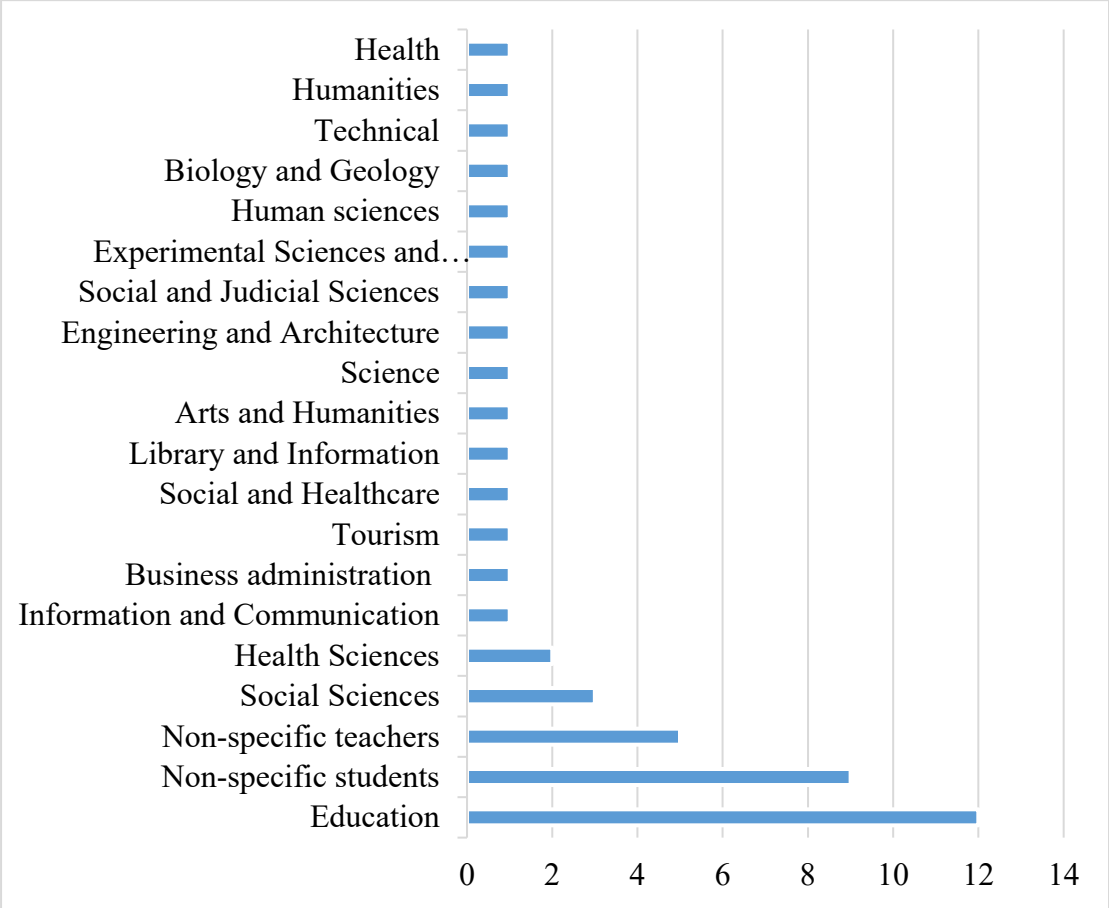
Distribution of the study sample subjects



Moreover, the following figure (Figure 8) indicates the number of investigations by study area, for each of these groups. It can be observed that 12 of the publications focused their research on university students within the faculty of education. There were three studies that gave their attention to social sciences teachers. It should be noted that nine research studies did not specify the students' major category. Moreover, teachers' knowledge areas were not specifically described in five research studies.

Figure 8

Results for participants' major categories



In Table 4, a summary of the mapping responses is provided.

Table 4

Summary of answers to mapping questions

Question	Answer
MQ1	From 2015 to 2021, although no studies were selected prior to 2016, there was an overall upward trend in research interest in digital competence in higher education up to the search date.
MQ2	Among the selected publications, the most prolific authors in this area were Francisco David Guillén-Gámez and María J. Mayorga-Fernández.
MQ3	All the studies (33) were published in research journals. The majority of the selected studies were published in the International Journal of Educational Technology in Higher Education.
MQ4	The most research studies on this topic of the selected publications were carried out in Spain.
MQ5	The most frequently used keywords in the selected studies on digital competence in higher education were "digital competence", "higher education" and "ICTs".
MQ6	The most frequently analyzed research sample subjects were students, particularly education majors.

2.2.2 Results of the SLR

The first question of the SLR focuses on exploring and summarizing the definition of digital competence in the context of higher education.

Digital competence is an evolving concept closely related to the development of digital technologies and the political goals and expectations of citizenship in today's society (Ilomäki et al., 2016). Although there has been a growing interest in this concept in recent years, the definition of digital competence is still not very clear. It varies whether the concept is defined by politicians, researchers or both, as well as depending on its focus on technical skills or social practices (Spante et al., 2018).

According to the results obtained in this SLR, it was quite common to define digital competences by citing both policy documents and researches (n=21), while seven selected publications presented the definition of digital competence by only referring to policy documents and five of them explained their definition through research references.

Moreover, when defining digital competence, most of the articles started from a general perspective. There were 10 publications explaining the concept of digital competence for university teachers in particular, and four publications pointing to the development of digital competence among university students.

It is very common for EU political documents or reports to be applied in those articles that define digital competence by referring to political documents. The following definition of digital competence presented by Ferrari (2012) has been noticed by 11 articles:

> Digital competence is the set of knowledge, skills, attitudes, abilities, strategies, and awareness that are required when using ICTs 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, participation, learning, and socializing. (p. 30)

The report written by Ferrari (2012, 2013) has presented a road-map for the potential use and revision of a digital competence framework and proposed digital competency descriptors for learners at all levels. The set of competence required by today's citizens to achieve full digital inclusion and the importance of incorporating digital technology into the educational process were highlighted in Ferrari's reports.

It is worth noting that there were nine selected articles that mentioned digital competence as one of the eight key competences for Lifelong Learning proposed by the European Commission. In 2006, these eight key competences were digital competence in conjunction 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; entrepreneurship; and cultural awareness and expression, and the definition of digital competence was "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, p. 15). In order to meet the need for inclusive and sustainable growth, social cohesion and the further development of a democratic culture, these eight key competences for lifelong learning have been updated in 2018, which were: digital competence; literacy competence; multilingual competence; mathematical competence and competence in science, technology and engineering; personal, social and learning to learn competence; citizenship competence; entrepreneurship competence; cultural awareness and expression competence (European commission, 2018). Digital competence is understood as "the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society" (European Commission, 2019, p. 10).

Five other articles referred to the European Digital Competence Framework (DigComp) to present the definition of digital competence. It has been broadly understood digital competence is "the confident, critical and creative use of ICTs to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society." (Ferrari, 2013, p. 2). DigComp was published in 2013 as part

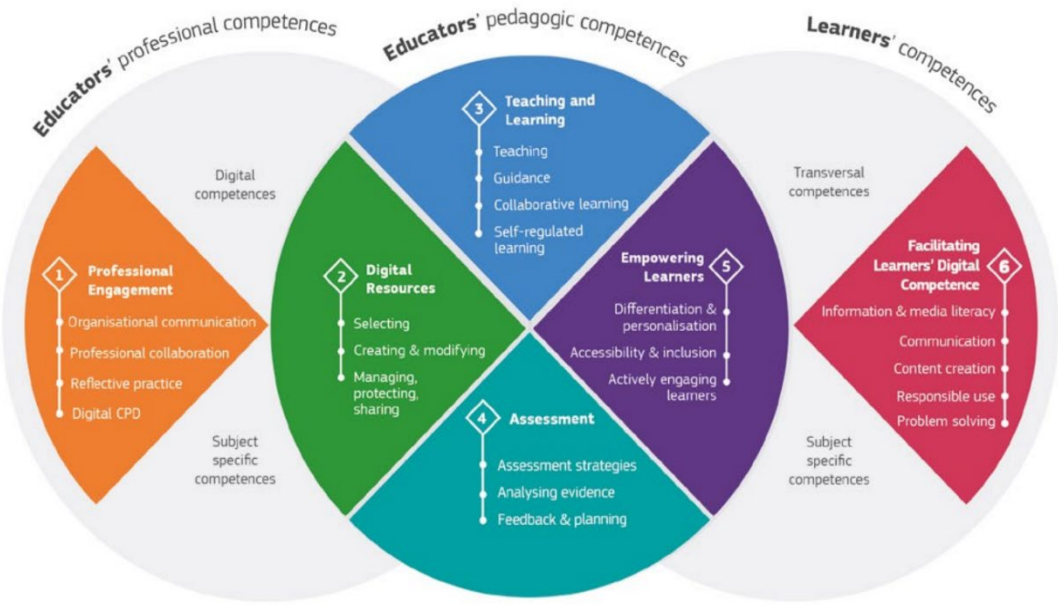
of a project on digital competence and provided not only a self-assessment grid but also a descriptive overview of the different aspects of digital competence. It was first established to determine detailed descriptors of digital competence, to identify the EU citizen's digital competence and to understand better its development in Europe. Now it is also known as a reference framework to support the development of strategies and policies and the advancement of digital competence in a wider context.

There are five different areas of digital competence identified in DigComp. It was first proposed in 2013 with five components of digital competence, such as information, communication, content creation, safety and problem solving. As new requirements emerge with the evolution of digitization, DigComp was updated into DigComp 2.0 in 2016 with new vocabulary and streamlined descriptors for competence, and the five areas of digital competence have been modified and recognized as information and data literacy, communication and collaboration, digital content creation, safety and problem solving (Vuorikari et al. 2016). In 2017, DigComp 2.0 was further developed to DigComp 2.1 with use cases in learning and employment contexts and the upgrading of the three proficiency levels in DigComp 1.0 (foundation, intermediate, advanced) to eight proficiency levels (Carretero et al. 2017). It is structured by dimensions, and within these categories there are specific sub-competencies that can be measured at eight levels of competence, ranging from "foundation" to "highly specialized" (McGuinness & Fulton, 2019). Moreover, the latest version DigComp 2.2 has been released in 2022, including examples of knowledge, skills and attitudes applicable to each competence and consolidating key reference documents on DigComp (Vuorikari et al., 2022).

Based on the above, the European Digital Competence Framework for Educators (DigCompEdu) has made it possible for this framework to be consolidated and promoted internationally (Gallego Arrufat et al., 2019). DigCompEdu, that was published in 2017 by the European Commission, has provided a general, scientifically sound framework that outlines the significance of digital competence for educators and supports the development of specific digital competence for educators at all levels (European Commission, 2017). Digital competence in DigCompEdu is defined as is the ability of people to use information and communication technologies safely, critically and creatively to achieve various goals related to their inclusion and participation in society (Guillén-Gámez & Mayorga-Fernández, 2020a). In DigCompEdu, 22 digital competences for educators have been identified into six areas by Redecker (2017): professional engagement; digital resources; teaching and learning; assessment; empowering learners and facilitating the digital competence of the learners (Ryhtä et al., 2020). Meanwhile, it has proposed a progression model to help educators better understand themselves along six proficiency levels, ranging from A1 (Newcomer) to C2 (Pioneer), with reference to the Common European Framework of Reference for Languages (CEFR). DigCompEdu has created a digital competence model for trainers by following logical progression (Romero-Tena et al., 2020). Figure 9 shows an overview of the DigCompEdu framework.

Figure 9

An overview of the synthesis of the DigCompEdu framework



Note. This Figure shows DigCompEdu areas and scopu, From "European framework for the digital competence of educators: DigCompEdu." by Redecker, 2017, Publications Office of the European Union, p. 15.

Teacher Digital Competence (TDC) has been mentioned by Ortega-Sánchez et al. (2020) who indicated that it can be understood as "the set of knowledge, skills and attitudes needed to be functional in a digital teaching environment" (p. 2). It is used to help teachers solve problems in the educational process through the integration of ICTs (Cabero-Almenara et al., 2020). Being aware of the need for TDC training, the Common Digital Competence Framework for Teachers (CDCFT) that was proposed by the National Institute of Educational Technologies and Teacher Training (INTEF) in 2017 has also been presented in the study of López-Belmonte et al. (2019). It is a descriptive framework established for teacher training purposes and the evaluation and accreditation process, with a total of 21 competences in five competency areas adapted from DigComp 2.1, having similar program objectives to DigcompEdu, which establishes six levels for each competency, with descriptors based on knowledge, skills and attitudes (Cabero-Almenara et al., 2021). Each of the competences in the five areas of the framework has three dimensions, from primary to advanced, which are "basic" (A1, A2), "intermediate" (B1, B2) and "Advanced" (C1, C2) (INTEF, 2017).

In addition to the references to the European Commission related policies and reports, and the definition of digital competence presented by other international

organizations, the United States Department of Education (1996) has been referred to by Cote and Milliner (2017), understanding it as the ability to use computers and other technologies to improve learning, productivity and performance. In the work of Romero-Tena et al. (2020), the theoretical work of the International Society for Technology in Education (ISTE) was explained as the purpose of helping educators to become digitally empowered learners. Bond et al. (2018) highlighted that the development of ICT skills and digital-related competence and the digitization of higher education institutions are increasingly important on the basis of works from the Organization for Economic Cooperation and Development (OECD, 2015, 2018).

There were 21 selected publications addressing the definition of digital competence through both political documents and research articles. Several publications focused on Calvani's article when describing the definition of digital competence, stating that it is a combination of concrete and non-quantifiable skills which can be used to explore and face new technological situations in a flexible way (Byungura et al., 2018; He & Zhu, 2017; He et al., 2018). The work of Calvani et al. (2012), and the definition of digital competence proposed by Calvani et al. (2009) have classified digital competence into three dimensions and have highlighted the coexistence of practical, high-order cognitive and socio-ethical dimensions, as well as the integration between these three dimensions. And there were three articles which cited the results of a digital competence exploration by Janssen et al. (2013), considering it a diverse, descriptive concept of a network of intricate purposes, domains and levels of the use of ICTs. It features a dynamic and transversal nature and encompasses cognitive, attitudinal and technical skills that help to alleviate many of the problems and challenges of the knowledge society (Gallego-Arrufat et al., 2019; Guillén-Gámez, Mayorga-Fernández & Álvarez-García, 2020; He & Li, 2019). In the study of Guillén-Gámez and Mayorga-Fernández (2020a), a similar comprehension of digital competence was found through their reference to Lázaro-Cantabrana et al. (2019) and From (2017). Moreover, digital competence as presented by Larraz (2013) includes informational, technological, multimedia and communicative dimensions; in addition, its association with digital literacy, media literacy, ICT literacy; information literacy and Internet literacy are also reflected in the selected articles (Esteve-Mon et al., 2019; He et al., 2018). The informational dimension is emphasized in the study of Sales et al. (2020) by referring to the update information from Cilip (2018, as cited in Sales et al., 2020). In addition, digital competence is described as "values, knowledge, and skills that determine an individual's experience or proficiency in a particular technology" (Byungura et al., 2018, p. 32). Through references to Venkatesh et al. (2003) and Hatlevik and Christophersen (2013), digital competence is seen as students' ability to use technology or ICT self-efficacy, which is believed to demonstrate how students use digital technology to communicate and produce information.

In this SLR, five publications define digital competence based on research studies only. Ala-Mutka (2011) presented a conceptual mapping of digital competence. Considering it as a reference, the concept of digital competence in academic work is understood as a set of technologies related to knowledge, skills and attitudes used to

identify and analyze what students should be able to achieve through digital technologies, and it supports the purposeful and effective use of technology in academic work (Blayone et al., 2018; Kim et al., 2019). With reference to Ananiadou and Claro (2009), and Navarro et al. (2016), it is also considered as pedagogical digital competence, which consists of three aspects: attitudes towards ICTs, knowledge and educational use of mentioned technologies (Guillén-Gámez & Mayorga-Fernández, 2020b). Gutiérrez Porlán & Serrano Sánchez (2016) provided an introduction to the complexity of the concept of competence and used the expression competence when explaining the definition of digital competence (Cebrián & Junyent, 2015; Escudero Muñoz, 2008). A description or identification of capacities and abilities was applied in other selected publications to present digital competence (He et al., 2018; Gutiérrez Porlán & Serrano Sánchez, 2016)

The second question of SLR (RQ2) refers to the dimensions that are commonly used to assess the digital competence of teachers and students in higher education.

The following table (Table 5) shows the dimensions used by the authors of the selected publications by year of publication in their research.

Table 5

Dimensions mentioned in the selected investigations to assess digital competence

Investigation	Participants	Dimensions mentioned
Gutiérrez Porlán and Serrano Sánchez (2016)	Students	Information; communication; creation of contents; safety and problem solving.
Jiménez-Cortés et al. (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; creativity and innovation.
Cote and Milliner (2017).	Students	Use of various applications; ability to complete digital tasks; ability to fulfill the following Internet-related tasks; general computer knowledge.
Cabezas González et al. (2017)	Students	Identification; possession of the ICT devices; knowledge related to ICT; management of the digital tools; attitude to ICT.
Guzmán-Simón et al. (2017)	Students	Information literacy and ICT literacy.
García-Esteban (2017)	Students	Information and data literacy; communication and collaboration; digital content creation; safety; problem solving.
He and Zhu (2017)	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 (digital informal learning); personal innovativeness.
Blayone et al. (2018)	Students	Socio-demographic and device-usage

		items; technical dimension, and communicational dimension, informational dimension and computational dimensions of use.
Byungura et al. (2018)	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.
Bond et al. (2018)	Teachers and Students	Teachers: The use and perceived usefulness of digital tools for teaching. Frequency of using the digital tools. Students: Frequency of use and perceived usefulness of digital tools and services.
Guillén-Gámez, Mayorga-Fernández and Álvarez-García (2020)	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.
He et al. (2018)	Students	Technological skills; cognitive skills and ethical knowledge.
Kim et al. (2018)	Students	Attitude toward digital technologies; learning agility; prior digital experience with family; student engagement; personal effort to learn ICT; perceived digital competence.
Madsen et al. (2018)	Teachers	Digital competence; professional attitude; professional applications of tools.
Esteve-Mon et al. (2019)	Students	Informational literacy, technological literacy, multimedia literacy and communicative literacy.
Gallego-Arrufat 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.
He and Li (2019)	Students	Digital competence: ISK, ASK, ASE; digital informal learning; Technology

		expectancy.
Kim et al. (2019)	Students	Academic engagement; e-learning adoption; e-learning attitude; digital readiness; academic achievement
López-Belmonte, et al. (2019)	Teachers	Social; navigation, search and filtering; evaluation; storage and recovery; massive data processing.
McGuinness and Fulton (2019)	Students	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.
Cabero-Almenara et al. (2020)	Teachers	Professional engagement; digital resources; teaching and learning; assessment; empowering learners; facilitating learners' digital competence.
Guillén-Gámez and Mayorga-Fernández (2020a)	Students and teachers	Attitude; knowledge; the use of digital technologies.
Guillén-Gámez and Mayorga-Fernández (2020b)	Teachers	Knowledge and use in 2.0 tools for teaching, evaluation and research.
Guillén-Gámez, Mayorga-Fernández, and Del Moral (2020).	Students	Attitude; knowledge; the use of digital technologies.
Grande-de-Prado et al. (2020)	Students	Information and data literacy; communication and collaboration; digital content creation; safety; problem solving.
Romero-Tena et al. (2020)	Students	Technological literacy; search and treatment of information; critical thinking; communication and collaboration; digital citizenship; creativity and innovation.
Llorent-Vaquero 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 information; interpersonal competence in the use of ICTs in a

		university context.
Martzoukou et al. (2020)	Students	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 well-being.
Ortega-Sánchez et al. (2020)	Students	Teaching skills and future teachers' TDC; university teachers' TDC.
Romero-García et al. (2020)	Students	Technological literacy; search and treatment of information; critical thinking; communication and collaboration; digital citizenship; creativity and innovation.
Ryhtä et al. (2020)	Teachers	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.
Sales et al. (2020)	Teachers	The use and value of information; agents responsible for information competence at the university; self-conception of information competence as a teacher.

After reviewing the instruments that appeared in the selected research, several different aspects and points of view to assess students and teachers' digital competence were indicated. By examining and comparing the dimensions that applied in the selected publications, it was found that most of them followed the dimensions used by DigComp 1.0 and DigComp 2.0, which included five dimensions developed from information; communication; content creation; safety; problem solving to information and data literacy; communication and collaboration; digital content creation; safety; problem solving. There were six studies which designed the dimensions of their instruments on the basis of technology, cognition and ethics. Other publications established their instruments from various aspects with other theoretical frameworks. As far as the research objects are concerned, the dimensions have not

changed much due to the participants, but they do include the pedagogical meaning. The dimensions most frequently encountered and considered in the remaining selected publications are: the use and the knowledge of ICTs, Internet and ICT related capacities, digital related experience and attitudes towards digital technologies.

With regard to the third research question, 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 (RQ3), the progress of research related to digital competence in higher education over the past seven years was investigated and explained.

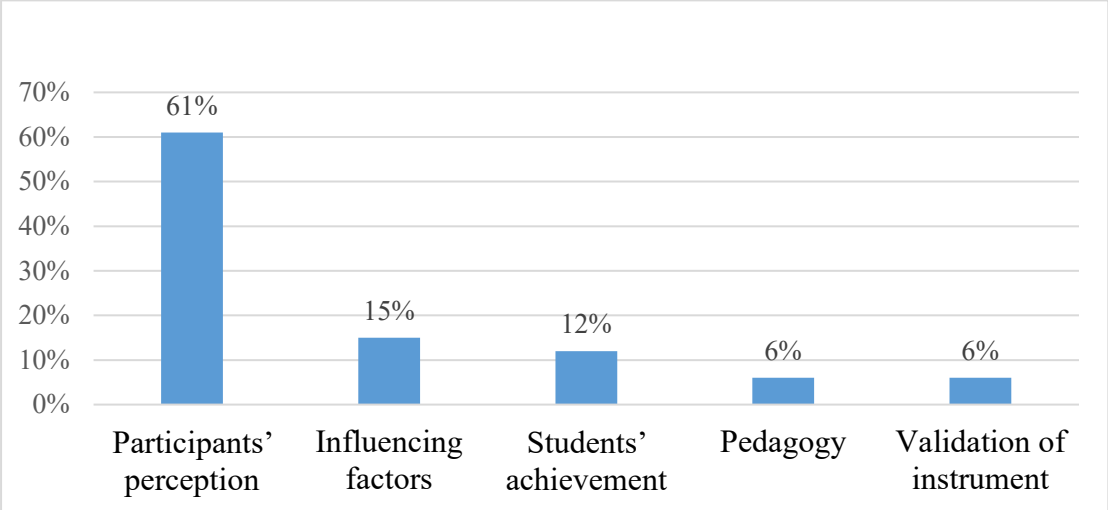
The research purposes of the selected publications are classified into five different categories:

- Investigating and assessing the participants' perceptions and their level of digital competence in higher education.
- Investigate the factors that can affect digital competence.
- Investigating the impact of digital competence on students' achievement.
- Investigating the pedagogical approaches involved in digital competence.
- Investigating the validation of digital competence related instruments.

The results after reviewing and studying the research purposes of the selected publications, are shown in Figure 10.

Figure 10

Results of the research purposes categories



Most of the selected publications investigated participants' perceptions of digital competence and their level (n=20, 61%). The participants' perceptions were assessed from a variety of perspectives. There were five publications (15 %) that explored the

influencing factors of digital competence. Four publications (12 %) examined the impact of digital competence on students' achievement. There were two articles that focused on the pedagogical approaches involved in digital competence. There were two selected articles investigating the didactic approaches involved in digital competence. Finally, two articles validated instruments for measuring digital competence.

With regard to the methods applied in the selected publications, we have examined and summarized them in Table 6. It was observed that most research studies on digital competence in higher education had followed a quantitative methodology.

Table 6

Summary of research methods for selected publications

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

In the RQ3, research outcomes from these 33 publications have been reviewed and investigated. They will be introduced following the categories of research purposes.

In these articles investigating the perception and level of teachers and students' digital competence, many teachers and learners maintained a basic and moderate level; a lack of competence could be still felt when encountering complex problems, and the safety dimension was specifically noted. Gender, previous digital experience, training received, the number of research and innovation projects involved, teaching experience and use of technology are also listed in articles exploring the impacting factors of digital competence. In articles exploring the impact of digital competence on students' achievement, it was confirmed that digital competence and digital readiness have a positive impact on university students' academic engagement. Also, there was a positive correlation between digital competence and university students' digital informal learning. As for the pedagogical approach involved in digital competence, an active methodology was recommended, using self-directed learning strategies in ICTs and developing independent and collaborative learning. Moreover, a questionnaire built by Mengual-Andrés et al. (2016) was presented and the questionnaire DigCompEdu Check-In has been confirmed with high reliability and validity (Cabero-Almenara et al., 2020).

In terms of the types of limitations that exist in the selected publications (RQ4), the implementation of data collection methods was identified as the most common limitation (n=14). Sample size was a frequent study limitation in the articles as well

(n = 12). There were 17 articles with more than one study limitation, while eight selected articles did not mention their study limitations.

Finally, to conclude this section, a summary of the answers to the four research questions proposed in this SLR is presented in Table 7.

Table 7

Summary of responses to SLR questions

Question	**Answer**	
RQ1	A general definition of digital competencies is provided in the publications reviewed by reference to policy documents and relevant research, being presented from different perspectives. The framework proposed in Europe has received worldwide interest and attention. It can be understood that digital competence for teachers is a combination of knowledge, abilities, skills, awareness, strategies and attitudes related to the mastery and integration of technology in teaching and learning contexts and processes, in order to achieve educational objectives. Digital competence for learners is a set of knowledge, skills, attitudes, abilities, strategies, and awareness that enable creative, critical and confident use of ICTs to satisfy several objectives required by individuals and today's society.	
RQ2	The dimensions usually used to assess the digital competence of university teachers and students are those of DigComp. Among its different versions, those of DigComp 2.0 are highlighted, such as information and informal literacy; communication and collaboration; digital content creation; safety and problem solving.	
RQ3	Research purposes	The majority of the selected publications investigated participants' digital competence perception and level. Many of them explored influencing factors on digital competence. There were some articles analyzing the impact of digital competence on students' academic achievement, while the rest of them focused on pedagogy involved in digital competence and the validation of digital competence-related instruments.
	Research methods	Most selected publications followed quantitative methodology by distributing questionnaires. The partial least squares structural equation modeling (PLS-SEM) method was applied in four articles to examine the impact of digital competence on DIL.

	Research outcomes	Basically, the digital competence of teachers and students in higher education was at a basic or moderate level, participants felt inadequate when problems became complex. Factors affecting digital competence were outlined. There was a positive correlation between digital competence and students' achievement. The application of appropriate teaching methods in digital competence was presented, and a further reliable and valid tool for assessing digital competence in education was introduced. These have provided a more refined view of digital competence in higher education.
RQ4	Data collection methods, sample size, lack of data are the most frequent types of research limitations in studies related to digital competencies in higher education over the past seven years.	

2.3 Limitations

There are some research limitations in this review. First, it should be noted that the databases used in this systematic literature review, although being the most representative, did not include all existing publications on the subject. Larger databases such as CNKI (China National Knowledge Infrastructure) and EBSCO HOST could have been included.

Second, it should be mentioned that we have limited the publication years in our search in order to highlight the results from recent years. In the process of deciding on search terms, sometimes the terms are not easy to select and another type of analysis must be used to determine them (Marcos-Pablos & García-Peñalvo, 2018, 2019). Considering the specialty of the term "digital competence", when searching with the keywords, we tried to include all related terms to ensure completeness.

Third, we have concentrated on publications written in English. Publications written in other languages on digital competence in higher education were not represented.

Fourth, publication bias has to be considered a limitation in the systematic review of the literature, which may lead to a higher number of investigations with positive results (Egger et al., 1997).

Last, as with other systematics literature reviews (SLR) are considered to be limited by the subjectivity of the reviewer. To potentially reduce self-bias in the selection of studies with regard to quality, it is recommended that future systematic literature reviews have at least two people review the papers using evaluation criteria. Furthermore, all steps from the search for publications to the selection and extraction

of data from the articles need to be recorded to ensure reproducibility and repeatability, and to maintain transparency of the study.

2.4 Conclusions

The mapping results help to complete the systematic literature review, by summarizing key information from the publications. Most of the research on this subject has been carried out in Spain, and regionally, the majority has been performed in the European region. It is recognized that researchers in the selected publications preferred to investigate students' digital competence rather than teachers', as students are the principal subjects of education. Moreover, mapping studies have identified the journals likely to be used for dissemination of the articles and to present the most relevant authors on the topic. Furthermore, according to the answers to the questions posed, although the number of publications decreased in 2019, it is clear now that the interest in digital competence in higher education is growing across the board. Authors and researchers have investigated it from various perspectives, with different subjects.

This review has provided an introduction and understanding to how the concept of digital competence has been defined and applied in higher education, and offers an overview of current research on digital competence in higher education contexts in relation to research purposes, research methods, research instruments, outcomes and existing limitations. Research advances and trends related to digital competence in higher education over the past seven years have been profiled.

First, it can be noted that although the definition of digital competence can be presented from a variety of perspectives, the publications studied have defined it at a macro level by referring to both political documents and relevant research articles. The framework proposed in Europe has received worldwide attention and has contributed to a better understanding of digital competence and its progress.

Second, the dimensions that are commonly used to make the educational design of digital competence in higher education have been presented, highlighting information and data literacy, communication and collaboration, digital content creation, safety and problem-solving dimensions from DigComp 2.0. This detailed review of the design of assessments on digital competence in universities has allowed for the detection of three clear trends in instrument design:

- Research that follows the DigComp dimensions without modification.
- Research that uses the DigComp dimensions expanded with some dimensions from other digital competence assessment theories such as ICTs use, attitude, experience and prior learning.
- Research that uses the dimensions from other frameworks, that offers a different point of view.

Prior training, ownership of ICTs, access of the Internet, use and attitude towards digital tools were of particular importance when designing the research instrument. It is not only technological developments, digitization and informatization that have penetrated into education. The outbreak of the COVID-19 pandemic and the shift in educational models have all required students, teachers and even future teachers to be equipped with adequate digital competence to face these challenges (Sánchez & Trigueros, 2017). These observations also gave us suggestions for future exploration and the creation of a tool to assess digital competence in universities in terms of dimension building.

Third, in light of the answers to the questions presented, the 33 selected publications were reviewed and analyzed in-depth. In terms of purpose, most of the research on digital competence in the context of higher education concentrated on teachers and students' perceptions and their levels of digital competence, especially students. With regard to research methods, quantitative research methods using questionnaires were the most frequently employed among these studies. Concerning the research results achieved in the past seven years of related studies, it showed that in general the digital competence of university teachers and students was at a basic or medium level. Some participants performed well in certain areas like communication and collaboration, but when the complexity and difficulty of the questions increased, the respondents were less than capable. Safety was also a point to which teachers and students need to pay more attention in the future. Factors that could have an impact on digital competence were also listed, and in addition to this, the positive influence of digital competence on students' achievement was also verified. Positive pedagogical developments regarding digital competence were presented. The description and presentation of the validation of the digital competency instrument will help to create future assessment tools or to carry out research studies on this topic. Results obtained were considered as evidence and a basis for educational strategies, which can help to improve the quality of education, to remind teachers to adapt to educational innovation, and to promote students' digital participation and immersion.

Moreover, this SLR has been able to summarize the limitations that have emerged in the previous research so that they can be avoided in future research studies, pointing out the implementation of the data collection method, the size of the sample, and the lack of data.

Furthermore, the gaps in research have been identified and some areas are perceived to be susceptible that can be explored in future studies:

- Research participants outside Europe. More concern and effort should be given to the development of digital competence in countries outside Europe. The framework proposed by the EU on digital competences is well established and continues to be refined. Most relevant studies have explored digital competences in the context of European higher education. It is suggested that attention could then be turned to other parts of the world, such as Asia, where there is both a large educated

population and an education system that is quite different from Western education one. Understanding the issue of digital competence in higher education in Asian regions and countries is worthwhile to investigate, as this can help build cross-cultural studies and comparisons in the future.

- University teachers. Apart from students, teachers' digital competence should be a subject of ongoing research in the future. It is also worth continuing to explore teachers' digital competence and proficiency as leaders of uninterrupted teaching and learning activities under the influence of social processes and pandemics.
- The evaluation of real digital competence level. Instead of understanding teachers' and students' perceptions of digital competence, assessing these participants' actual levels of digital competence is an area of future research interest.
- Pedagogical approaches involved in digital competence and the validation of digital competence related instruments. From the findings of this SLR, it can be seen that few articles have investigated digital competence related pedagogical approaches and instruments' validation. It is recommended to further explore pedagogical approaches to better integrate digital competence into teaching and learning, so as to exert a positive impact, as well as to create more reliable instruments to analyze and evaluate digital competence.
- Correlational studies. There is a need to continue investigating the influencing factors on digital competence, and to explore in depth the relationships between these independent and dependent variables.

| Chapter 3 |

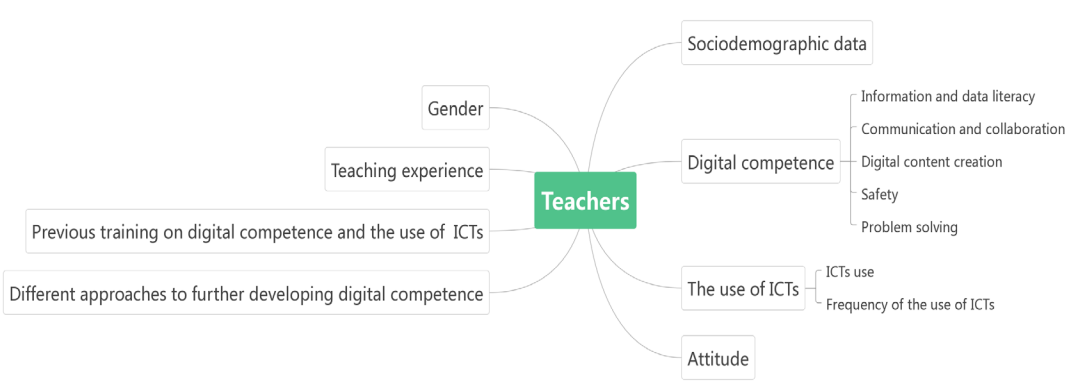
Exploration of university teachers' digital competence at Gansu Agricultural University

After a literature review to understand the definition of digital competence and the existing research gaps in recent years, we decided to expand the scope of the study to the Asian region. Considering the rapid development of technology over the past few years, the progress of informatization and the digitization of education in China, the huge educated population in China, the uneven regional development within China, and the fact that few studies on this topic that have been conducted within the underdeveloped areas, we decided to explore teachers' and students' digital competence in the west of China. Gansu Agricultural University was chosen as a case study.

The research presented in this chapter focuses on two main parts. The first part presents the teachers' digital competence, the use of ICTs, and their attitudes towards the use of ICTs in education at Gansu Agricultural University in the west of China. The second part presents the impact of the teachers' gender, years of teaching experience, previous training related to digital competence, and the use of ICTs and various approaches used to improve their digital competence on these factors. Figure 11 shows an overview of the variables relevant to this research.

Figure 11

An overview of the variables related in the teachers' digital competence



Most results related to teachers' digital competence have been published in *Sustainability* (Zhao et al., 2021a) and it can be consulted in full, in Appendix B. Results on the use of ICTs, their frequency and participants' attitudes, as well as the impact of previous training and different approaches to improving digital competence on each dimension are the original contributions of this thesis.

3.1 Objectives

To conduct a study to identify teachers' digital competence at Gansu Agricultural University, with the support of the use of ICTs and their attitudes towards using ICT in education, was the overall aim that guided this research. An analysis of the

relationship between the detection and definition of practical problems and the development of metacognitive processes are also presented in this chapter, which allows changes and developments to take place from the perspective of the participants themselves (Pérez Escoda, 2015).

The significance of this study is to understand and to promote the development of digital competence within higher education teachers in less developed regions, with the example of Gansu Agricultural University, to ensure the optimal implementation of technological tools, and contribute to the improvement of the quality of education. The results obtained will provide reliable data when conducting relevant training and when formulating development strategies. With this consideration as a starting point, the research objectives of this study are:

- To describe the university teachers' digital competence.
- To identify university teachers' uses of ICTs and their frequency of using ICTs.
- To know university teachers' attitudes towards using ICTs in education.
- To explore if teachers' digital competence varies with variables such as gender, teaching experience, previous training and approaches to developing in-depth digital competence in higher education.
- To analyze the impact of university teachers' gender, teaching experience, previous training and approaches to developing digital competence on the use of ICTs and their frequency of ICTs use.
- To investigate whether university teachers' gender, teaching experience, previous training and approaches to developing digital competence have influence on their attitudes towards applying ICTs in education.

In order to permit a better comprehension, it is this main research question with three sub-questions that this study attempts to answer.

RQ1: What is the teachers' digital competence at Gansu Agricultural University to determine their needs?

RQ2: What is teachers' proficiency and frequency in the use of ICTs?

RQ3: What are teachers' attitudes towards the use of ICTs in education?

RQ4: What factors could influence university teachers' digital competence, the use of ICTs and their attitudes towards ICTs in education?

The methodology used in this study, a summary of the most relevant results, and the implications for the development of digital competence, the use of ICTs, and attitudes derived from the study are presented below.

3.2 Methodology

The methodology followed in this research study allows us to gather the necessary data that will be used as a basis for inference, interpretation, explanation and prediction of future actions, and to develop the strategies that will provide answers to the objectives set out in the study (Cohen et al., 1990; Rodríguez & Valldeoriola, 2009).

Within the stated research objectives, a quantitative non-experimental, descriptive and inferential approach was adopted for this design mode (Arnal et al., 2021; Hernández et al., 2014; Kerlinger & Lee, 2002). In this way, there was neither control nor manipulation of variables. Data was recorded from what occurred naturally, and was described as obtained from reality (Bisquerra, 2004). We investigated the relationship between these variables in order to point out their correlation nature (McMillan & Schumacher, 2005).

For data collection, an online survey was used, which can help to generalize results to a specific population (Buendía et al., 1998). Rather than involving all teachers from all universities in the west of China, this study collected information from teachers at one university in this region. Care was taken to ensure that the sample was appropriate and representative for statistical analysis. With these methods, this study allows for the collection of detailed factual information describing a particular situation (Dalen & Meyer, 1981).

3.3 Instruments

The instrument designed for the collection of information in this research was the questionnaire. The questionnaire developed for university teachers (Appendix E) was adapted from a self-evaluation tool of digital competence based on the CDCFT, and from a questionnaire designed for teaching staff to assess their level of use and appropriation of ICTs (López et al., 2019; Taquez et al., 2017;).

The final questionnaire was designed in several stages. The initial questionnaire was first established in Spanish and was later translated into Chinese, given the background of the study participants. First, the draft of the questionnaire was designed, including all the items that had to be taken into account. The second step was the process of checking the questionnaire characteristics and the external validity of the instrument. It was analyzed by a group of judges, which consisted of ten experts from both Spain and China, three in research methodology and statistics, two in pedagogy, three in educational technology, and two in linguistics. The experts analyzed the setting of the questions, the clarity and wording of the descriptions, the correct use of terminology, the relevance of the items to the dimensions studied and the placement of the different questions in the questionnaire, and then made some suggestions and

recommendations for changes. Third, to complete this phase, the questionnaire was modified according to the contributions of the experts.

This questionnaire was made up of 56 items and was divided into four parts (Table 8):

Table 8

Structure of the questionnaire for university teachers

Socio-demographic and identification data	Age; gender; teaching experience; faculty; mentor situation; number of classes you teach; type of classes you teach; type of training about ICTs, how digital competence training was acquired and motivation for using ICTs.
Teachers' digital competence	Information and data literacy; communication and collaboration; digital content creation; safety and problem solving.
The use of ICTs	Using ICTs, frequency of using ICTs.
Attitude	Attitude towards ICTs in education.

In the section on teachers' digital competence, the use of ICTs and attitudes, there were subdivisions under each dimension into different items. The items consisted of closed-ended, multiple choice, open-ended and Likert-type ordinal scale questions from 1 to 4 to prevent possible negative effects arising from applying the questionnaire. The content of the items can be found in Appendix E.

The internal consistency of the instrument was measured later through Cronbach's α statistic with $\alpha = 0.974$, which is very satisfactory and demonstrated that those items had a relatively high internal consistency. The external validation of the questionnaire was carried out by the judges; as mentioned earlier, there were ten experts from both Spain and China.

3.4 Population and sample

The population of this study was composed of teachers working in Gansu Agricultural University (n=1226), to whom the QR code created from Qualtrics to distribute the survey was sent.

The final sample of this study was composed of 536 teachers from different faculties of Gansu Agricultural University in China. It was a representative and random sample. All members of the population had the same chance of being selected and it was also desired to generalize the results to the population. The final sample that required to be sufficiently representative was confirmed by the formula proposed by Cea D'Ancona (2001) with a margin of error of 5%. 61.2% were female and 38.8%

were male, with ages ranging from 23 to 68 years. More characteristics of the participants are detailed in Table F1.

Regarding their teaching experience, 26% had less than 5 years of teaching experience, 20% had worked for 5 to 9 years, 33% had worked for 10 to 19 years, 16% had worked for 20 to 29 years, and 5% had worked for more than 30 years. There were 20.5% teachers who were supervisors for postgraduate or doctoral students and 79.5% who were not. In addition, most teachers taught more than one course. There were 28.7% teachers who taught two different courses. 27.1% of them had three courses and 25% were teachers with more than four courses. The majority of teachers were teachers of compulsory professional courses.

In terms of received training on digital competence and the use of ICTs, most of them (70.5%) stated that they had received such training before. With regard to different approaches to further developing digital competence, there were 33% of them who developed their digital competence by self-study, 31.2% participated in seminars, 23.9% of them went to online classes to improve their digital competence. Only 11.9% had traditional classes.

As for their motivation for using ICTs in their educational activities, many of them (81.7%) were motivated by their personal experience and knowledge. 48.9% indicated that they used ICTs in the teaching process due to the review of studies or experiences presented in other academic contexts. 34.9% followed the recommendations of friends or colleagues. 23.7% were asked to do so by their job requirements. Only 12.5% of them received suggestions from their students.

3.5 Data collection and analysis

Data collection took place in China during the 2019-2020 academic year. The questionnaire was completed digitally through the Qualtrics platform and shared with teachers in Gansu Agricultural University through the QR codes and links created by Qualtrics. The questionnaire was anonymous.

The statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS v.26). Different types of analysis were carried out in order to meet the objectives of the study, and to answer the research questions. First, descriptive analyses were conducted, calculating the mean and standard deviation of the items and by presenting frequency and percentage for each valid response. Second, inferential analyses were carried out, using non-parametric statistics due to the data following a non-normal distribution. Normality was checked by the Kolmogorov-Smirnov test with a 5% level of significance, and p-values of < 0.05 were found in all cases. The non-parametric Mann-Whitney U test was applied for the variables of gender and previous training. The non-parametric Kruskal-Wallis test was applied for the variables of teaching experience and different approaches to improving digital competence.

3.6 Outstanding results

This section presents the results of the study in which the questionnaire was distributed to teachers at Gansu Agricultural University and is divided into two parts. The first part presents the results obtained through descriptive analyses of the data. The second part shows the results of the inferential analyses.

3.6.1 Descriptive results

The descriptive results in this section concentrate on teachers' digital competence, the use of ICTs and frequency of use, their attitudes towards the use of ICTs in educational activities. Details of the descriptive results of the five aspects of digital competence observed have been presented in Appendix B. All others are original contributions to this thesis.

In terms of teachers' digital competence, the results obtained indicated that teachers' digital competence concerning information and data literacy, communication and collaboration and safety were high, while more than half of teachers thought that they were good at solving problems. However, they didn't perceive themselves good in terms of digital content creation (Table F2).

The following are the results obtained by the teachers in response to the third part of the questionnaire; it consists of two sub-chapters, one assessing the use of ICTs and the other the frequency of using ICTs.

Table F3 shows the descriptive results of the exploration of teachers' uses of ICTs by presenting the mean and standard deviation, as well as the percentage of valid responses for each value on the Likert scale. The majority of teachers were good at using e-mail, communication software, information search tools, classic Office tools, institutional repositories, screen capture tools, and audiovisual content platforms ($M>3.00$). However, more than half of these teachers felt overwhelmed by the use of social networking, collaborative networking tools, audio editors, video editors, learning management platforms, social bookmarking, real-time response systems, content management systems, source management and citation review tools, match detection tools and tools for creating questionnaires ($M<2.5$).

The results obtained in the descriptive analysis are illustrated in Table F4. Teachers used e-mail, communication software, information search tools, classic Office tools, content creation tools, institutional repositories, screen capture tools and audiovisual content platforms with high frequency ($M>3.00$). There were many teachers who never or seldom used collaborative networking tools, social bookmarking, real-time response systems, content management systems and source management and citation review tools ($M<2.00$).

In terms of teachers' attitudes, the results of the descriptive analysis indicated that teachers at Gansu Agricultural University had positive attitudes towards the use

of ICTs in educational activities, with mean scores above 2.5 for all items and above 3.00 for most items, although teachers were slightly less likely to agree with the statements that students are more willing to learn with the integration of ICTs and ICTs facilitate personal and detailed monitoring of each student (Table F5).

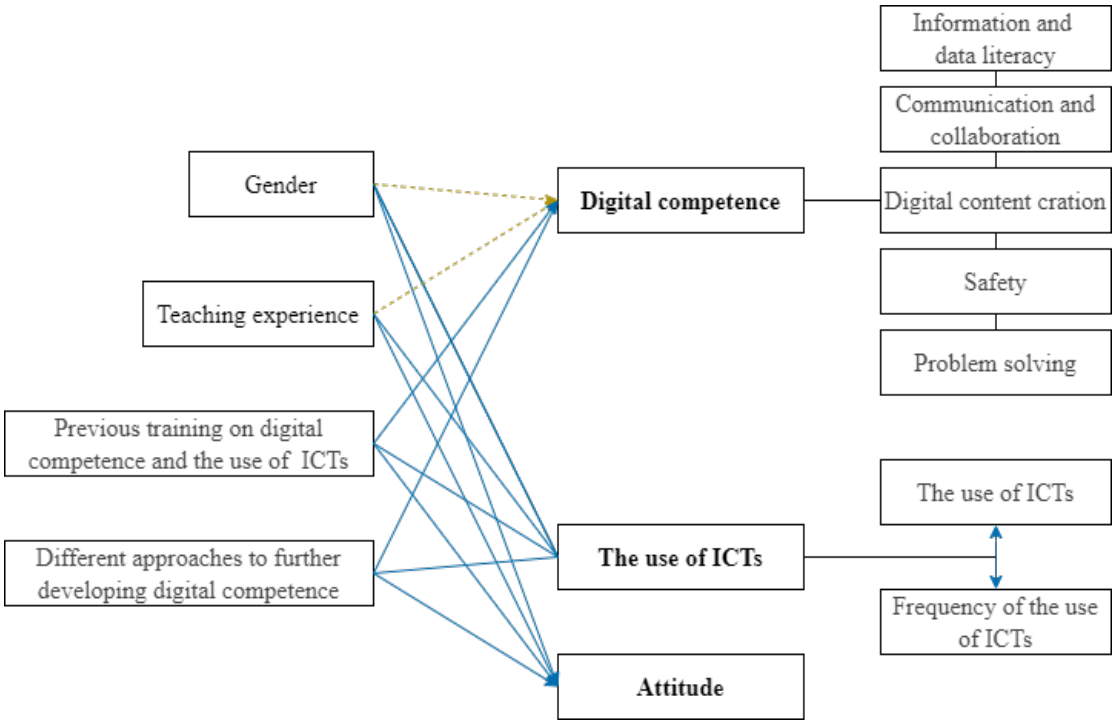
3.6.2 Inferential analyses

This section will present the results of the inferential analyses comparing teachers' uses of ICTs, frequency of the use, and their attitudes based on variables such as gender, teaching experience, previous training and different approaches to improving digital competence. Differences in digital competence by gender and teaching experience are presented in Appendix B.

For clarity and understanding of the results of this study, Figure 12 shows the relationships between the variables analyzed. The yellow dashed lines in the figure linked the variables whose relationships have been previously analyzed in Appendix B. The relationships between the variables connected by the blue line are the main ones studied in this paper. The results will be presented in the order of the independent variables on the left for each variable on the right.

Figure 12

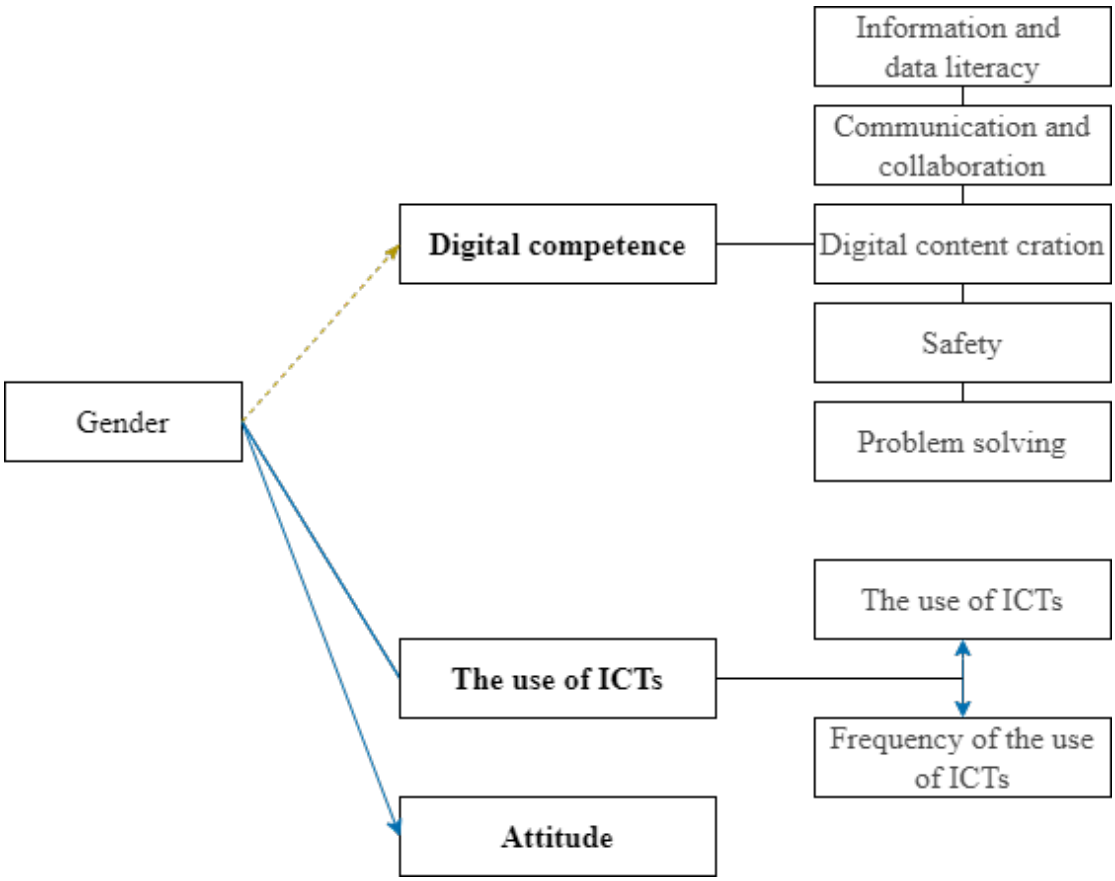
Flowchart of the inferential analyses relating to teachers' research



First, whether five areas of digital competence; the use of ICTs and the frequency of using ICTs, and teachers' attitudes towards the use of ICTs in educational activities differed by gender were investigated (Figure 13).

Figure 13

Flowchart of the inferential analyses based on teachers' gender



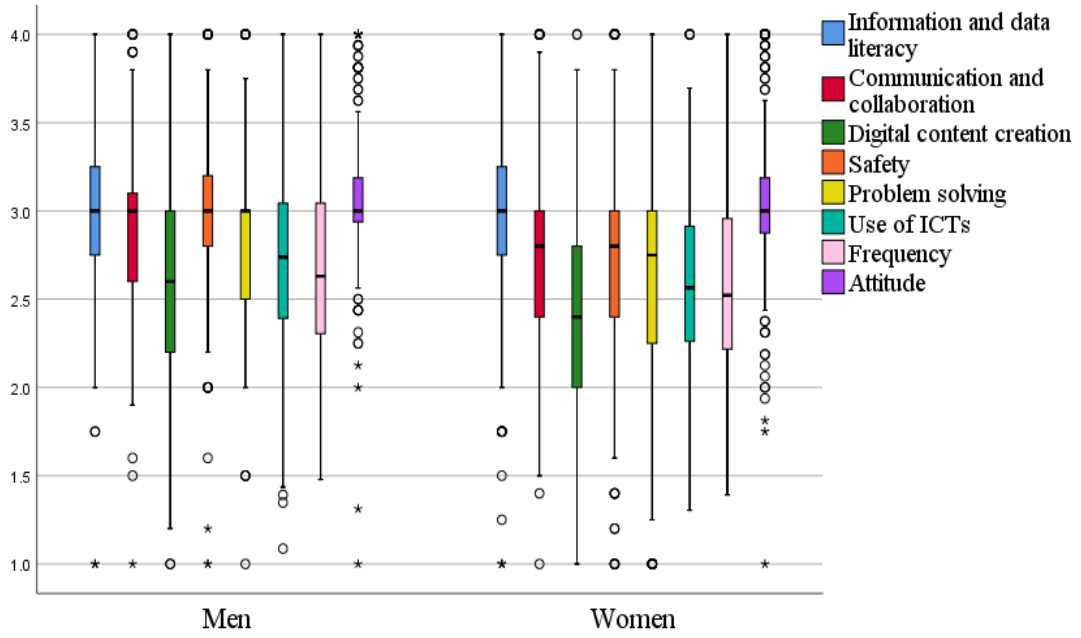
Considering the distribution of the data, the Mann-Whitney U test was applied to identify if there existed differences between male and female teachers in five areas of digital competence, the use of ICTs, the frequency of using these ICTs and their attitudes towards using ICTs in educational activities. It was observed that teachers' digital competence differed significantly by gender in the areas of information and data literacy (MW p-value=0.032), communication and collaboration (MW p-value=0.000), digital content creation (MW p-value=0.000), safety (MW p-value=0.000) and problem solving (MW p-value=0.000), with all p-values being less than 0.05. With regard to the use of ICTs, a significant difference was found between genders as well (MW p-value=0.001). However, there was no statistically significantly difference between male and female teachers in terms of the frequency of using these ICTs (MW p-value=0.067) and teachers' attitudes towards using ICTs in the educational activities (MW p-value=0.417).

Figure 14 illustrates the gender differences in the areas of information and data literacy, communication and collaboration, digital content creation, safety and problem solving, the use of ICTs and their frequency, and in teachers' attitudes. It can

be observed than male teachers considered themselves better than female teachers in five areas of digital competence, as well as in the use of ICTs.

Figure 14

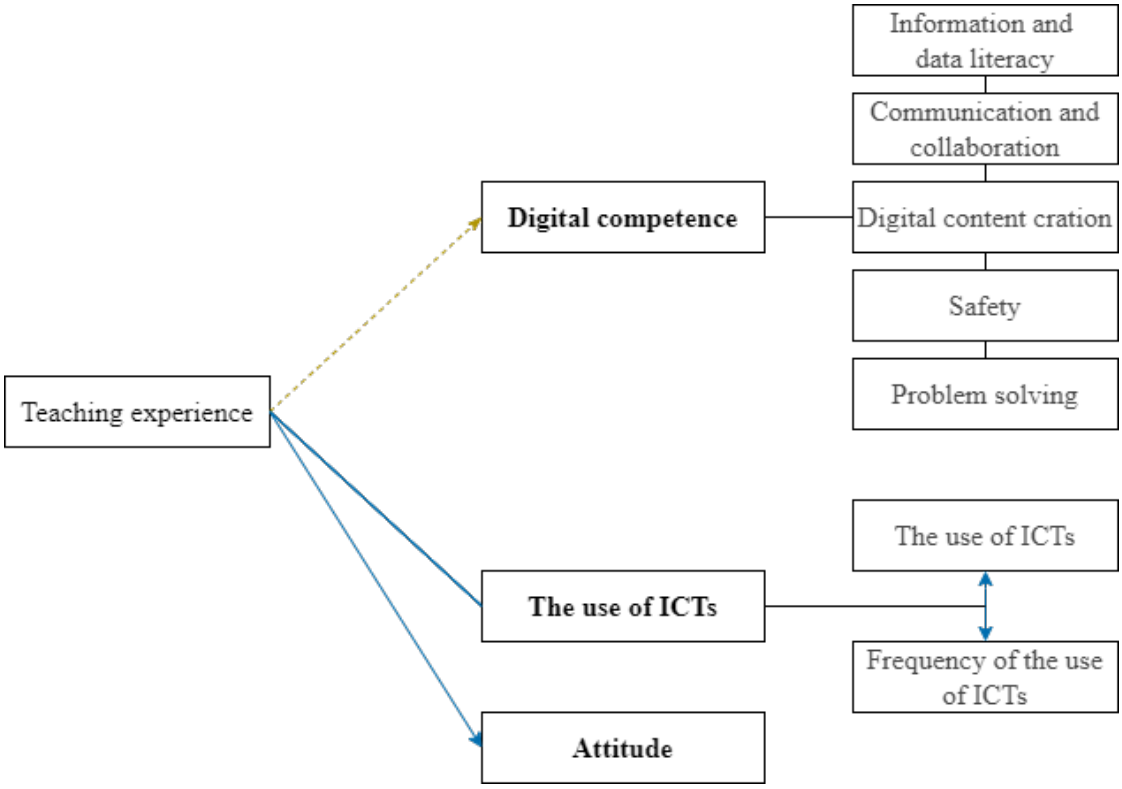
University teachers' digital competence, the use of ICTs, their frequency and attitudes, divided by gender



Second, differences in five areas of digital competence; the use of ICTs and the frequency of using ICTs and teachers' attitudes towards the use of ICTs in educational activities by different teaching experience were investigated (Figure 15).

Figure 15

Flowchart of the inferential analyses based on teachers' teaching experience

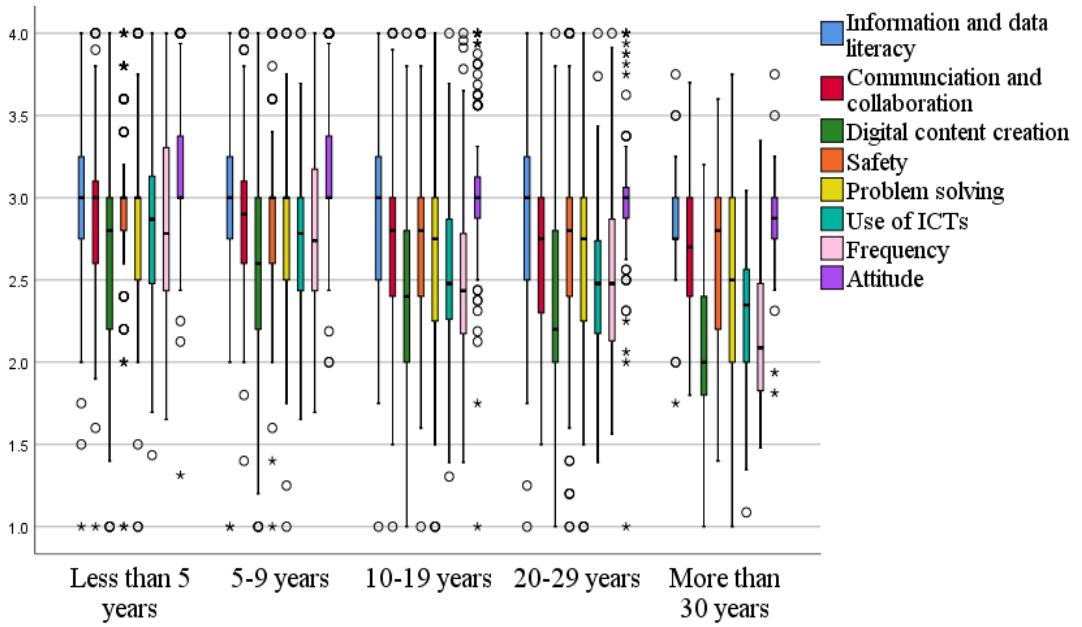


The results obtained according to the Kruskal-Wallis test showed that in terms of digital competence, no differences were observed in the areas of information and data literacy among teachers with different teaching experiences (KW p-value=0.084). However, when considering teachers who had different teaching experience, significant differences were found in areas of the communication and collaboration (KW p-value=0.000), digital content creation (KW p-value=0.000), safety (KW p-value=0.001) and problem solving (KW p-value=0.001), as well as in the use of ICTs (KW p-value=0.000), their frequency (KW p-value=0.000) and teachers' attitudes (KW p-value=0.000).

Figure 16 shows the differences of the variables analyzed according to teachers' teaching experience. In general, teachers with less teaching experience considered themselves to have higher digital competence in areas of communication and data literacy, digital content creation, safety and problem solving. Similar results were obtained in teachers' uses of ICTs, frequency of using these ICTs and their attitudes.

Figure 16

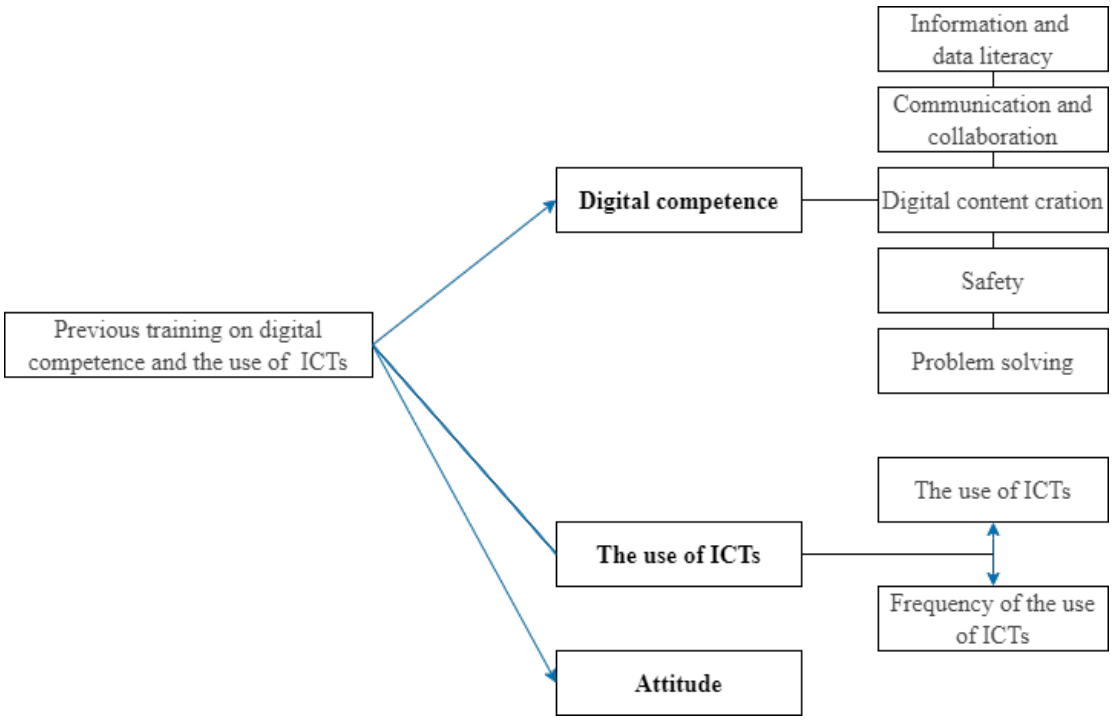
University teachers' digital competence, the use of ICTs, their frequency and attitudes, divided by groups of teachers' teaching experience



Third, the differences between previous training on digital competence and ICTs in these dimensions were explored (Figure 17).

Figure 17

Flowchart of the inferential analyses based on teachers' previous training on digital competence and the use of ICTs

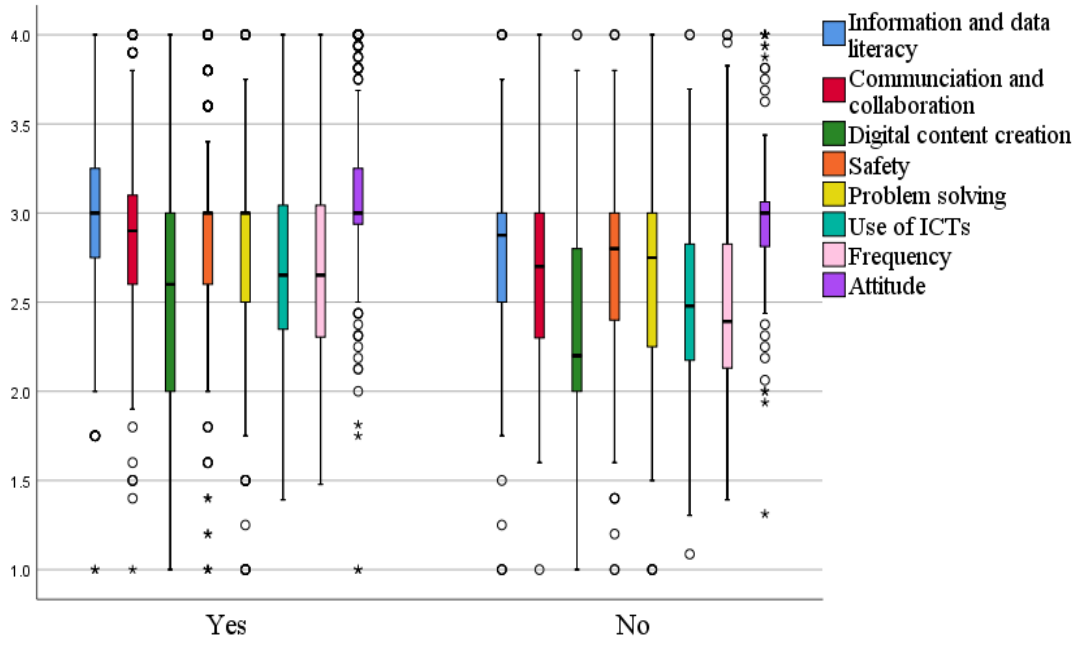


The Mann-Whitney U test was used to explore whether there were differences between teachers who had received previous training in relation to digital competence and the use of ICTs. Statistically significant differences were found in previous training received by teachers in the five areas of digital competence (MW p-value=0.000; MW p-value=0.000; MW p-value=0.002; MW p-value=0.000; MW p-value=0.001), use of ICTs (MW p-value=0.000), frequency of using ICTs (MW p-value=0.000) and attitudes (MW p-value=0.003) with all p-values being less than 0.05.

In general, teachers who had received training on acquiring digital competence and learning the use of ICTs considered themselves better in digital competence. The use of ICTs, and frequency in using these ICTs, are presented in Figure 18.

Figure 18

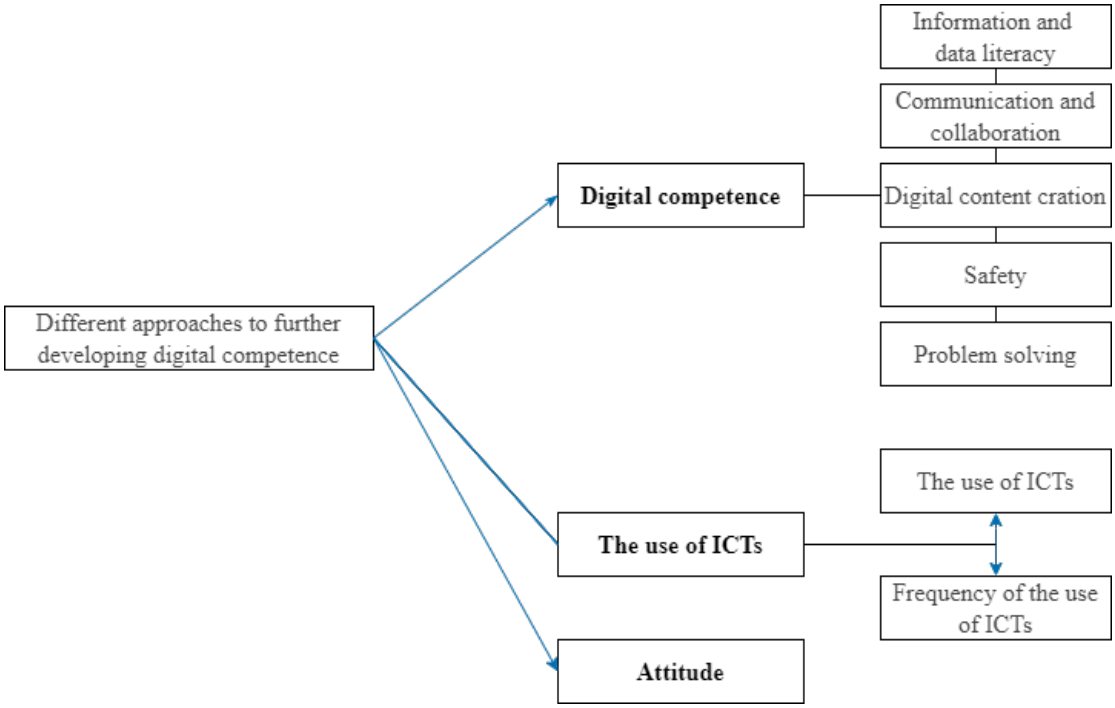
University teachers' digital competence, the use of ICTs, their frequency and attitudes, divided by teachers' previous training



Fourth, the influence of different approaches to further developing digital on five areas of teachers' digital competence, the use of ICTs, their frequency, and attitudes was analyzed (Figure 19).

Figure 19

Flowchart of the inferential analyses based on teachers' different approaches to further developing their digital competence

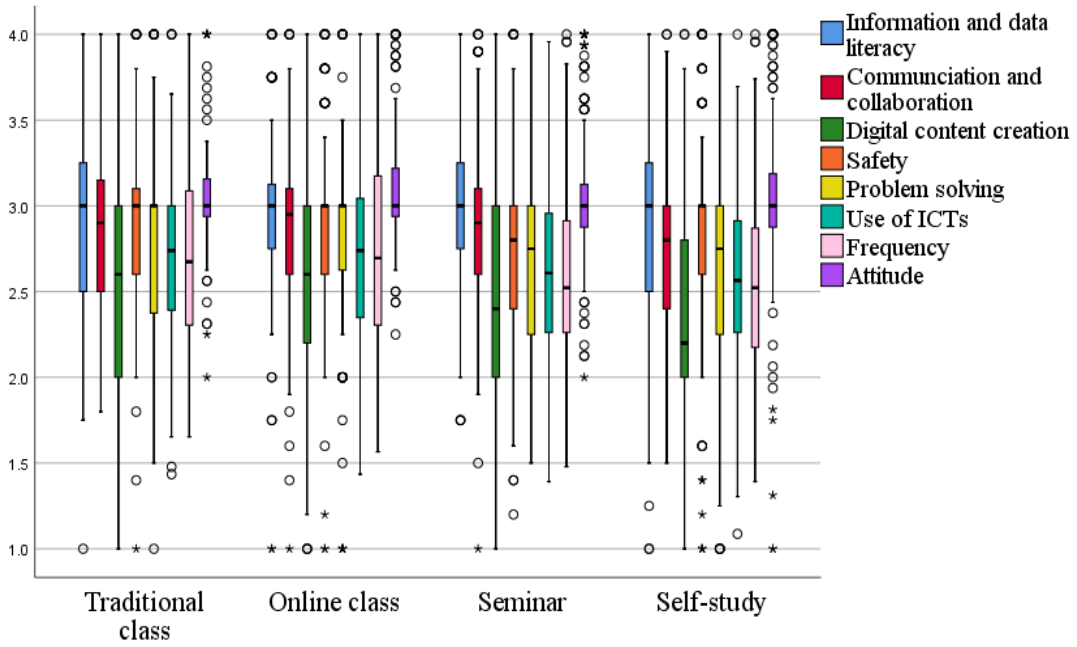


Results from the Kruskal-Wallis test indicated that there were significant differences between different approaches to improving teachers' digital competence in terms of communication and collaboration (KW p-value=0.011), digital content creation (KW p-value=0.012), problem solving (KW p-value=0.013) and frequency of using ICTs (KW p-value=0.014). In contrast, no significant difference was found in terms of information and data literacy (KW p-value=0.054), safety (KW p-value=0.227), teachers' uses of ICTs (KW p-value=0.054), and attitudes (KW p-value=0.505).

Regarding communication and collaboration, digital content creation and problem solving in digital competence, teachers who developed digital competence through traditional courses, online courses, and seminars thought themselves better than teachers who improved digital competence through self-study. Teachers who took online courses used ICTs more often than those who had traditional classes, went to seminars, and studied by themselves (Figure 20).

Figure 20

University teachers' digital competence, the use of ICTs, their frequency and attitudes, divided by teachers' different approaches to further developing digital competence



3.7 Conclusions

There are several personal and contextual characteristics on which the development of digital competence may depend (Cebrián-Cifuentes et al., 2021). The conduct of this study has provided a valid tool to assess university teachers' digital competence and the use of ICTs. It helped to understand teachers' digital competence at Gansu Agricultural University in the west of China, the use of ICTs and their attitudes towards the use of ICTs in their pedagogical activities. In this study, we have identified several factors that have an impact on their digital competence and the use of ICTs, which will provide us with useful information and knowledge to improve digital competence and the use of ICTs, and to help build development strategies in the future.

Teachers rated themselves as good at information and data literacy, communication and collaboration, safety and problem solving, but showed a low level in the area of digital content creation. They were good at using common, classic ICTs, and frequently used communication and office tools, but overall, they showed a low

level of expertise in the use of tools related to content creation or conducting collaborative work. However, teachers' attitudes towards the use of ICTs in teaching and learning activities remained positive.

On the one hand, the gender gap was confirmed with differences in digital competence and ICTs use between male and female teachers. So did teachers with different teaching experience, with differences in their digital competence in terms of communication and collaboration, digital content creation, safety and problem solving; and differences in the use of ICTs, frequency of use, and attitudes towards the use of ICTs in educational activities.

On the other hand, the importance of past training on digital competence and ICTs was recognized. Different approaches to improving digital competence had an impact on communication and collaboration, digital content creation and problem solving, as well as the frequency in using ICTs. The significance of systematic courses has been identified.

The subjects of interest and the results obtained from the analyses conducted in this study complement the research areas identified in the previous literature review in Chapter 2. The findings of this study suggest that the development of teachers' digital competence continues to be a challenge that the education community needs to address. The exploration of the relationship between these variables has highlighted the importance of training, and has contributed to the establishment of strategies for developing teachers' digital competence. This will allow us to be more purposeful in future teacher training or in the development of teaching strategies, so as to develop effective training programs for different target populations, and to help reduce the emerging digital divide.

| Chapter 4 |

Exploration of university students' digital competence at Gansu Agricultural University

University of Salamanca

Teachers today are required to have a certain level of digital competence to face some of the implications and challenges of the knowledge society and of the pandemic context, and so too are the students.

Today's university students are digital natives who have grown up with a deep connection and association to ICTs, and live surrounded by computers, videogames, digital music players, video cams, cell phones, and all the other toys and tools of the digital age (Kennedy & Fox, 2013; Prensky, 2001, 2009). Not only do university students have to deal with knowledge related to their school studies, they also have to be able to adapt to the in-depth environment of ICTs. In particularly, fourth-year university students confront a range of issues when they are about to enter society and become true citizens of the digital world.

After contacting and collaborating with researchers at Gansu Agricultural University to collect data from teachers, the possibility of an international stay was considered in the student-oriented research development. It is expected to help us gain insight into the informatization and digitization of education in the west of China, so as deepen our knowledge of local teachers and students' digital competence and the use of ICTs, and collaborate with and learn from researchers with more experience in the field and understand the consideration of digital competence in different educational contexts.

For this purpose, professor Liping Zhao from Gansu Agricultural University was contacted. She is dean of the College of Humanities in Gansu Agricultural University, and director of Gansu Translation Association and member of Gansu University English Steering Committee. She is dedicated not only to the study of English linguistics, but also to the study of educational technology for professional reform and teaching models. As a result of this contact, an opportunity for a three-month stay at the Gansu Agricultural University emerged from the end of August 2021.

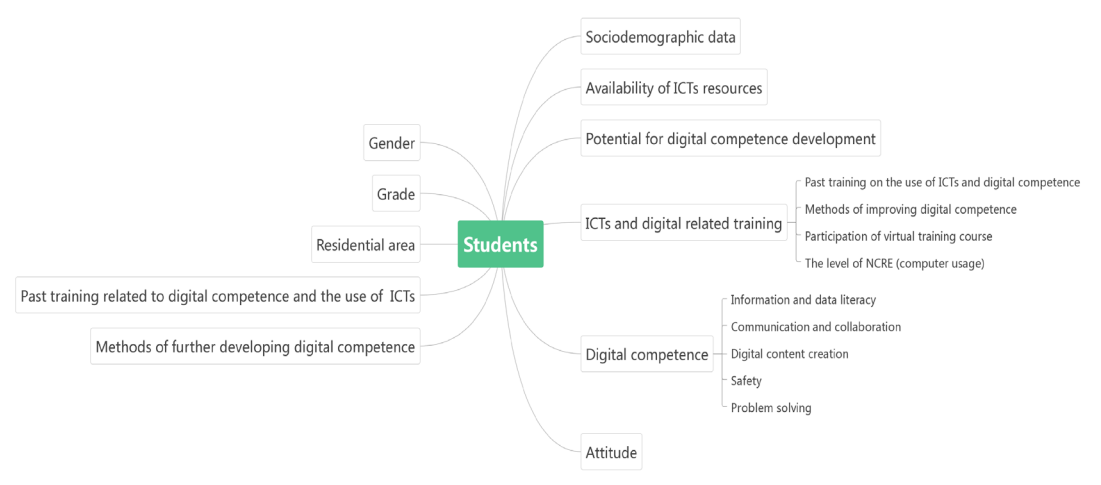
During this stay, a study focusing on the digital competence and attitudes towards ICTs among university in the west of China was carried out, taking into account the existing research gaps in digital competence, China's large educated population, the regional development differences that exist within China, and the promotion of an optimal adjustment of the regional strategic layout of higher education (Ministry of Education of China, 2022), taking Gansu Agricultural University as an example. Moreover, students from first and fourth grade were selected for the study with the consideration of cognitive change.

The research presented in this chapter concentrates on two parts. The first part presents the first- and fourth-year university students' sociodemographic data, their availability of technological resources, the potential for digital competence development through their Internet connection and ICTs usage preference, students' ICT and digital competence related training, their digital competence and attitudes towards ICTs. The second part presents the impact of students' gender, grade, area of residence and previous formal training in the use of ICTs and digital competence, as well as methods of enhancing digital competence on students' digital competence and

their attitudes towards ICTs. Figure 21 presents an overview of the variables relevant to the research on this group of students.

Figure 21

An overview of the variables related in the students' digital competence



The results related to these students' digital competence have been published in the Journal *Sustainability* (Zhao et al., 2021b) and can be found in their entirety in Appendix C. The results on students' availability of technological resources, potential for digital competence development, ICT and digital competence related training, and their attitudes toward the use of ICTs, the impact of different digital competence enhancement methods on the dimensions of digital competence and the impact of these individual factors on students' attitudes are the original contributions of this thesis.

4.1 Objectives

Digital competence is interpreted as a transversal competence related to several today's society required knowledge, skills, abilities and attitudes for people to participate in work, learning, entertainment and society, with the definition of using ICTs confidently, critically and creatively (Ferrari, 2013).

The general objective of this study is to identify the digital competence of university students from various perspectives, based on the example of Gansu Agricultural University, located in a less developed region of China. It is not only to investigate students' digital competence, but also to detect any training needs and to provide the necessary guidance and support in the development of educational activities and training concerning digital competence, and to help us to integrate ICTs in teaching and learning activities, develop future educational policies and promote

informational digital education based on an understanding of the impact of digital competence.

Taking these into account, the following specific objectives in this study are:

- To explore students' availability to technological resources.
- To find out the potential for students' digital competence development.
- To know about students' ICT and digital competence related training.
- To identify the students' digital competence.
- To understand the attitudes of university students towards the use of ICTs.
- To analyze the impact of university students' gender, grade, residential area, past training and methods of further developing digital competence on their digital competence.
- To investigate the impact of students' gender, grade, residential area, past training and methods of further developing digital competence on their attitudes towards the use of ICTs.

These objectives are also concretized in the following research questions that guide the empirical study in terms of university students:

RQ1: How is the availability of technical resources for students, their potential for developing digital competence and their past training related to ICTs and digital competence?

RQ2: What is the first- and fourth-year students' digital competence at Gansu Agricultural University to determine their needs?

RQ3: What are students' attitudes towards ICTs?

RQ4: What factors could influence university students' digital competence, and their attitudes towards ICTs?

The subsequent sections will present the methodology employed in this study, as well as the most relevant results and implications for the development of digital competence and the use of ICTs.

4.2 Methodology

This study undertook a work to determine or explain a situation that was unknown from the beginning. The characteristics of the chosen methodology are defined by the kind of information we need to answer the research questions that have been formulated (Latorre et al., 2021).

In accordance with the research objectives, it was employed a quantitative methodology with an ex-post-facto non-experimental design. Variables were not modified (Simon & Goes, 2013). As mentioned in Mateo (2000), this methodology is

most widely used in the field of education, describing reality, analyzing relationships, categorizing, simplifying and organizing the variables that make up the study.

This research is based on a survey study, using descriptive and inferential analysis techniques for the different sample strata considered in this study. These methods are useful for gathering detailed factual information describing a particular situation; for identifying problems; for making comparisons and assessments and planning for future changes and making decisions (Dalen & Meyer, 1981). Instead of controlling and manipulating the variables, the phenomena and the data obtained from reality was described and recorded (Bisquerra, 2004). The variables and their relationships were studied by analyzing their correlational character (McMillan & Schumacher, 2005).

4.3 Instruments

For the collection of information for this study, we adapted the questions designed by Martínez et al. (2010) to measure the basic ICT skills of university students and the questionnaire of the DigComp-based Ikanos self-assessment tool of the Ikanos Project that helps to define one's digital profile and give an indication of the level of digital competence based on the five competency areas of the DigComp model (Appendix G).

The Ikanos self-assessment test indicates the digital knowledge, skills and attitudes that professionals, and in this case, students, are required to have in order to adequately perform tasks involving the use of ICTs.

The questionnaire used in this study was first drafted in Spanish and later translated into Chinese for the convenience of the participants, including all the items considered necessary to meet the objectives of the study. A team of experts from Spain and China reviewed the characteristics and external validity of the questionnaire. Among them were three experts in research methodology and statistics, two in pedagogy, three in educational technology and two in linguistics. The experts made several comments and suggested changes to the setting of the questions, the clarity and wording of the descriptions, the correct use of terminology, the relevance of the items to the dimensions studied and the placement of the different questions in the questionnaire. As a result, the final questionnaire was modified on the basis of these suggestions.

The final questionnaire variables were divided into three sections and consisted of a total of 70 items (Table 9).

Table 9

Structure of the questionnaire for university students

Socio-demographic and identification data	Age; gender; grade; residential area; major and reason for choosing a major.
Availability of technological resources	Device connection to the Internet; owned equipment and device; campus networking and equipment and devices available in the faculty.
Potential for digital competence development	Frequency of connecting to the Internet; connectivity with the Internet and the motivation of using the ICTs.
ICT and digital competence related training	Past training on digital competence and the use of ICTs; methods to further improve digital competence; virtual classes participation experience and level of computer usage.
Students' digital competence	Information and data literacy; communication and collaboration; digital content creation; safety and problem solving.
Attitude	Attitude towards ICTs.

The items include closed, multiple choice, open-ended and Likert-style questions on a scale of 1-4 to prevent possible negative effects in the implementation of the questionnaire. An overview of the items can be found in Appendix G. Moreover, in the section of digital competence and attitude, subdivisions under each dimension into different items can be found.

To verify the reliability of the instruments in this study, Cronbach's Alpha test was used and its value was 0.978, which indicated a high internal consistency and high reliability (Thorndike, 1997). With regard to the external validation of the questionnaire, this was carried out by a group of judges mentioned above.

4.4 Population and sample

For the study, the population comprising the sample consisted of first- (n=4223) and fourth-year (n=4045) students from various faculties of Gansu Agricultural University in China, with a total of 8268 students.

The research sample was a representative and random sample. Population members all had an equal chance of being selected. For the determination of the representative probability sample size of the above population, the formula proposed by Cea d'Ancona (2001) was applied.

The final sample consisted of 3,136 first-year students and 2,940 fourth-year students, with a total of 5,164 students aged between 15 and 30 years old, which

ensured the minimum size required with a margin of error of 5% and was sufficiently representative to allow broad conclusions to be drawn. 56.9% of the students were female and 43.1% were male. In relation to the residential area, most of them lived in the rural areas (70.5%), while 29.5% of them lived in the urban areas. More characteristics of the students that participated can be found in Table H1.

With regard to the students' major, it is divided into six categories according to the custom of Chinese universities. The majority of the students majored in Agronomy (36.3%), 21.6% studied Liberal arts, 13.4% of them studied Management， 12.5% of these students belonged to Science， there were 11.9% in Engineering, and the rest of them studied Economics (4.3%). Students were asked about their reasons for choosing their major. 21.2% of the students chose their major for personal preference, 16% of them considered their personal development prospects, 8.8% selected their major because of the major's reputation in this university, and 53.6% chose their major for other reasons.

4.5 Data collection and analysis

The anonymous questionnaire was distributed by sharing QR codes and links created in Qualtrics. Before the students filled in the questionnaire, the instructor explained the purpose of the study, gave instructions and asked for the cooperation of the students. Data were collected in China in the academic year 2019–2020.

Data from the questionnaires was organized using Excel and statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS v.26). To achieve the objectives of the study and to answer the research questions, different types of analyses were carried out. The first was descriptive analyses in which the mean and standard deviation of the items were calculated, and the frequency and percentage of valid responses were shown. The inferential analysis was carried out by applying non-parametric statistics since the normality was checked with the Kolmogorov-Smirnov test at the 5% level of significance and a p-value < 0.05 was found in all cases as a result of the non-normal distribution of the data. The non-parametric Mann-Whitney U test was employed for the dual variable, such as gender, grade, residential area, past training on the use of ICTs and digital competence. The Kruskal-Wallis test was used for the variable methods of further developing digital competence.

4.6 Outstanding results

This section introduces the results of the study in which the questionnaire was distributed to the first- and fourth-year students at Gansu Agricultural University and is presented in two parts. The first part presents the results obtained through descriptive analyses of the data. The second part shows the results of the inferential analyses.

4.6.1 Descriptive results

The descriptive results in this section will be concerned with students' availability of technological resources, their potential for digital competence development, past ICT and digital competence related training, students' digital competence and their attitude towards ICTs. These are the original contributions to this thesis, except for the descriptive results of the observations of the five areas of students' digital competence, which have been included in Appendix C.

Considering students' availability of technological resources (Table H2), students were first asked about the Internet connection of their devices; there were 97.7 % of them who answered yes and 2.3% of these students indicated no. In terms of what equipment and devices they owned, most of these students had a smartphone (95.7%), a laptop (71.8%) at their home or in their student residence. Many of them did not have a desktop computer or a tablet at their home or in the students' dormitories. When students were asked about their Internet connection, 97.4% of them said they could connect to the Internet on campus, while 2.6% of them indicated no. Students were asked what equipment and devices were available in their faculty, the majority of the students said they could use desktop (77.6%) and laptop (66.8%), as shown in Table H2.

Table H3 indicates the descriptive results concerning students' potential for digital competence development. First, the frequency of students' uses of the Internet was measured. The results showed that more than half of these students used the Internet every day and even several times a day (53.8%), while 40.1% chose every day. There were 2.2% students who used the Internet several times in a week. Only 1.7% did not normally use the Internet. The remaining students responded occasionally. Second, students were asked what devices they generally used to connect to the Internet. Most students used their phones to connect the Internet (73.3%), 23.7% connected to the Internet through various devices. 2.7% of them usually used computers to connect with the Internet. There were only 0.3% who connected to the Internet by using portable devices such as tablets. Third, in relation to students' motivation for using ICTs, there were 75.5% who had various motivations for using ICTs. Most of them used ICTs for entertainment, study activities and work activities.

In the fourth part of the questionnaire, students were asked about several questions about training related to ICTs and digital competence as presented in Table H4. First, with regard to past training on digital competence and the use of ICTs, there were 49.5% of them who had received specific training and 50.5% who had not. Considering the different methods of improving their digital competence, more than half of these students (59.1%) further developed their digital competence through school courses, 37.4% studied by themselves, only 2.4% participated in seminars and 1.1% of them improved their digital competence through group study, which involved the collaborative learning. Moreover, there were 75.3% who had participated in virtual training course.

Regarding the National Computer Rank Examination (NCRE), which is a Chinese national computer proficiency examination system for the community to test the computer application knowledge and skills of test candidates, and has four levels (NCRE, 2022):

- Level 1: Operational Skills Level/Information Literacy.
- Level 2: Programming / Office Software Advanced Application Level.
- Level 3: Preparatory engineer level.
- Level 4: Engineer level.

Among these students, most of them (80.8%) had not passed or participated in the NCRE exam. The majority of the students (15%) who had passed this exam had reached level 2. There were 3.5% who had passed the level 1, and only 0.4% and 0.3 had arrived at Level 3 and Level 4. The results are shown in Table H4.

In terms of students' digital competence, students thought positively in the areas of information and data literacy, communication and collaboration, safety and problem solving. However, they showed a lower confidence in digital content creation (Table H5).

In relation to the descriptive results of students' attitudes towards ICTs, most of them had a positive attitude towards ICTs (M>2.5). Students showed a high interest in ICTs. Most students agreed (71.7%) or even strongly agreed (9.8%) that students have got used to using ICTs in their study activities. The majority of them confirmed that ICTs provided support for their activities. Students also recognized the positive role of ICTs in their learning, knowledge creation, autonomous learning, collaborative learning, self-assessment and communications between teachers and students (Table H6).

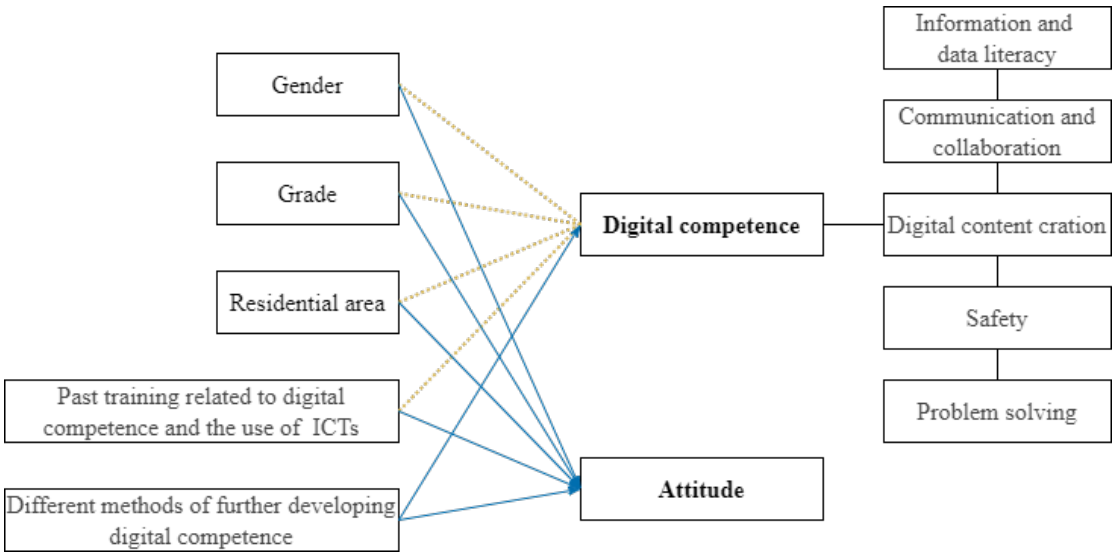
4.6.2 Inferential analyses

This section will present the differences between first- and fourth-year university students' digital competence and their attitudes towards ICTs according to variables such as gender, grade, residential area, past training on digital competence and ICTs, and different methods to further developing digital competence. Differences in digital competence by students' gender, grade, area of residence, and past digital competence and ICTs training have been introduced in Appendix C.

In order to make the results of this study more visible and understandable, Figure 22 presents the variable relationships to be studied in this section. The yellow dashed lines in the diagram connect the relationships between the variables that have been analyzed in the document in Appendix C as mentioned above.

Figure 22

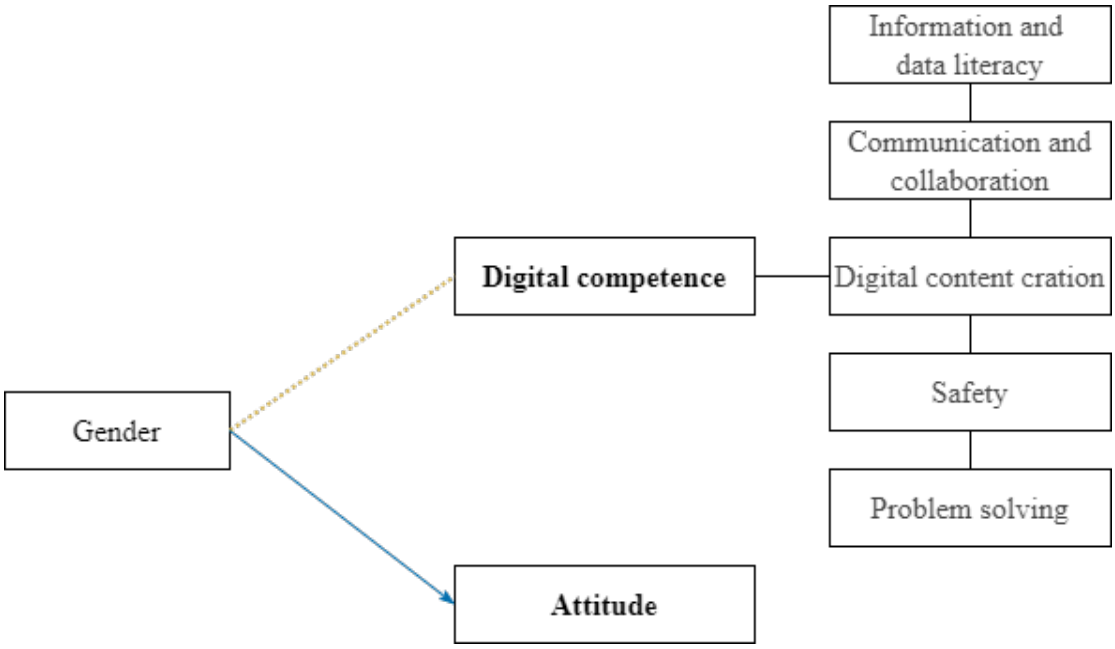
Flowchart of the inferential analyses relating to students' research



First, the influence of students' gender on their digital competence and attitudes was analyzed. Figure 23 shows the related variables.

Figure 23

Flowchart of the inferential analyses based on students' gender



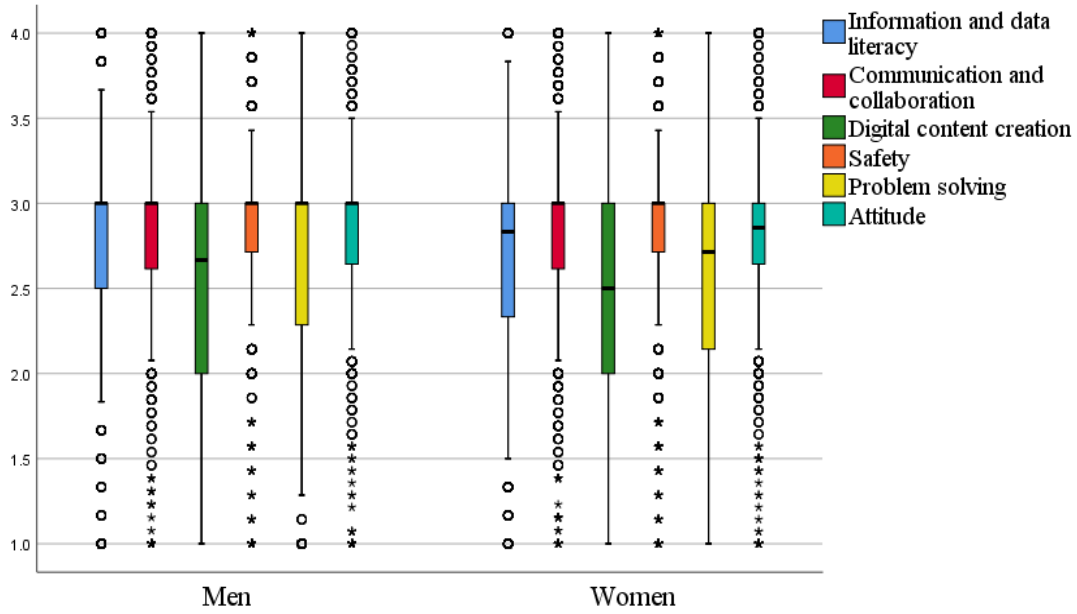
The Mann-Whitney U test was used to investigate whether there were differences between male and female students in various aspects of digital competence and

students' attitudes. Statistically significant differences were found in terms of information and data literacy, digital content creation, problem solving, aspects of digital competence, and students' attitudes towards ICTs with all MW p-values equal to 0.000. No significant differences were observed in communication and collaboration (MW p-value=0.053) and safety (MW p-value=0.709).

Figure 24 shows that male students had a higher rating themselves in these dimensions and showed more positive attitudes towards ICTs than female students.

Figure 24

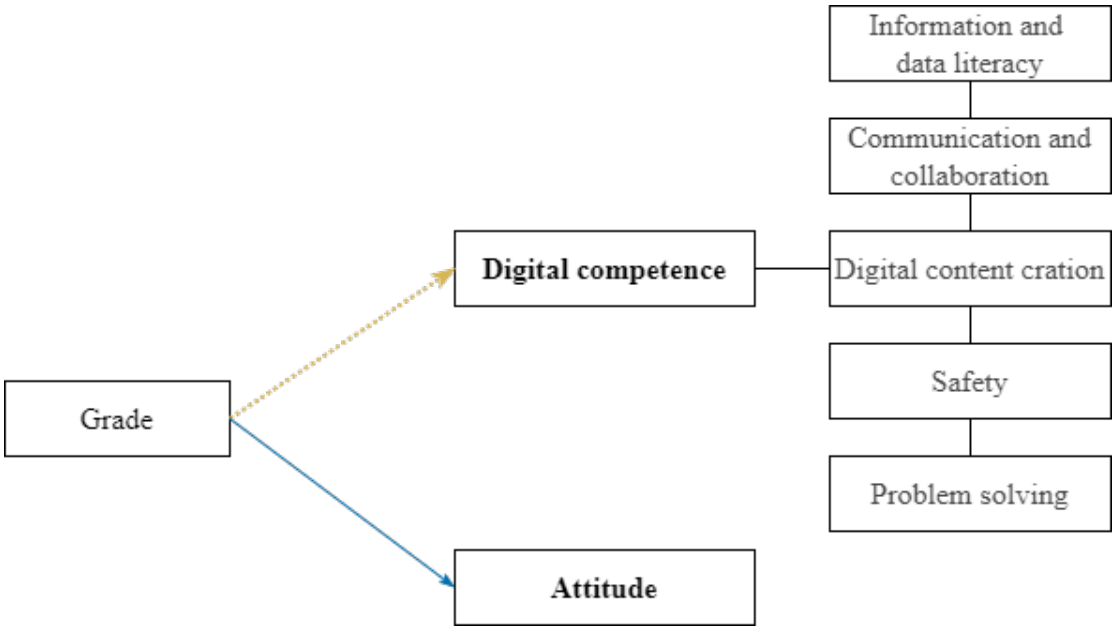
University students' digital competence and attitudes, divided by gender



Second, differences in students' digital competence and their attitudes towards ICTs across grades were examined (Figure 25).

Figure 25

Flowchart of the inferential analyses based on students' grades

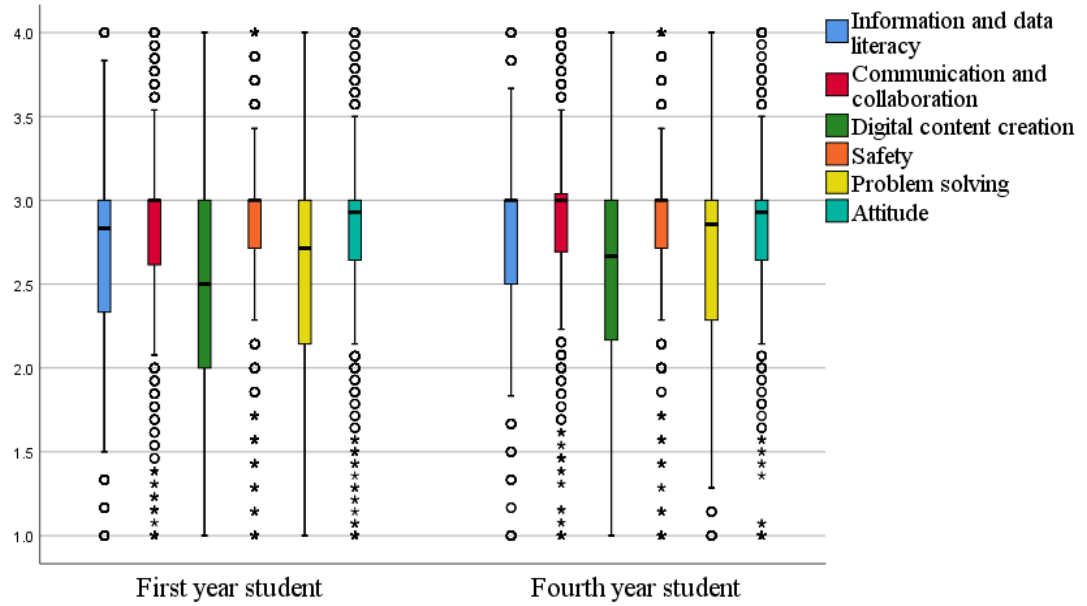


With regard to students' grades, it was found that there were significant differences between the first year and fourth year students in the areas of information and data literacy (MW p-value=0.000), communication and data collaboration (MW p-value=0.000), digital content creation (MW p-value=0.000), problem solving (MW p-value=0.000) and their attitudes towards ICTs (MW p-value=0.016). In terms of safety, no significant difference was indicated (MW p-value=0.221).

The upper grades exceeded the first-year students in all four areas of digital competence, except for the safety area where no significant differences were observed. Regarding students' attitudes towards ICTs, the results showed that the fourth-year students showed a slightly more positive attitude than the first-year students (Figure 26).

Figure 26

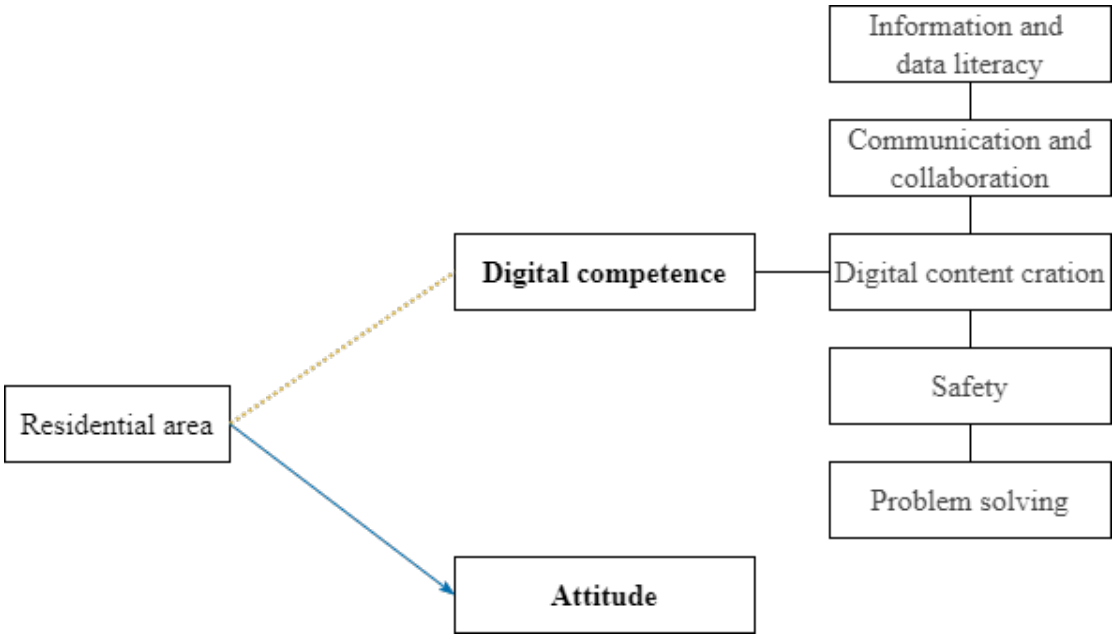
University students' digital competence and attitudes, divided by the grade level



Third, whether students' digital competence and attitudes towards ICTs differed with respect to their residence in rural and urban areas was studied (Figure 27).

Figure 27

Flowchart of the inferential analyses based on students' residential areas

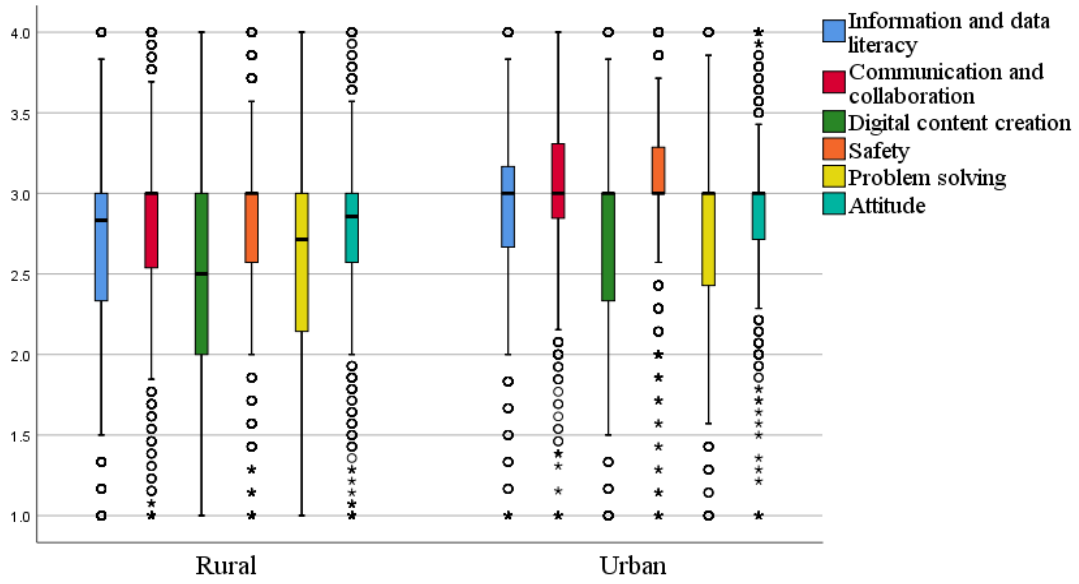


The results obtained from the Mann-Whitney U test indicate that students from different residential areas differed significantly in five areas of their digital competence, as well as in students' attitudes towards ICTs (MW p-value=0.000).

University students, who lived in urban areas, thought themselves better in the five areas of digital competence than those students from rural areas. In terms of their attitudes towards ICTs, similar results were observed (Figure 28).

Figure 28

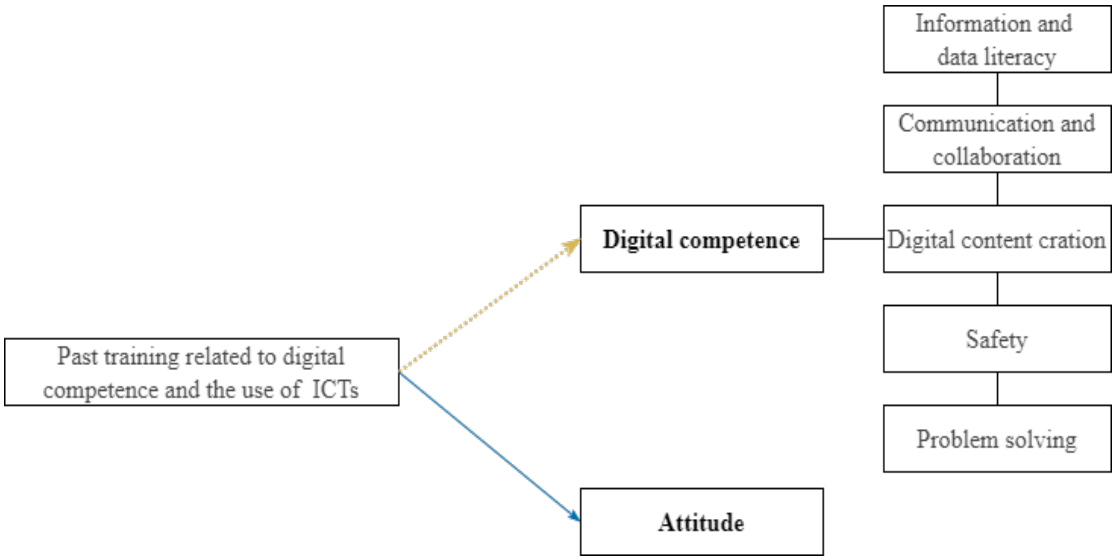
University students' digital competence and attitudes, divided by the residential area



Fourth, the impact of students' past training related to digital competence and ICTs on their digital competence and attitudes was examined (Figure 29).

Figure 29

Flowchart of the inferential analyses based on students' past training on digital competence and ICTs

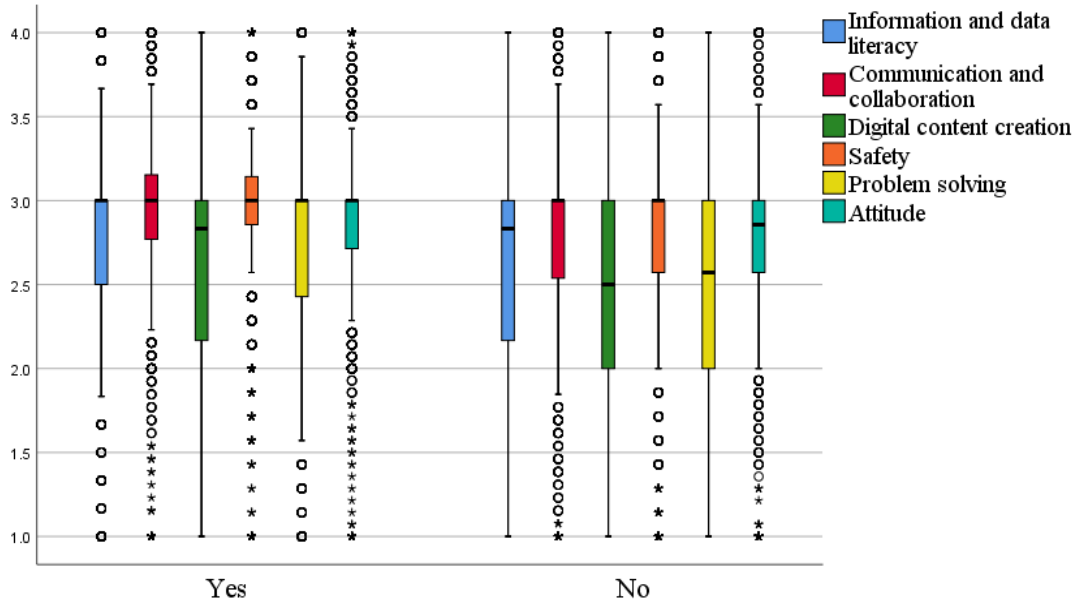


In relation to the results obtained, there were significant differences in the five areas of students' digital competence in the past training variable, with all Mann-Whitney U tests having a p-value of less than 0.05 and all being 0.000. Similar results were obtained for students' attitudes (MW p-value=0.000).

Students who had received earlier training on digital competence and ICTs rated themselves higher in the areas of information and data literacy, communication and collaboration, digital content creation, safety and problem solving than those who had not received previous training. Regarding students' attitudes towards ICTs, we found similar results (Figure 30).

Figure 30

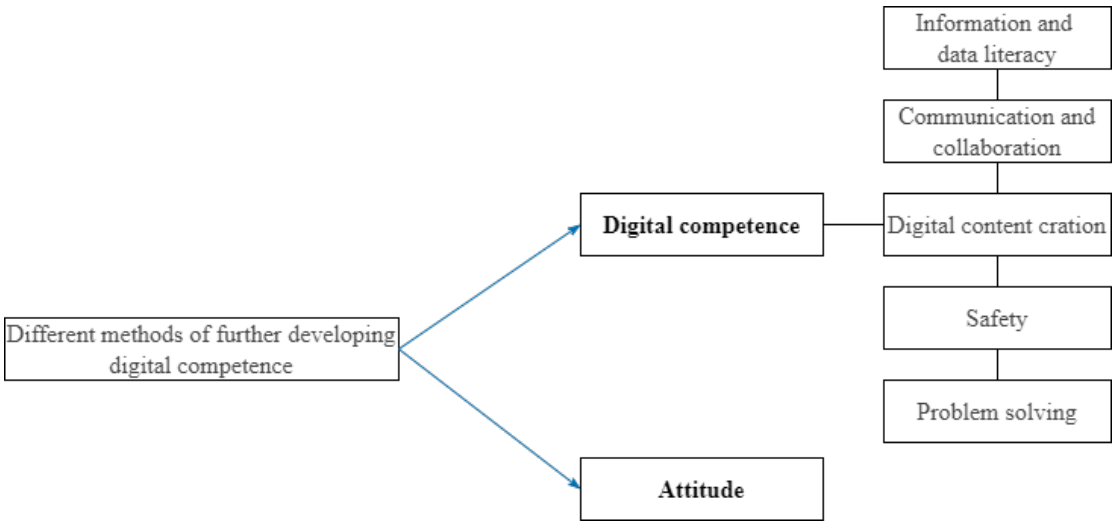
University students' digital competence and attitudes, divided by the training received in digital competence and ICTs



Finally, the differences between methods for enhancing digital competence on students' digital competence and ICTs attitudes were investigated (Figure 31).

Figure 31

Flowchart of the inferential analyses based on students' different methods of further developing digital competence

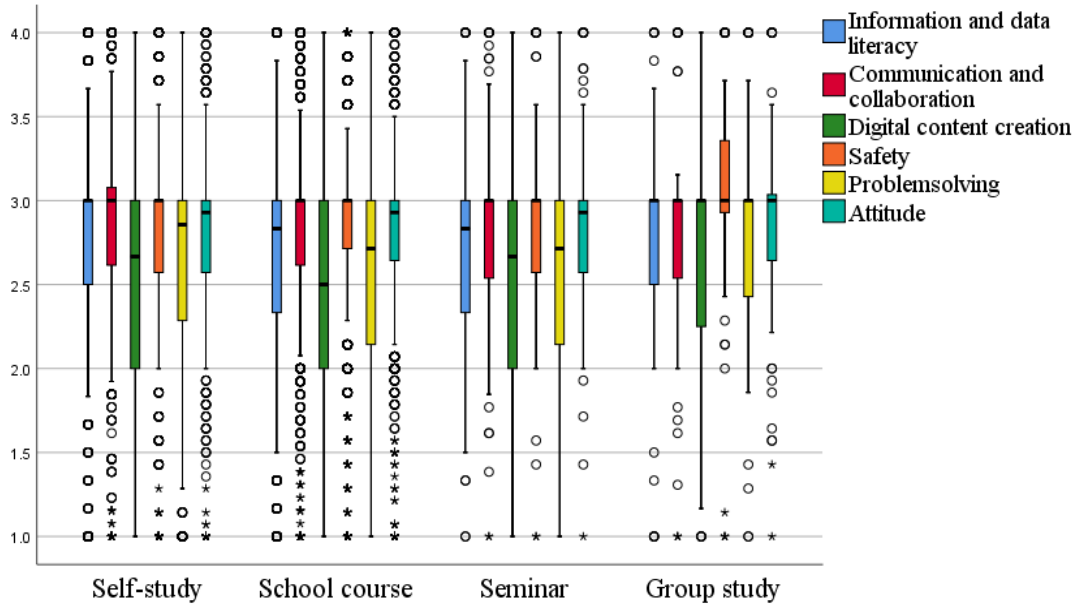


Concerning the influence of the different methods to further developing digital competence, which was one of the original contributions of the thesis, a Kruskal-Wallis test was used. There were statistically significant differences in the information and data literacy (KS p-value=0.000), communication and collaboration (KS p-value=0.010), digital content creation (KS p-value=0.000) and problem-solving dimensions (KS p-value=0.000) of digital competence when students used different methods to make further development of their digital competence. In contrast, no significant differences were found when considering different approaches to developing digital competence in terms of safety (KS p-value=0.096) and students' attitudes towards ICTs (KS p-value=0.108).

Students who studied in groups and learned by themselves with collaborative learning and independent learning rated themselves better in the area of information and data literacy than those who went to school courses and seminars. In terms of communication and collaboration, students who studied on their own believed themselves higher level than those who attended school courses, participated in seminars and learned by group study. Considering students' digital content creation, it was found that students who improved their digital competence in groups believed themselves to be better than those who studied on their own, which showed also more capable than students who attended seminars and school courses. In relation to the area of problem solving, students who further developed their digital competence through group study considered themselves a higher level in solving problems than those students who did self-learning, went to seminars and attended to school classes (Figure 32).

Figure 32

University students' digital competence and attitudes, divided by students' different methods of further developing digital competence



4.7 Conclusions

This study was conducted to understand the availability of technological resources, the potential for developing digital competence and related training among school students at Gansu Agricultural University in the west of China. It aimed to capture the level of students' digital competence and attitudes towards ICTs in one part of the less developed regions of China, and to provide the impact of gender, grade, residential area, prior training and methods of improving digital competence on these variables. The results generated from these inferential analyses are intended to help establish the basis for planning and to provide action strategies to improve digital competence.

Firstly, almost all students were connected to the Internet, mostly using mobile phones and laptops in the dormitories. Meanwhile, the devices provided at school were mainly desktop computers. Students were mainly connected mainly by mobile phones, and students often used the Internet for entertainment, study, and work activities. As far as training in digital competence and ICTs is concerned, more than half of the students had not had any formal training in this area beforehand, and those who wanted to improve their digital competence mainly chose to attend school courses or studied on their own. Most of them had experience in participating in virtual classes. The

majority of students had not yet taken or passed the computer level examinations offered by the state.

In terms of students' digital competence, students perceived themselves positive in areas of information and data literacy, communication and collaboration, safety and problem solving. At the same time, students proved to be less knowledgeable in the digital content creation. As for attitudes towards ICTs, the majority of responses we received were positive.

Moreover, the results generated by the inferential analysis of this study identified the persistence of a gender gap in certain areas of students' digital competence, the grade-level gap, and differences between urban and rural areas were also confirmed. The positive impact and importance of digital competence and ICTs training on students' digital competence and attitudes was pointed out; the inferential analysis of the different methods used in developing digital competence showed the need to focus on independent and collaborative learning when developing students' digital competence in the future.

| Chapter 5 |

Conclusions, limitations and prospective

The results have been discussed in the previous chapters and in the articles corresponding to each study. In this chapter, the most important contributions and educational implications of this doctoral thesis will be summarized. Limitations encountered in the conduct of these investigations and orientations offered for future research will be presented in this part as well.

5.1 Contributions and implications

The aim of this doctoral research is to explore the status of teachers' and students' digital competence in the west of China by identifying their digital competence and determining the influencing factors of digital competence, using Gansu Agricultural university as an example. The results obtained can be used in later projects, to reveal teachers and students' digital competence status in the less developed western regions of China, and can help develop appropriate training programs and educational strategies as needed.

This section will interpret the main results obtained and focus on the contributions resulting from the empirical study of this research, which is divided into two parts, teachers and students, in the order of the research questions posed.

5.1.1 contributions for teachers

The following research questions were identified to guide the empirical study with regard to teachers:

RQ1: What is the teachers' digital competence at Gansu Agricultural University to determine their needs?

RQ2: What is teachers' proficiency and frequency in the use of ICTs?

RQ3: What are teachers' attitudes towards the use of ICTs in education?

RQ4: What factors could influence university teachers' digital competence, the use of ICTs and their attitudes towards ICTs in education?

First, of the five areas of digital competence, teachers considered themselves as being good at information and data literacy, communication and collaboration, safety and problem solving. Teachers' responses on digital content creation were lower than in the other dimensions and they were less confident in creating digital content.

In this sense, the development and training needs in the area of digital content creation have been identified. Previously designed training for teachers may have concentrated on theoretical knowledge, with less consideration given to digital content development and related practices.

Second, most teachers were aware of the need to use ICTs through their personal experience or knowledge, and many others were encouraged by their academic experience. Most teachers were good at using commonly available communication,

information search and office software. The use of these tools was correspondingly high, as well as with content creation tools.

This suggests that if teachers are to become familiar and skilled in the use of ICTs, they need to have appropriate application purposes and application scenarios. This reality will inform our future training priorities. Moreover, teachers are indeed using some ICTs, yet the true pedagogical potential of ICTs has not yet been released (Guillén-Gámez et al., 2019; Tømte et al., 2015). These findings will inform our future training priorities; that is, facilitating communication, collaborative work, multimedia content production and pedagogical assistance tools need to be the main emphasis of teacher training in the use of ICTs. Content should be contextualized for teachers, integrating educational objectives and developing appropriate exercises and work scenarios to achieve the training goals and to make them effective.

Third, teachers' attitudes towards the use of ICTs in educational activities were quite positive. This indicates that teachers recognized the positive impact of ICTs on teaching and learning activities and were willing to use ICTs in their own teaching activities.

Fourth, the results obtained from the inferential analyses revealed the existence of a gender gap and a teaching experience gap. Gender-related differences were found, in which male teachers showed a higher digital competence than female teachers, as well as in the use of ICTs. No significant difference was found in the frequency of using ICTs and both male and female teachers had a positive attitude towards the use of ICTs. In terms of teachers' teaching experience, the lesser the years of teaching experience, the higher level of the digital competence areas such as in the areas of communication and collaboration, digital content creation, safety and problem solving, as well as in the use of ICTs, their frequency and teachers' attitudes towards using ICTs in educational activities.

Based on these results, the teacher training program needs to be rethought, with specific training content tailored to specific target groups, taking into account the variables analyzed (Cabero-Almenara, et al., 2022; Roussinos & Jimoyiannis, 2019). Teacher training projects or programs should be designed and developed with the aim of equal opportunities for both men and women, bridging the digital gender gap that already exists, and providing special digital competence generalization and assistance with ICTs use for teachers with long teaching experience.

Moreover, the importance and significance of the training related to digital competence and the use of ICTs have been affirmed. Since not all the teachers had been trained in digital competence and the use of ICTs before. Those teachers who had received previous training showed higher digital competence, better use of ICTs, more frequent use of those ICTs and had more positive attitudes towards the use of ICTs in educational activities.

Many research studies in different educational contexts have confirmed the scarcity of teachers' digital competence (Domingo-Coscolla et al., 2020; Valdivieso

Guerrero & Gonzáles Galán, 2016). Combined with the findings of this study, the need to arrange relevant training for teachers was identified. Educational institutions need to strengthen ongoing teacher training as well as improve initial teacher training to encourage digital teaching competence (Garzon Artacho et al., 2020).

Last but not least, the outcomes based on the impact of different approaches to improving teachers' digital competence on their digital competence, use of ICTs, frequency of use and attitudes indicated the effectiveness of systematic training. It is indicated that in general, teachers who participated in traditional and online class demonstrated higher levels in the areas of communication and collaboration, digital content creation, problem solving of digital competence and the frequency of using ICTs. Teachers who attended seminars considered themselves better at communication and collaboration in digital competence, as did teachers who participated in traditional and online courses.

On the one hand, traditional and online courses both have a systematic framework for learning and both require a lot of work. Moreover, in both environments, it is important to give and receive feedback. On the other hand, seminars can provide an opportunity to interact with experts in a particular field, where relevant topics on a particular subject can be discussed. Those who participate in seminars often learn about the latest information and new skills relevant to the topic. With all this in mind, when it comes to designing training and programs to enhance teachers' digital competence and ICTs use, the first step is to figure out whom to train and what the training needs are. It is therefore recommended to follow a systematic framework, create scenarios and connections that are relevant to the teachers' work, receive feedback from participants during the training, and schedule seminars based on specific needs to facilitate communication between experts and participants.

5.1.2 contributions for students

The interpretation and contribution of the results will be presented in the order of the research questions posed, which led to the empirical study of university students:

RQ1: How is the availability of technical resources for students, their potential for developing digital competence and their past training related to ICTs and digital competence?

RQ2: What is the first- and fourth-year students' digital competence at Gansu Agricultural University to determine their needs?

RQ3: What are students' attitudes towards ICTs?

RQ4: What factors could influence university students' digital competence, and their attitudes towards ICTs?

First, results on the availability of technological resources to students showed that the devices owned by students were mainly mobile phones and laptops. Although the majority of students were able to connect to the Internet on campus, the coverage

level was not yet one hundred percent. The devices provided by the faculty were mainly desktop computers and laptops.

These results indicated the need not only to improve the coverage of campus network, but also to add other types of devices to those that the faculty could provide. Due to the unexpected outbreak of the pandemics, the type of devices owned by students needs to be taken into account for compatibility with course content when having educational activities online. Moreover, if digital resources are to be provided, or university students' digital competence is to be developed, these goals need to be arranged on the basis and characteristics of the devices they have available.

With respect to university students' potential for digital competence development, more than half of the students connected to the Internet many times a day. The majority of them got used to connecting to the Internet through their mobile phones. Students used ICTs primarily for entertainment and to complete tasks for study and work.

The pathway for the development of university students' digital competence should take into account the Internet connection, connectivity and use preferences of the students, with exercises and training that can be tailored to the characteristics of smartphones, using content that is both entertaining and that has a learning purpose. At the same time, it is essential to popularize and promote the use of other ICTs, so that the different tools can be selected according to the objectives of the tasks that students have to complete, rather than having to singularly choose only one device.

As was mentioned in the previous chapter, students were asked several questions about ICT and digital competence related training. It is clear that more than half of the students had no previous training in this area. Many of them further developed their digital competence by attending school courses. Although the majority of them had experience of participating in virtual classes, most of them had not taken or passed the NCER exam, which measures the level of computer use.

It is confirmed that ICTs and digital competency-related training for university students at Gansu Agricultural University is insufficient. If students wished to further improve their digital competence, they would still seek to attend relevant courses at school, which reinforces the requirement for universities to conduct relevant training or to carry out related programs. Moreover, university students are encouraged to take the NCRE exam, which will help them in their future studies and work experience. Universities ought to launch relevant training courses or seminars to help students to obtain this exam certificate.

Second, as for students' digital competence, most students had positive considerations of their digital competence in terms of information and data literacy, communication and collaboration, and safety. They showed lower level in terms of solving problems. And the results pointed out that students' digital content creation were the lowest among these five areas.

Most of the students who participated in this research study are "digital natives" as defined by Prensky (2007, 2009). It is one of the common discussions to explore

whether their digital competence matches their true digital native identity. As mentioned by Sánchez-Caballé et al. (2020), using digital tools does not automatically empower someone with digital competence. It can be concluded that there is still room for improvement in terms of students' abilities to integrate previous knowledge and content, create and edit new content, generate creative expression, media output and programming, as well as in their abilities to solve several problems encountered when using and interacting with technology. University students at the research site in the west of China had basic or intermediate skills related to adapting to social development and technological penetration, but their perception of digital competence decreased when the complexity of the task increased.

Third, in terms of students' attitudes towards ICTs, they were generally positive. Most students showed their interest in ICTs and were aware of its role in their studies. It is worth noting that although more than half of the students believed that using ICTs was easy, that the theoretical training received in the use of ICTs was adequate and that access to technological resources was easy, there were still almost 40% of students who expressed a different view in comparison, which will require our attention in the future. It reiterated the training needs of students and the need to improve the availability of digital and technological resources.

Fourth, from the results of the inferential analysis, some differences were found in each of the five areas of digital competence or attitudes toward ICTs, depending on the variables analyzed, such as gender, grade level, area of residence, past training related to digital competence and the use of ICTs, and methods of further developing digital competence.

According to the results obtained, the existing gender gap was demonstrated, with male students thinking themselves to be more digitally competent than female students in the areas of information and data literacy, digital content creation, problem solving, and their attitudes towards ICTs. Grade level differences were also observed, with fourth year students being higher in areas of information and data literacy, communication and collaboration, digital content creation, problem solving, and their attitudes towards ICTs than students just entering college. Gaps between residential areas were identified in all five areas of digital competence and student attitudes as well, with students from urban areas having higher level and attitudes than those from rural areas.

Aspects of digital competence that need to be improved have been pointed out in the results of the descriptive analysis. Exploring differences clarified the enhancement needs of different student groups that can help teachers and universities to establish effective educational strategies and guidelines. The results of the inferential analysis regarding the area of residence can provide reference data that demonstrates the importance of advancing digital capabilities in rural areas, contributing to the overall effort to promote educational equity. To a certain extent, these findings underline the importance of vigorously promoting education informatization strategies in the west of China.

Moreover, implications of the training were illustrated by the results of exploring the impact of past ICT and digital competency-related training, which showed that students who had received past training related to digital competence and ICTs use showed higher digital competence and more positive attitudes than students who had not received the training before.

The urgent necessity to launch training programs for students on how to use ICTs and develop their digital competence is stated. Meanwhile, the priority should be given to the related introductory training programs even before students' campus life.

Furthermore, in relation to the methods for further development of digital competence, differences in digital competence and attitudes towards ICTs among university students were studied. Students who studied on their own and in groups considered themselves to be better at information and data literacy, digital content creation, and problem solving in digital competence; students who studied on their own and attended school courses showed higher level of communication and collaboration in digital competence; students who studied in groups with collaborative learning and participated in school courses demonstrated more capable in terms of safety; and students who studied in groups and went to seminars had more positive attitudes toward ICTs than others.

In contrast to the results obtained from teachers, there was an emphasis on collaborative and autonomous learning for students. A systematic curriculum is recommended when the purpose of the training is to promote student communication and collaboration and digital safety for safe and responsible use of the Internet.

To conclude, apart from meeting the objectives set at the beginning of the study, it is worth noting that the studies conducted during this PhD thesis have made progress on three of the five areas of interest identified in the second chapter.

5.2 Limitations

These studies were not without limitations. Certain limitations were encountered throughout the research process and these should be kept in mind for future studies.

First, the sample size and the sample diversity. Samples in these studies were from the same university, which may limit the generalizability of the results. Although teachers were from different faculties of the same university, it is recommended that the sample size be expanded and that teachers from different universities be investigated. The same considerations should also apply in a student-oriented study.

Second, the studies of both teachers and students were based on self-perception questionnaires where their digital profiles were self-presented rather than by measuring the true teachers and students' digital competence levels. Participants' self-reports could be subjective and their true level of digital competence may not be reflected.

Apart from the above-mentioned limitations related to the sampling type and the implementation of self-reports, the third limitation is that these studies only explored the influencing factors that brought differences in teachers' digital competence, ICTs use and attitudes towards ICTs use in educational activities, and pointed out variables that could influence students' digital competence and attitudes towards ICTs. It is suggested that future studies apply correlation and regression analysis to further identify and assess associations or relationships between variables.

5.3 Future research lines

After the implications and limitations of these studies have been pointed out, future research directions will be outlined in this section.

- To conduct interviews with teachers and students to further learn about the difficulties that they have encountered and the reasons for their reticence in developing digital competences and in using ICTs in education.
- To conduct a comparative analysis through samples from different regions within China. To identify further details of the differences in the development of digital competence and the use of ICTs by teachers and students in the east and west of China.
- To carry out a comparative analysis between a sample of Chinese teachers and students and a sample of teachers and students from the European Union to study in-depth the effects of cultural values. To explore the differences in the development of digital competence in different cultural contexts and to investigate whether the variable of cultural context has an impact on the development of digital competence in higher education.
- To design measurement tools that fit the Eastern educational system and can be used to investigate the level of digital competence of teachers and students separately.
- To design and validate an instrument or experiment that could contribute to determining the true level of teachers and students' digital competence.

| Chapter 6 |

Publications derived from the research work

University of Salamanca

The following publications have resulted from the development of this doctoral thesis:

- **Articles in JCR-indexed journals:**

Zhao, Y., Pinto-Llorente, A. M., & Sánchez-Gómez, M. C. (2021). Digital competence in higher education research: A systematic literature review. *Computers & Education, 168,* 104212. https://doi.org/10.1016/j.compedu.2021.104212

Zhao, Y., Pinto Llorente, A. M., Sánchez Gómez, M. C., & Zhao, L. (2021). The Impact of Gender and Years of Teaching Experience on College Teachers' Digital Competence: An Empirical Study on Teachers in Gansu Agricultural University. *Sustainability, 13*(8), 4163. https://doi.org/10.3390/su13084163

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| Chapter 7 |

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Appendix A.

Digital competence in higher education research: A systematic literature review.

Zhao, Y., Pinto-Llorente, A. M., & Sánchez-Gómez, M. C. (2021). Digital competence in higher education research: A systematic literature review. *Computers & Education, 168,* 104212. https://doi.org/10.1016/j.compedu.2021.104212

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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?

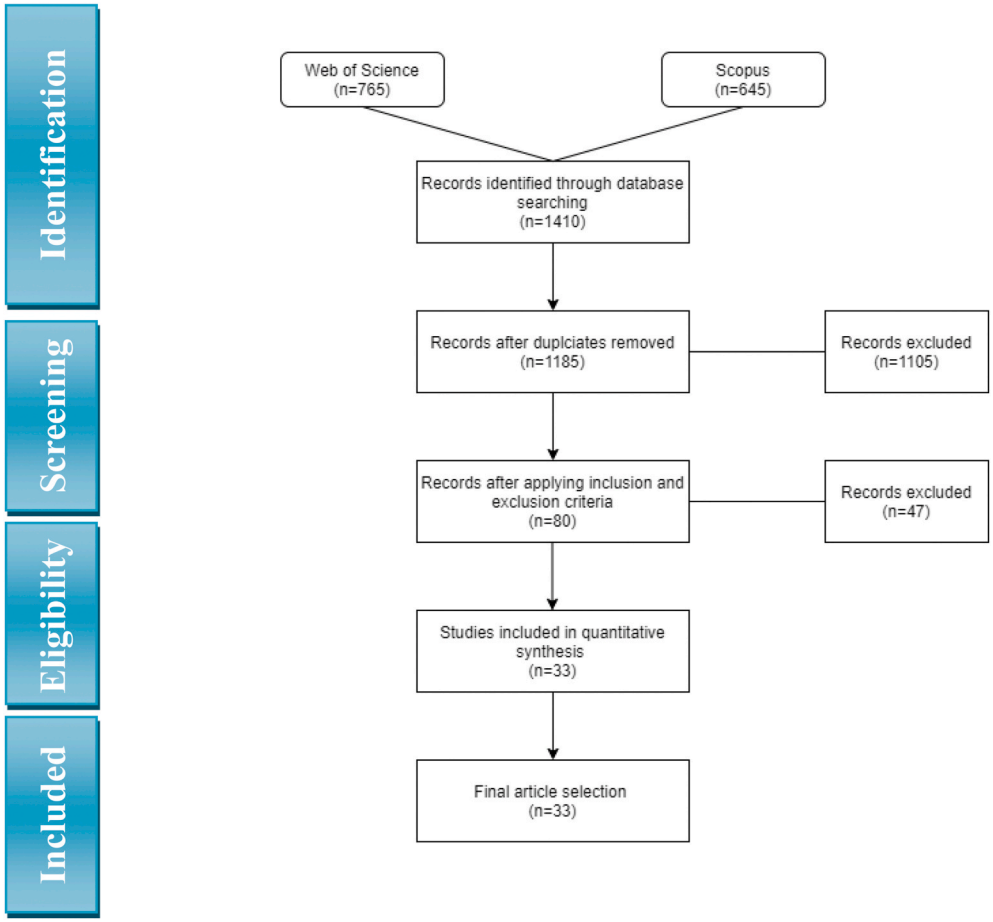

Fig. 1. PRISMA flow: data extraction procedure.

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 Lázaro-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

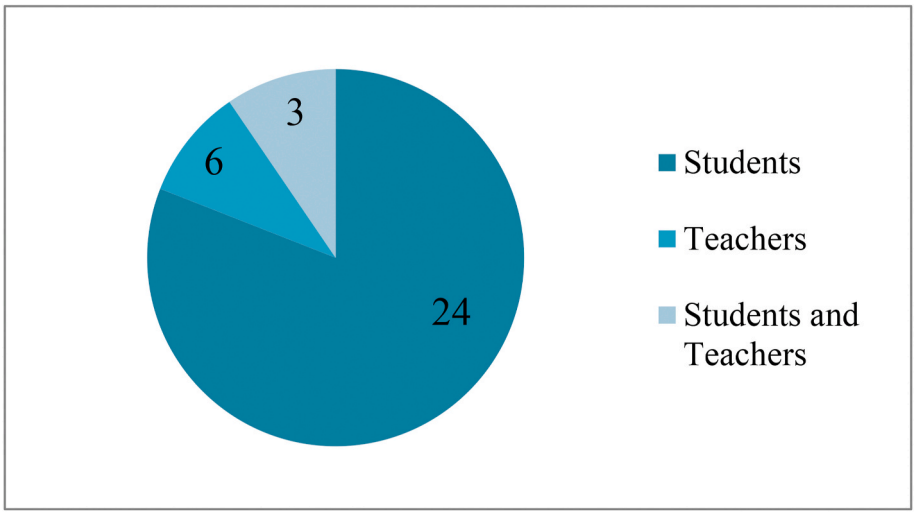

Fig. 2. Results of the category of participants.

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 combing 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

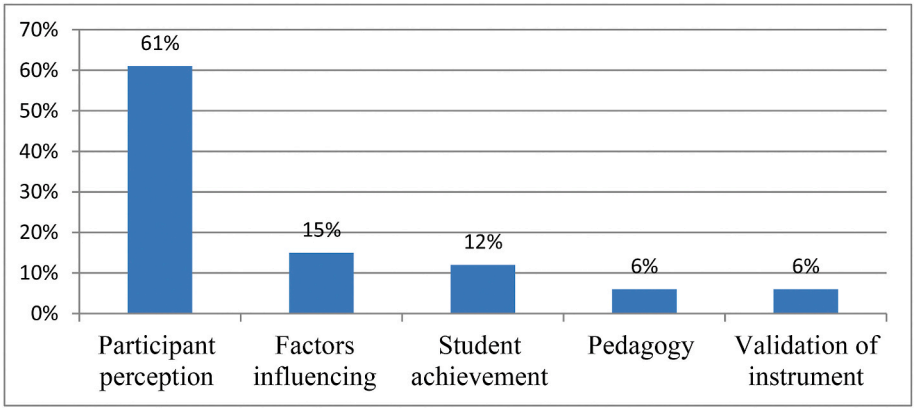

Fig. 3. Results of the category of the research purposes.

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, Cañón, 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 (PLSE-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 (Ryhtä 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-Gáme, 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.
Guillen-Gamez, 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.
Martzoukou 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 vadality (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; Ryhtä 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
		Use of varies applications; ability to complete the digital tasks; ability to fulfill the following Internet-related tasks; general computer knowledge.
Cabezas González et al. (2017)	Students	Identification; possession of the ICT devices; knowledge related to ICT; management of the digital tools; attitude to ICT.
Guzmán-Simón et al. (2017)	Students	Information literacy and ICT literacy.
García-Esteban (2017)	Students	Information and data Literacy; communication and collaboration; digital content creation; safety; problem solving.
He and Zhu (2017)	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.
Blayone et al. (2018)	Students	Socio-demographic and device-usage items; technical dimension, and communicational dimension, informational dimension and computational dimensions of use.
Byungura et al. (2018)	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.
Bond et al. (2018)	Teachers and Students	Teachers: The use and perceived usefulness of digital tools for teaching. Frequency of using the digital tools. Students: Frequency of use and perceived usefulness of digital tools and services.
Guillén-Gáme, Mayorga-Fernández & Álvarez-García (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.
He et al. (2018)	Students	Technological skills; cognitive skills and ethical knowledge.
Kim et al. (2018)	Students	Attitude toward digital technologies; Learning Agility; Prior Digital Experience with Family; Student Engagement; Personal effort to learn ICT; Perceived digital competence.
Madsen et al. (2018)	Teachers	Digital Competence; professional attitude; professional applications of tools.
Esteve-Mon et al. (2019)	Students	Informational literacy, technological literacy, multimedia literacy and communicative literacy.
Gallego Arrufat 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.
He and Li (2019)	Students	Digital competence: ISK, ASK, ASE; digital informal learning; Technology expectancy.
Kim et al. (2019)	Students	Academic engagement; E-learning adoption; E-learning attitude; Digital readiness; Academic achievement
López-Belmonte et al. (2019)	Teachers	Social; Navigation, search and filtering; Evaluation; Storage and recovery; Massive data processing.
McGuinness and Fulton (2019)	students	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.
Cabero-Almenara et al. (2020)	Teachers	Professional engagement; digital resources; teaching and learning; assessment; empowering learners; facilitating learners' digital competence.
Guillén-Gámez and Mayorga-Fernández (2020a)	Students and teachers	Attitude; knowledge; the use of digital technologies.
Guillén-Gámez and Mayorga-Fernández (2020b)	Teachers	knowledge and use in 2.0 tools for teaching, evaluation and research.
Guillen-Gamez et al. (2020).	Students	Attitude; knowledge; the use of digital technologies.
Grande-de-Prado, Cañó, García-Martín & Cantón (2020)	Students	Information and data Literacy; communication and collaboration; digital content creation; safety; problem solving.
Romero-Tena et al. (2020)	Students	Technological literacy; search and treatment of information; critical thinking; communication and collaboration; digital citizenship; creativity and innovation.
Llorent-Vaquero 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 Information; interpersonal competence in the use of ICTs in a university context.
Martzoukou et al. (2020)	Students	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.
Ortega-Sánchez et al. (2020)	Students	Teaching skills and future teachers' TDC; university teachers' TDC.
Romero-García et al. (2020)	Students	Technological literacy; search and treatment of information; critical thinking; communication and collaboration; digital citizenship; creativity and innovation.
Ryhtä et al. (2020)	Teachers	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.
Sales et al. (2020)	Teachers	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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Appendix B.

The Impact of Gender and Years of Teaching Experience on College Teachers' Digital Competence: An Empirical Study on Teachers in Gansu Agricultural University.

Zhao, Y., Pinto-Llorente, A. M., Sánchez-Gómez, M. C., & Zhao, L. (2021). The Impact of Gender and Years of Teaching Experience on College Teachers' Digital Competence: An Empirical Study on Teachers in Gansu Agricultural University. *Sustainability, 13*(8), 4163. https://doi.org/10.3390/su13084163

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Article

The Impact of Gender and Years of Teaching Experience on College Teachers' Digital Competence: An Empirical Study on Teachers in Gansu Agricultural University

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Abstract: With the development of Information and Communication Technologies (ICT) and the emergence of the Corona virus (COVID-19,) our way of life and even our education have been affected. The education approach has changed from traditional tutorials to online education. As a result, it has been a necessary for not only students but also teachers to improve their digital competence. The aim of this study was to describe in-service teachers' self-perceptions of digital competence in the context of higher education and analyze the impact of gender and years of teaching experience on college teachers' digital competence. For this purpose, a quantitative methodology has been used. A sample of 536 in-service teachers from Gansu Agricultural University, China, completed a questionnaire on digital competence. The data were collected in the academic year of 2019–2020. The results show that the sample considered themselves positively in information and data literacy, communication and collaboration, security and problem solving, while they self-evaluated their digital content creation negatively. Regarding the variables studied, significant differences were found in favor of male college teachers in the perception of digital competence. In relation to the teaching experience, teachers with less teaching experience thought themselves better in the areas of communication and collaboration, digital content creation, security and problem solving.

Keywords: digital competence; gender; years of teaching experience; higher education; China

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1. Introduction

Nowadays, we are in an information and knowledge society, which originated from profound changes in the construction of knowledge and learning, and is characterized by its complexity and its increasing globalization, and its use of Information and Communication Technologies (ICT) [1]. The rising pace of technological change and the characteristics of ICT itself have led to important and significant changes in many areas, and the use of ICT continues to grow in the field of education.

The integration of emerging technologies into the educational environment and daily life has promised a boom of digital media and e-learning environments in which educational resources with open access and learning objects express their optimal educational potential [2]. Some of the features of the tremendous transformative potential offered by these technologies are the possibility to store and rapidly transmit information, the disappearance of space and time barriers and the use of multiple media formats. Within this technological context, it is crucial to be able to operate successfully in the digital domain or to develop digital related competence [3].

Moreover, since the whole world is suffering from the COVID-19 pandemic, many institutions and organizations are changing the way they teach and seek to provide a convenient, safe and flexible educational environment for their students. The COVID-19 crisis has indeed brought different changes and tensions to the education system, and a

fast and strong transition has been brought to distance training with technical support [3]. In such a context, the weak points of teacher training have emerged. Teachers perceived a higher workload during the lockdown along with negative emotions because of their shortcomings in digital competence-related formation [4]. Teachers, as an indispensable role in educational activities, should improve their digital competence accordingly. In addition to upgrading their teaching content, they should also attach great importance to tailoring their teaching methods to meet these new challenges; they need to enhance their abilities to adapt to the current situation and to improve the quality of education [5,6].

Over the past several years, several studies have analyzed digital competence level in the field of education in different contexts [7–10]. Some studies have focused on factors that could influence digital competence [11–14]. Other studies have explored the pedagogical approaches involved in digital competence [15,16]. Many of the studies have been conducted with students; to accompany young learners in the development of competence, to guarantee optimal implementation of technological tools and to promote improvements in the quality of education, it is necessary that teachers are, in turn, capable.

Our study focused on the level of digital competence of university in-service teachers as well as the impact of variables such as gender and teaching experience upon digital competence. The goals of our study are:

1. To describe in-service teachers' self-perceptions of digital competence in the context of higher education.
2. To analyze whether their self-perception of digital competence varies with variables like gender and age.

2. Theoretical Framework: Digital Competence

With the advancement of technology, the ability to deal with technological tools in everyday life is in the spotlight, especially with the outbreak of the COVID-19 pandemic and its huge impact on the educational industry, and digital competence has become today's hot topic.

The concept of digital competence has been frequently addressed and raised by scholars and policy-related discussions. It has been identified as one of the eight key life skills in the recommendation on key competences for lifelong learning that is proposed by European Commission, understood as follows [17]:

> " . . . 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, participation, learning, socializing, consuming and empowerment" [18] (p. 30).

Digital competence takes the form of cognitive, attitudinal, and technical skills that help to mitigate and solve numerous problems and challenges in the knowledge society [19]. Moreover, digital competence includes issues related to technology, information, multimedia, and communication that encourage critical, responsible, and creative use of technology, which are essential to the learning process and participation in the 21st century [9].

After the European Commission considered digital competence as one of the eight key life skills, they developed DigComp (European Digital Competence Framework) as a reference framework to explain the meaning of "digital competence", and there are updated versions of DigComp according to the development of society. The report known as DigComp 2.0 presented an updated list of 21 capabilities from five competence areas (Table 1): (1) information and data literacy; (2) communication and collaboration; (3) digital content creation; (4) safety; and (5) problem solving [20–22]. In 2017, this framework was updated into DigComp 2.1, in which eight capability levels and examples of use can be found [20]. With these categories, specific sub-competencies can be assessed at different

levels of proficiency and it can help set learning goals, identify training opportunities and facilitate job searches.

Table 1. The digital competence framework for citizens [20].

1. Information and data literacy	1.1 Browsing, searching, filtering data, information and digital content 1.2 Evaluating data, information and digital content 1.3 Managing data, information and digital content
2. Communication and collaboration	2.1 Interacting through digital technologies 2.2 Sharing through digital technologies 2.3 Engaging in citizenship through digital technologies 2.4 Collaborating through digital technologies 2.5 Netiquette 2.6 Managing digital identity
3. Digital content creation	3.1 Developing digital content 3.2 Integrating and re-elaborating digital content 3.3 Copyright and licenses 3.4 Programming
4. Safety	4.1 Protecting devices 4.2 Protecting personal data and privacy 4.3 Protecting health and well-being 4.4 Protecting the environment
5. Problem solving	5.1 Solving technical problems 5.2 Identifying needs and technological responses 5.3 Creatively using digital technologies 5.4 Identifying digital competence gaps

The basis for effective teaching and learning with ICT comes from the interaction between content, pedagogy and technical knowledge (T-PACK) [23]. Considering teachers as the principal dominant performers in the digital learning environment, teachers' digital competence can be understood as "the use of ICT with a good pedagogical-didactic ICT understanding and to be aware of how this might impact the learning strategies and educational formation of pupils" [24] (p. 68).

In 2017, the Joint Research Centre (JRC) published the European Digital Competence Framework for Educators: DigCompEdu. In the DigCompEdu project, digital competence is considered as the ability of users to make safe, critical and creative use of ICT to satisfy different objectives [25]. It established a model of digital competence for trainers [26]. Additionally, Redecker [27] 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 [28]. Teacher Digital Competence (TDC) was presented following the main skills of digital competence and it can be defined as the set of knowledge, skills and attitudes needed to be functional in a digital teaching environment [29].

Moreover, the Spanish National Institute for Educational Technology and Teacher Training (INTEF), in collaboration with other institutions, has developed and expanded an educational initiative since 2012 and launched a document called the Common Digital Competency Framework for Teachers (CDCFT), which provides a descriptive reference for relevant educational institutions, sectors and educators that can be used for training purposes, assessment, certification and accreditation processes; adapted from DigComp and DigCompEdu, the framework is highly comprehensive and is also divided into five competence areas (information and data literacy, communication and collaboration, digital content creation, safety and problem solving) including 21 competences. These are competences that teachers need to develop for improved educational practice and continuous professional development in the 21st century, and a new revised version was launched in 2017 [30].

The policies and documents launched by countries show the importance of technology and digital-related capabilities. In China, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council [31] and the Chinese Ministry of Education [32] have released several plans and blue papers on digitization and informatization, covering the economy, education and other industries, considering digital competence as a part of the lifelong learning process [33]. China is one of the largest technology and knowledge exporting countries among the eastern countries, and it has a large population. However, compared with developed countries, the development of digital competence in China and China's education informatization is still at an initial step and it is still in the process of exploring the establishment of China's digital competence framework; meanwhile, there has been a comprehensive evaluation system in the European countries. People's digital ability in China is uneven, which is highlighted as the international information gap and the domestic information gap. The domestic information gap is also reflected between regions and groups of people [34]. As an underdeveloped region in China, the differences are more obvious in western China. In the 13th Five-Year Plan of Education Informatization, it is emphasized that the evaluation index system and assessment methods for regions, schools, curricula, resources, educators and students' informatization level should be developed, which provides the development direction and policy basis for the introduction of China's digital literacy framework [35].

3. Materials and Methods

The purpose of this study is to describe in-service teachers' self-perceptions of digital competence in the context of higher education and analyze the impact of gender and age on their self-perception of digital competence. With established research goals, this study used a quantitative non-experimental, descriptive and inferential methodology [36]. The data were collected through an online questionnaire.

3.1. Sample

The collection of data was targeted at all of the teachers who were working at Gansu Agricultural University, which is located in the western part of China.

The final sample of this study consisted of 536 in-service teachers from 22 faculties of Gansu Agricultural University in China, which was a representative sample. A total of 61.2% (n = 328) of the sample were female and 38.8% (n = 208) were male, ranging in age from 23 to 68.

3.2. Instrument Used to Collect Information

The survey instrument used in this study was adapted from a seminal questionnaire designed for teaching staff in higher education by Taquez, Rengifo and Mejía [37] and a tool for self-diagnosis of digital competences from López [38]. The questionnaire was originally written in Spanish and was translated into Chinese for the research participants. A draft was made including all the items considered necessary to carry out the research. The validity of the instrument was analyzed from two perspectives: content validity, through rational analysis by a panel of judges, and empirical validity, through an exploratory factorial analysis. With the collaboration of experts in the field of research methodology and education, the characteristics and external validity were checked. To finish this phase, the contributions of the experts were analyzed and changes were made to the instrument. We measured the Cronbach's alpha to know the internal consistency of the surveys. The questionnaire had an internal consistency of α = 0.974. The alpha coefficient of this survey suggested that the items had relatively high internal consistency.

This questionnaire included 56 items and was divided into four sections (Table 2): Identification (data to identify the respondents), teachers' self-perception in digital competence, the use of ICT tools, and the teachers' attitude and opinion concerning using ICT tools in the teaching process. The items are made up of closed-ended, multiple choice, open-ended and Likert-type ordinal scale questions.

Table 2. Sections of the questionnaire. ICT: Information and Communication Technologies.

Identification	Age; gender; teaching experience; faculty; mentor situation; number of classes you teach; type of classes you teach; type of training about ICT, how digital competence training was acquired and motivation for using ICT tools.
Teachers' self-perception in digital competence	Information and data literacy; communication and collaboration; digital content creation; safety and problem solving.
Use of ICT tools	Use of ICT tools, frequency of using ICT tools.
Attitude	Attitude in using ICT tools in the teaching process.

3.3. Procedure of Data Collection and Analysis

The questionnaires were prepared using Qualtrics and were shared with the in-service teachers through QR codes and links. The anonymity of the data was ensured. The data were collected in the academic year 2019–2020 in Gansu Agricultural University in China.

The statistical analysis of the data was performed with Statistical Package for the Social Sciences (SPSS v.22) software. We performed a univariate descriptive analysis, calculating the mean and the standard deviation. Data were also processed by inferential analysis. Once the parametric assumptions of normality and homoscedasticity had been checked, we chose to use the non-parametric Mann–Whitney U test for the dual variable of gender and the non-parametric Kruskal–Wallis test for the variable of teaching experience.

4. Results

Due to the volume of data obtained in the complete study, this paper only presents data from the second section: Self-perception of teachers' digital competence.

In this section of our paper, we present the results obtained with the descriptive analysis of data, and the results obtained with the inferential analysis. These results focus on the teachers' self-perception in terms of their digital competence.

4.1. Descriptive Analysis

The following are the results obtained from the teachers when answering the second section of the questionnaire; composed of 28 items, it evaluates the respondent's perception of digital competence, and is divided into the following competence areas: information and data literacy (four items), communication (10 items), content creation (five items), security (five items) and problem solving (four items). Participants responded, as explained above, in a Likert-type rating scale from 1 to 4 trying to avoid deviations.

Table 3 shows the descriptive statistical results of the teachers' self-perception in digital competence in terms of information and data literacy.

Table 3. Descriptive statistical results regarding teachers' self-perception of digital competence in information and data literacy.

Information and Data Literacy	Mean	SD	Very Bad	Bad	Good	Very Good
I find interesting sources of information for the teaching.	2.88	0.634	3.0	17.9	67.4	11.8
I am aware of the restrictions of published copyrighted educational resources.	3.05	0.665	2.1	13.6	61.8	22.6
I evaluate the quality of the online educational resources for accuracy and consistency with the curriculum.	2.88	0.649	3.0	19.2	57.1	20.7
I use social media to organize resources for teaching purposes.	2.96	0.719	3.0	16.8	65.5	14.7

Teachers perceived themselves to be good at handling information and data literacy. Most of them rated themselves as good in finding sources of information (67.4%, n = 361). When they were asked about copyright, evaluation of resource quality and the use of social media to organize resources in accordance to their teaching purpose, more than half of them considered themselves as good (61.8% n = 331, 57.1% n = 305, and 65.5% n = 351, respectively).

With regard to teachers' self-perception in digital competence in communication (Table 4), more than 50 percent believed that they were good at interacting, sharing and collaborating through digital technologies as the means were all over 2.5. When teachers were asked whether they communicated with their students through digital means, 65.5% (n = 349) considered they did a good job, and 14.7% (n = 9) rated themselves as very good. Similar results were obtained when they assessed their content and educational resources selection: 62.3% (n = 334) thought they were good at it, while 20.5% (n = 110) believed they were very good in selecting content and educational resources found in different social media and virtual communities.

Table 4. Descriptive statistical results about teachers' self-perception of digital competence in communication and collaboration.

Communication and Collaboration	Mean	SD	Very Bad	Bad	Good	Very Good
I create digital work environments to communicate with my students.	2.92	0.655	3.0	16.8	65.5	14.7
I organize interaction activities through digital tools and share these activities with information accompanied by images, links and videos.	3.00	0.670	1.5	17.9	59.7	20.9
I select educational contents and resources that are found in different social media and virtual communities.	3.02	0.641	1.1	16.0	62.3	20.5
I identify digital services according to their educational usefulness.	2.86	0.683	2.6	23.5	59.3	14.6
I participate in virtual communities and social networks actively for the purpose of updating and achieving professional development.	2.72	0.736	4.7	30.8	52.2	12.3

Regarding teachers' self-perception in terms of digital competence in digital content creation, the results obtained (Table 5) show that teachers were less confident in creating digital content. When they were asked about whether they could recreate digital content and license it properly, 46.8% (n = 251) of them thought they were good and 9.5% (n = 51) rated themselves as excellent. Of the 536 teachers, 255 (47.6%) stated that they knew well the regulations applicable to the online use of educational materials while 6.7 % (n = 36) thought they were very good. Additionally, less than half of teachers thought they were good at creating websites for students (33.0%, n = 177), reusing digital content from virtual communities (39%, n = 209) and modifying the advanced functions of digital tools in relation to the needs of teachers' work (41.2%, n = 221).

In relation to teachers' self-perception in terms of digital competence in security (Table 6), the majority of the participants self-assessed their level between good (69.6%, n = 373) and very good (16.2%, n = 87). Similar results were obtained when teachers were asked if they could maintain an active attitude in the management and protection of digital identity, where 61.2% (n = 328) considered they were good and 6.2% (n = 33) very good. In the case of private data and the prevention of social and psychological conflict situations in the use of digital tools, the main results were between good (59.7% n = 320, 58.8% n = 315) and very good (14.9% n = 80, 10.1% n = 54). The data analysis also led to results that showed that teachers self-assessed themselves as good at updating and protecting their devices (49.4%, n = 264).

Table 5. Descriptive statistical results about teachers' self-perception of digital competence in digital content creation.

Digital Content Creation	Mean	SD	Very Bad	Bad	Good	Very Good
I create websites where multimedia educational contents adapted to the learning needs of students are published.	2.23	0.807	19.2	43.3	33.0	4.5
I rework digital sources and turn them into new and creative digital content, and I can license them appropriately.	2.58	0.767	7.6	36.0	46.8	9.5
I reuse the digital content of virtual teaching communities creatively.	2.41	0.761	10.4	44.2	39.0	6.3
I know the regulations that apply to the use of online educational materials and I know how to license my own digital production.	2.50	0.781	11.2	34.5	47.6	6.7
I tailor the advanced features of digital media to students' personal learning styles and interests.	2.49	0.799	10.3	39.4	41.2	9.1

Table 6. Descriptive statistical results about teachers' self-perception of digital competence in security.

Security	Mean	SD	Very Bad	Bad	Good	Very Good
I update and protect my devices frequently.	2.65	0.757	6.3	33.4	49.4	10.8
I know how my private data are collected and used.	2.87	0.682	2.6	22.8	59.7	14.9
I maintain an active attitude in managing and protecting my own digital identity and that of my students.	2.90	0.701	3.7	18.8	61.2	6.2
I know and I can apply prevention protocols for social and psychological conflict situations in the use of digital media.	2.74	0.704	5.0	26.1	58.8	10.1
I know the positive and negative effects of the use of technology on the environment.	3.00	0.601	1.9	12.3	69.6	16.2

In-service teachers were asked about their self-perception in terms of problem solving (Table 7). Regarding resolving simple technical problems, more than 50 percent thought they were good (63.1% n = 338). Similar results were obtained when teachers were asked whether they could choose the right tools to accomplish tasks evaluating different digital environments, as 56.5% (n = 303) thought they were good, and 8.0% (n = 43) very good. Moreover, the majority of these teachers considered they were good in using various technologies to analyze their everyday job needs (55.8% n = 299), and in using emerging digital technologies to fill gaps in teaching and professional development (57.5%, n = 308).

Table 7. Descriptive statistical results about teachers' self-perception of digital competence in problem solving.

Problem Solving	Mean	SD	Very Bad	Bad	Good	Very Good
I can solve non-complex technical problems with the help of a manual or available technical information.	2.82	0.667	3.5	22.0	63.1	11.4
I can critically evaluate the different possibilities that digital environments, digital tools and digital services could provide to solve teaching work related tasks.	2.68	0.676	3.9	32.1	56.0	8.0
I can use technologies to analyze my daily work needs and manage innovative solutions.	2.68	0.680	4.1	22.1	55.8	8.0
I try to use emerging digital technologies to help me keep up with the times and to fill possible gaps in the digital competence that I need for my teaching and professional development.	2.72	0.683	3.9	29.3	57.5	9.3

4.2. Inferential Analysis

In this section, the results of the comparison of mean values according to the variables of gender and teaching experience are presented, and the significant differences found in this inferential analysis will be discussed in a detailed way.

4.2.1. Gender

According to the Mann–Whitney U test (Table 8), the results showed significant differences in five dimensions in teachers' self-perception in digital competence ($p < 0.05$). Moreover, the results indicated that men always rated themselves higher than women in digital competence in information, communication, digital content creation, security and problem solving by comparing the mean of their selection results in different dimensions.

Table 8. Mann–Whitney U test with regard to the gender variable.

Dimensions	Gender						
	U	Z	P	Men		Women	
				Mean	SD	Mean	SD
Information	30,461.000	2.142	0.032	3.01	0.531	2.90	0.513
Communication	26,882.500	4.157	0.000	2.93	0.473	2.76	0.506
Creation	25,589.000	4.912	0.000	2.63	0.654	2.32	0.620
Security	23,794.500	6.007	0.000	3.00	0.547	2.72	0.554
Solve problem	23,627.500	6.146	0.000	2.91	0.531	2.61	0.584

4.2.2. Teaching Experience

Overall, among the 536 teachers, there were 26% (n = 13) who had a teaching experience of less than five years, 20% (n = 106) of them had five to nine years of teaching experience, 33% (n = 177) have worked 10 to 19 years as a teacher, 16% (n = 86) of them had a teaching experience of 20 to 29 years, and there were 5% (n = 29) who had been a teacher for more than 30 years.

In relation to teachers' perception of digital competence in information and data literacy, the results indicated that there were no obvious differences among teachers with different teaching experience (Figure 1, Table 8). However, teachers with five to nine years' teaching experience rated themselves as good (x = 3.03).

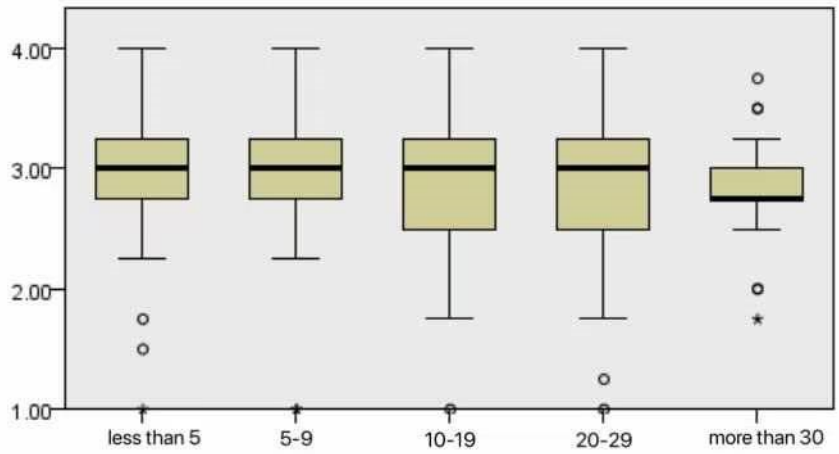

Figure 1. Mean values in information and data literacy divided by teaching experience.

With regard to communication and collaboration, teachers with less teaching experience considered themselves as more capable in communicating and collaborating (Figure 2, Table 8).

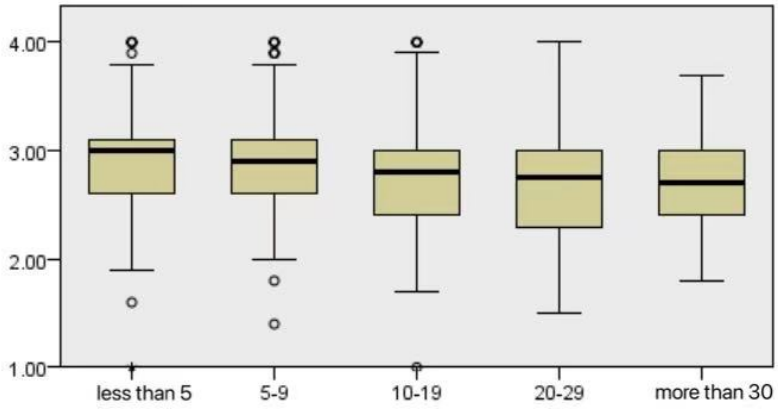

Figure 2. Mean values in communication and collaboration divided by teaching experience.

In relation to teachers' self perception in digital content creation, the scores were higher for teachers who had less than five years of teaching experience, while those with over 30 years' teaching experience thought they were not as good in creating digital content (Figure 3, Table 8).

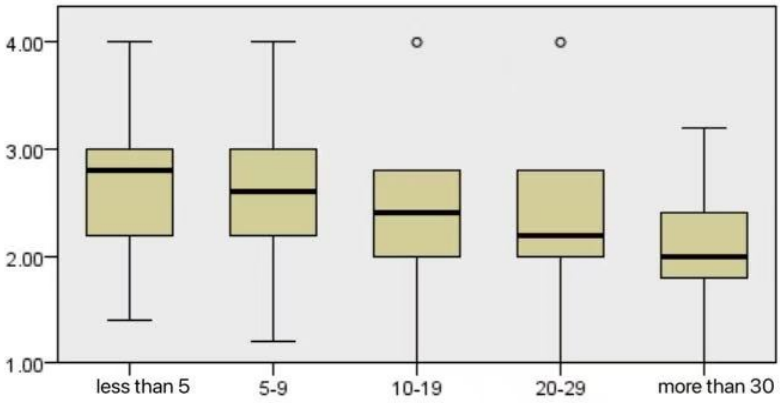

Figure 3. Mean values in digital content creation divided by teaching experience.

When teachers with different teaching experience were asked about their perceptions in terms of digital competence in security, teachers with less teaching experience rated themselves better (Figure 4, Table 8). When asked about their perception in terms of digital competence in solving problems with ICT tools, similar results were obtained (Figure 5, Table 8).

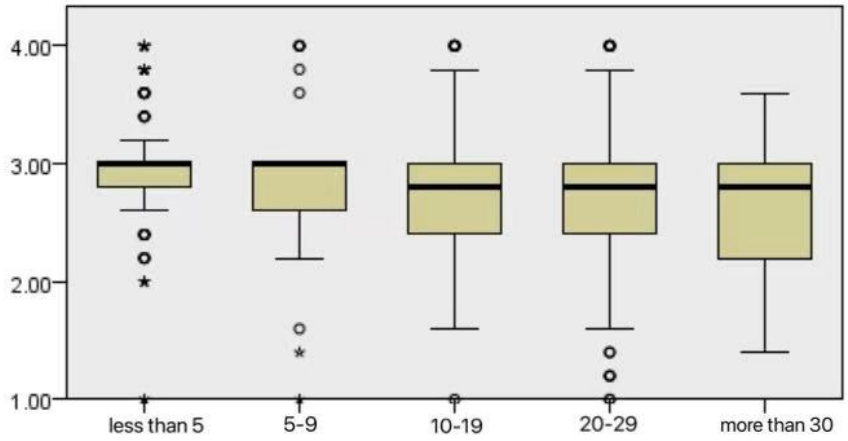

Figure 4. Mean values in security, divided by teaching experience.

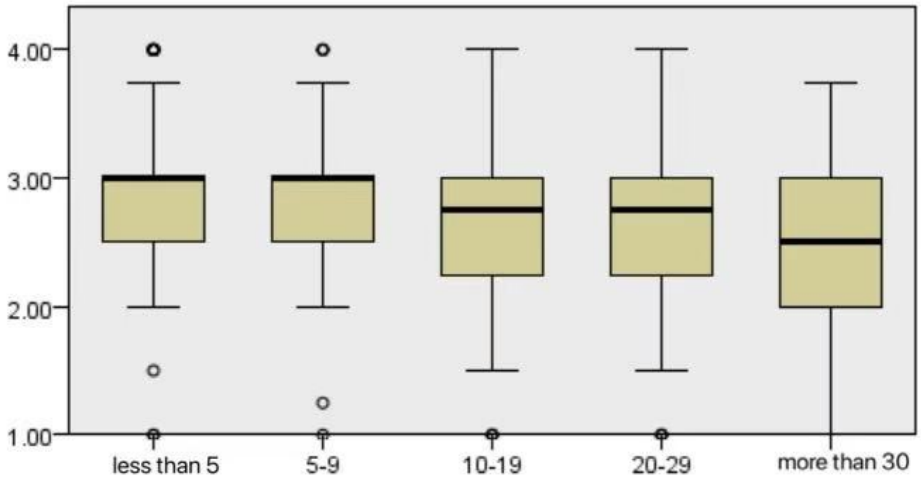

Figure 5. Mean values in problem solving, divided by teaching experience.

Teaching experience was considered as a differentiating variable, according to the results of the Kruskal–Wallis test (Table 9). There was no significant difference in the area of information and data literacy ($p > 0.05$). Meanwhile, there were significant differences among areas in communication and collaboration, digital content creation, security and problem solving ($p < 0.05$).

Table 9. Kruskal–Wallis test divided by teaching experience.

Dimensions	P.	Teaching Experience									
		Less than 5 Years		5–9 Years		10–19 Years		20–29 Years		More than 30 Years	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Information and data literacy	0.084	2.94	0.485	3.03	0.509	2.92	0.555	2.91	0.549	2.83	0.444
Communication and collaboration	0.000	2.93	0.465	2.92	0.508	0.2.75	0.495	2.74	0.524	2.69	0.466
Digital content creation	0.000	2.66	0.620	2.56	0.642	2.35	0.678	2.26	0.679	2.06	0.610
Security	0.001	2.97	0.500	2.87	0.487	2.79	0.557	2.72	0.718	2.63	0.578
Problem solving	0.001	2.88	0.551	2.82	0.522	2.65	0.564	2.62	0.657	2.44	0.607

5. Discussion

Modern digitalization implies an increasingly complex school environment [39]. As ICT tools are becoming a central part of everyday work, teachers have to rethink and change their previous educational methods through technology. At this point, the teacher's digital competence has become an essential part of the educational process.

This study described in-service teachers' perceptions of digital competence in the context of higher education and attempts to outline the variables of gender and teaching experience. An instrument to demonstrate validity and reliability content was used to reach study objectives.

This study identified the teachers' perception of digital competence by performing a descriptive analysis that enabled us to know how teachers thought about their digital competence. In general, their perception of digital competence was positive. If we focus on the dimensions analyzed in the study, across the five dimensions of digital competence, teachers perceived themselves as performing well in the areas of information and data literacy, communication and collaboration, and security and problem solving; more than half of the in-service teachers self-rated themselves as "good" or "very good". Their self-perceptions of information and data literacy, communication and collaboration and security were quite high. Most of the in-service teachers considered that they are capable of solving problems related to using ICT tools in their routines. However, their confidence in digital

content creation was low: 43.3% of in-service teachers thought they were bad at creating internet spaces for public educational resources and 44.2% of them thought they were bad at creating digital content. This shows that teachers consider ICT tools as a minimum support tool but they do not feel capable to create their own digital content and share it with other users [40]. Similar results can be found on this topic [41–43].

Some significant differences were observed regarding the effects of the gender and teaching experience variables on the five dimensions of digital competence.

There are several studies that have investigated the impact of gender on digital competence. Some studies have revealed the significance difference between the gender [11,13,38,44,45]. There are also studies that have not observed any differences between genders [46]. The results in this study show that men rated themselves higher than women in teachers' perceptions of digital competence, and there was significant difference in the areas of communication and collaboration, digital content creation, security and problem solving. Similar results were obtained in the studies of Cabezas and Casillas [11], González, Martín, Sanchez-Ferreira and Diogo [13] and López, Pozo and Fuentes [38]. The public perception is that men have higher scores in their self-perception of digital competence. However, many novel findings about gender stereotypes associated with the use of ICT tools and digital competence are provided. Moreno-guerrero, Fernandez Mora and Alonso Garcias [45] indicated that women rate themselves better than men in some areas, such as storage and retrieval of data and digital content, and Garcia Gonzalez, Gros, and Escofet [47] found that women in the context of higher education consider themselves to be very competent in the informal use of ICTs, choosing more academic and informational uses, and oriented to more engaging and communicative pedagogy. With the results obtained in this study, we can provide a gender perspective from the standpoint of Asian university in-service teachers.

In relation to the variable of teaching experience, many studies have analyzed age as a variable [13,48,49]. However, only a few studies have explored the relationship between teaching experience and digital competence [50,51]. In this study, we observed a significant difference among teachers with different lengths of teaching experience in the areas of communication and collaboration, digital content creation, security and problem solving. Teachers who had less teaching experience thought of themselves as more capable, while teachers with more teaching experience demonstrated a lower level of self-perception in the four dimensions of digital competence; in the study of Martín, Usart and Carnicero [50] similar results regarding teaching experience were observed among Spanish teachers.

6. Conclusions

The findings of this study describe the self-perceptions of Chinese university teachers' digital competence, with particular attention given to gender and teaching experience. As for future lines of research, further study should be done to compare teachers' self-perceptions of their digital competence between group samples coming from western and eastern universities, and to explore the reasons why there are differences between male and female teachers in terms of self-perception of digital competence and what causes teachers with more years of teaching experience to perceive themselves as less competent in some areas. All component areas of college teachers' digital competence need to be investigated in depth in the future as diagnosing and promoting the development of digital competence has become one of the main challenges for schools today [52]. Moreover, it will be interesting to analyze the gap between teachers' self-perceptions and their actual digital competence. On the basis of these findings, teachers' digital competence could be assessed in a rather reasonable way and thus appropriate projects and programs could be launched to improve their competence accordingly, in an effort to meet the challenges and needs in the new age, and thus eventually to improve the quality of education.

There are several limitations to this study. First, the limitation of methodology; throughout this study we refer to teachers' self-perceptions rather than to real data about their level of digital competence, and the real state of teachers' digital competence may

not be reflected. Second, the in-service teachers in this study are from one university but different faculties and their participation in completing the online questionnaire was voluntary, which could have influenced the sample size. Third, this study was particularly focused on gender and teaching experience; future research needs to be conducted so as to explore more factors that could affect digital competence. This study, was an initial step to explore the level of digital competence of college teachers; using correlation and regression analyses is recommended in future studies to show how the components of digital competence are related to each other.

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Appendix C.

Digital Competence in Higher Education: Students' Perception and Personal Factors.

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Article

Digital Competence in Higher Education: Students' Perception and Personal Factors

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Abstract: University students are expected to have the appropriate digital competence to face the demands of the changing educational model and to meet the challenges of the future work. This paper describes university students' perceptions of digital competence and analyzes the impact of personal factors on digital competence in a sample of 5164 students from all majors in the first and fourth year of their studies at Gansu Agricultural University (China). A quantitative methodology was followed, employing a non-experimental method and the survey technique to collect data. The results obtained show that students' perceptions of digital competencies in terms of information and data literacy, communication and collaboration, and safety were positive. Furthermore, there were significant differences in students' self-perceptions of digital competence related to gender, grade level, area of residence, and prior relevant training in the DigComp framework-based instrument. The development of key competency areas for digital competence, such as the creation of digital content, should be promoted, along with helping students to gain knowledge when dealing with everyday technological issues. The need for training related to the use of ICT and digital competencies was also highlighted, as well as supporting the promotion of female students in selected areas of digital competence and assisting lower grade students and students from rural areas in digital competence development.

Keywords: digital competence; students; higher education; ICT

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1. Introduction

Over the past decade society has witnessed many social, economic and cultural changes. Technological developments have allowed information and communication technologies (ICT) to permeate all areas of human activity. The increasingly accelerated digitalisation process has led to an increased focus on and demand for digital related competencies. The new demanding skills for the development of future talents in society have led to new strategies.

Issues of digital competence have become more crucial after the novel coronavirus (COVID-19) outbreak was declared as a global pandemic by the World Health Organization (WHO) on 11 March 2020, since that time, school closures in response to COVID-19 have disrupted conventional schooling and educational activities have been transformed into an online model [1]. Indeed, the spreading of the epidemic has forced an acceleration in the integration of technology into the education field, meanwhile, new digital skills, knowledge and attitudes have determined the current shape of crisis e-learning. Events are exposed the weaknesses of education systems around the world today and have highlighted the impact of the digital divide on education. For the past year, the importance of digital competence at different educational levels has been clearly observed worldwide [2–4].

States and institutions have been responding to ensure the quality of education and to accelerate progress towards Sustainable Development Goals (SDGs), which have been

presented by the United Nations and are aimed at achieving a better and more sustainable future for all. In order to support the sustainable and effective adaptation of education and training systems, the European Union released a digital education action plan (2021–2027) that focuses primarily on promoting the development of a high-performing digital education ecosystem and on improving digital skills and capabilities for digital transformation [5]. In alignment with the European Commission in fostering digitization in education, the 2025 Digital Spain has been presented. This includes guaranteeing adequate digital connectivity, bridging the digital divide in education and strengthening competencies in cybersecurity [6]. Moreover, the 48th China Statistical Report on Internet Development indicates that there are 325 million online education users in China and emphasizes the regulation of online education management [7]. Also the Cyberspace Administration of China published a Digital China Development Report, that takes the construction of Digital China as the overall strategy for the development of national informatization in the new era, through reducing the digital divide, developing the digital citizenship and enhancing the development of digital competence [8].

In addition to the new pedagogical challenges faced by teachers, the digital competence of students plays an important role in the new learning paradigm. As they are the main subjects of education, students should be prepared to use digital competence in their academic life and in their careers [9]. Digital competence is not only the basis for the use of digital technologies, but can also link to various required literacy for students. Students with higher digital competence can have better academic engagement and study enthusiasm, which are major concerns among world-wide universities and higher education institutions [10–12]. The development of digital competence needs to be perceived as part of lifelong learning [13].

1.1. Digital Competence

Digital competence has been frequently investigated and discussed by academic scholars and in policy documents, and it is also growing focus in higher education. Now that the teaching and learning environment has indeed changed, the use of ICT has penetrated into the study process and is closely linked to the academic performance of teachers and students alike [14].

There are several interpretations of the concept of digital competence, which is a broad concept [15]. Digital competence is defined as a set of required knowledge, skills and attitudes when using digital technologies to effectively optimize our everyday life [16]. It has been included in the recommendations on key competences for lifelong learning proposed by the European Commission as one of the eight key life skills, and it is defined as "the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society " [17] (p. 10). Digital competence is also understood as a cognitive, attitudinal and technological skill that helps to alleviate many of the problems and challenges in today's knowledge society and it has a dynamic and transversal character [18]. Digital competence involves not only digital skills, but also the social and emotional aspects of using and understanding digital devices and related technologies. Referring to the OECD project, "A competency is more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilizing psychosocial resources (including skills and attitudes) in a particular context" [19] (p. 4). Digital competence is conceived as a multifaceted moving target, covering different areas and incorporating multiple fields. Moreover, Calvani generalized that digital competence is made up of both specific and non-quantifiable skills. In this context, the coexistence of dimensions at the technical, cognitive and ethical levels, and the integration of relevant skills within these dimensions, are highlighted [20,21].

In the context of education, digital competence is considered as the ability, along with a strong theoretical foundation, investigation and experimentation to apply the knowledge, attitudes and skills necessary to plan, implement, evaluate and continually review ICT-supported teaching and learning processes [22].The pedagogical community

has realized the importance of digital competence for teaching and learning and considered it to be helpful in solving many problems in the teaching and learning process [23]. For educational organizations, the Joint Research Centre (JRC) published a Framework for Digitally Competent Educational Organizations (DigcompOrg), which helps to facilitate the process of systematically integrating digital learning in educational organizations from a pedagogical, technological and organizational perspective [24]. For teachers, digital competence is using ICT with a good pedagogical-didactic ICT understanding and being aware of how this might impact the learning strategies and educational formation of pupils [25]. A digital Competence Framework for Educators (DigcompEdu) was published in 2017, indicating the six competency areas that trainers need to develop [26]. The ministry of Education of China also released a project to enhance school teachers' ICT related abilities.

Digital competence is defined in a variety of ways and there is currently no single concept that is accepted and agreed upon by the general public. However, it is clear from the above-mentioned understandings and perceptions of experts and scholars that digital competence should be seen as an important survival skill and knowledge asset in the digital age, referring to the ability to learn, work, relax, play and use ICT confidently and creatively.

Today's students are growing up in a background of modern technology, and are recognized as digital natives [27]. Students with the ability to create and manage content and information, the control of communication tools, and the resolution of technological problems can make themselves more capable and competitive in order to meet the demands of today [28,29]. Moreover, influenced by the COVID-19 pandemic, innovation has driven teaching and learning, profoundly affecting learning models and teaching philosophies. Students, as the main participants in education, need to be equipped with digital competence to face the new challenges [30]. However, most students do not have the required digital competence level [31]. Technology is still not well blended into either classroom or online learning. Although some studies have shown that students perform positively in some areas of digital competence, there is still a long way to go before they are fully competent [32–34]. The fact that the students do not have sufficient digital competence is confirmed by all the difficulties and challenges that arose during the lock-downs.

It is also worth noting that the importance of digital competence and the incorporation of ICT tools into the educational process has been recognized by organizations, institutions and scholars. Several plans and blue papers aimed at accelerating the digitization and informatization process, with the purpose of strengthening digital competence, have been released [35,36]. There are studies focusing on investigating teachers' digital competence [4,37,38]. Other studies have investigated the factors influencing the development of digital competence, or the teaching methods involved in digital competence [39–42]. However, few studies have investigated the digital competence of Chinese university students, despite the fact that there are over 30 million undergraduate students in general higher education institutions in China [43].

1.2. Digcomp

In recent years, digital competence has been assessed and certified by different dimensions in the context of education from various perspectives [44]. A European Digital Competence Framework (Digcomp) is widely used to support strategic planning and policy-making, to develop education and training initiatives and to assess participants' digital competence [45]. Digital competence is defined as the use of ICT confidently, critically and creatively to achieve the goals related to work, employability, learning, leisure, social inclusion, and participation in society [46].

The European Commission first proposed Digcomp in 2013 as a road map on how to use and revise digital competence, and it identifies the key elements of digital competence, which address the knowledge, skills and attitudes required for digital competence. In 2016, Digcomp version 2.0 was launched in response to the new requirements brought about

by the rapid development of digitization in all areas of society since the digital evolution has made itself re-written, which the competence areas, the competence descriptors and their titles have been updated. The report DigComp 2.0 presents 21 competencies with an updated list of five competency areas: (1) information and data literacy; (2) communication and collaboration; (3) digital content creation; (4) safety; and (5) problem solving. Digcomp 2.1 added eight proficiency levels and new examples of use. Moreover, from January 2021, the Digcomp 2.2 version is already being drafted and will be released in 2022. It focuses on the list of examples of knowledge, skills and attitudes applicable to each one of the 21 DigComp competences [13,45]. A comparison of DigComp 1.0, DigComp 2.0 and DigComp 2.1 is presented in Table 1.

Table 1. The comparison of Digcomp 1.0; Digcomp 2.0 and Digcomp 2.1.

Digcomp 1.0		**Digcomp 2.0**		**Digcomp 2.1**
Information	1.1. Browsing, searching and filtering information 1.2. Evaluating Information 1.3. Storing and retrieving information	Information and data literacy	1.1. Browsing, searching and filtering data, information and digital content 1.2. Evaluating data, information and digital content 1.3. Managing data, information and digital content	Based on the dimensions from Digcomp 2.0, eight proficiency levels for each of the 21 competences and examples of use of the eight proficiency levels applied to learning and employment scenario in the 21 competences have been added and updated.
Communication	2.1. Interacting through technologies 2.2. Sharing information and content 2.3. Engaging in online citizenship 2.4. Collaborating through digital channels 2.5. Netiquette 2.6. Managing digital identity	Communication and collaboration	2.1. Interacting through digital technologies 2.2. Sharing through digital technologies 2.3. Engaging in citizenship through digital technologies 2.4. Collaborating through digital technologies 2.5. Netiquette 2.6. Managing digital identity	
Content creation	3.1. Developing content 3.2. Integrating and re-elaborating 3.3. Copyright and Licences 3.4. Programming	Digital content creation	3.1. Developing digital content 3.2. Integrating and re-elaborating digital content 3.3. Copyright and licences 3.4. Programming	
Safety	4.1. Protecting devices 4.2. Protecting personal data 4.3. Protecting health 4.4. Protecting the environment	Safety	4.1. Protecting devices 4.2. Protecting personal data and privacy 4.3. Protecting health and well-being 4.4. Protecting the environment	
Problem Solving	5.1. Solving technical problems 5.2. Identifying needs and technological responses 5.3. Innovating and creatively using technology 5.4. Identifying digital competence gaps	Problem Solving	5.1. Solving technical problems 5.2. Identifying needs and technological responses 5.3. Creatively using digital technologies 5.4. Identifying digital competence gaps	

The five areas of digital competencies and the 21 subdivided competencies identified in the DigComp conceptual reference model provide a strong common understanding of the digital competencies demanded by today's society [47].

Within each of the digital competency areas, a range of skills are included that are often associated with it. Of these specific competencies, professional knowledge, skills, attitudes, technical and operational competencies including operating processes are the main components [48]. Furthermore, there is a large amount of overlap and cross-reference between areas and competencies. It is also important to emphasize that the DigComp framework is not prescriptive, but rather descriptive, and that this descriptive nature can help to adapt to the specific needs of the target group.

On the basis of the preceding literature review, it is argued that the digital competence of students is crucial to society. Moreover, understanding their digital competence can provide information, recommendations and support for the future development of education in a digital environment. Digital competence has been recognized as a key competence in different European frameworks and has a solid theoretical foundation. China is now in a critical process of digitization, but compared to the well-established digital competence frameworks in European countries, a framework for assessing Asian students' digital competence in line with Eastern education systems has not yet been released. Digital competence is one of the challenges facing both the EU and China, so the development of communication, frameworks, platforms, methods and validation schemes could be instructive for both sides as well as for education [49]. In this paper we bring the European digital competence framework into the context of the Eastern education system and use the Digcomp-based instrument to explore the digital competence of Chinese students. Also, as university students are not only under pressure to study, but also to enter society, face the challenges of the workplace and exercise their digital citizenship rights, it is vital to understand their digital competences.

Therefore, in this paper, we concentrate on students' digital competence in higher education, with the goals of describing university students' perception of their digital competence and exploring whether there are significant differences based on established variables such as gender, grade, residential areas and previous formal training in ICT use and digital competence.

Based on this, the research questions are:

1. What are university students' perception of their digital competence?
2. Whether there are significant differences based on established variables (gender, grade level, residential areas and previous formal training in the use of ICT and digital competence)?

2. Materials and Methods

To carry out this study, a quantitative methodology with survey-based was employed. We used a non- experimental design for this study that there is no treatment of any variables for modification or application, but only selection, observation and collection of information needed to solve the research questions. In order to reach the study's objectives, we also performed a descriptive, inferential data analysis [50].

2.1. Sample

The population that constituted the study sample was composed of students from all faculties who were freshmen and fourth-year students at Gansu Agricultural University in China in the 2019/2020 academic year. We used random sampling techniques. The random, representative sample consisted of 5164 subjects (estimation error E = 1.36, $\alpha = (100 - 95)/100 = 0.05$).

In total, there were 3136 (60.7%) first year students and 2028 (39.3%) students in their fourth year. The average age was 20.15 and ranged from 15 to 30 years old. And in the sample, 56.9% (n = 2940) of the students were women and 43.1% (2240) were men. Most of them lived in rural areas (70.5%, n = 3634).

50.5% of the subjects had received formal training in the use of ICT and digital competence. The majority of them had participated in online class (75.3%). In order to improve students' digital competence, 59.1% of the subjects chose to attend school courses.

2.2. Instrument

The instrument used for this study was a questionnaire adapted from a diagnostic questionnaire for university students presented by Martínez Vidal y Cervera [51] and the Ikanos self-assessment tool from the Ikanos project.

In 2012, The Basque Government (Spain) launched the Ikanos project to meet both common and specific digital competence needs. It has been developed and expanded several times promoting the Information and Knowledge Society and motivating the acquisition of digital competence [45,52]. Inspired by Digcomp, Ikanos was designed to satisfy the digital competence requirements of different segments and aspects of society. The Ikanos self-assessment tool can help to provide a personal digital profile, indicating the level of digital competence according to the five competency areas of the DigComp model.

We wrote a draft that included all items deemed necessary to meet the study objectives. The validation of the instrument was reviewed by a panel of experts who analyzed the content validity and an exploratory factor analysis was applied to complete the construct validity. The questionnaire was initially written in Spanish and translated into Chinese, considering the participants' mother tongue. The characteristics and external validity of the questionnaire were examined in discussion with experts in the fields of research methods, education and linguistics. The questionnaire was then revised in line with the recommendations of the experts. The reliability of the instrument was measured. The Cronbach's Alpha coefficient reached a value of 0.978, representing a very high level of reliability [53].

The questionnaire has 70 items and it is divided into six sections (Table 2).

Table 2. Sections of the questionnaire.

Identification	Age; gender; grade; residential zone; major and reason for choosing a major.
Availability of ICT resources	Device connection to the Internet; campus networking and owned equipment and device
Potential for digital competence development	Frequency of connecting to the Internet; connection with the Internet and the purpose of using the ICT tools.
ICT and digital related training	Previous training on the use of ICT and digital competence reception; approaches to improving digital competence; online classes participation and level of computer usage.
Self-perception in digital competence	Information and data literacy; communication and collaboration; digital content creation; safety and problem solving.
Attitude	Attitude towards ICTs.

The items are made up of closed-ended, multiple choice and 4-interval Likert-type ordinal scale questions, with the intention to avoid deviations. Participants should respond to all questions according to their real situation.

2.3. Data Collection and Analysis Procedures

Data collection was carried out in the academic year 2019–2020 in the subject in China. The questionnaire was completed digitally through the Qualtrics platform and was distributed to the first and fourth year students by sharing the OR code created by Qualtrics. And the questionnaire was anonymous. Before answering the questionnaire, supervising teachers explained the purpose of the study and asked for the cooperation of the students.

The data obtained were analyzed with the Statistical Package for the Social Sciences (v.26). A confidence level of 95% was used in all analyses. Descriptive statistical analysis was carried out on all responses, with the mean and standard deviation calculated. In order to have a better understanding of the personal variables that determine the digital competence of university students, several inferential statistical analyses were performed.

Analyses were carried out, to determine whether there were significant differences in their perception of digital competence due to gender, grade, residential area and previous training. According to the Kolmogorov-Smirnov test, there was no normality in the distributions (p-value is 0.000). And the non-parametric Mann-Whitney U test was employed for the dual variable.

3. Results

As there is a large amount of data available throughout the entire study, this paper will only focus on the fifth part of the data: students' self-perceptions of digital competence.

3.1. Descriptive Analysis

University students' perception of their digital competence (39 items) will be presented according to the following competency areas: information and data literacy (6 items); communication and collaboration (13 items); digital content creation (6 items); safety (7 items) and problem solving (7 items). As mentioned above, to avoid bias, participants responded on a Likert-type scale of 1 to 4.

Table 3 shows basic descriptive statistical results of students' self-perceptions of digital competence in terms of information and data literacy.

Table 3. University students' self-perception of digital competence in information and data literacy.

Information and Data Literacy	Very Poor	Poor	Good	Very Good	Mean	SD
I use ICT tools to search, locate, select, organize, evaluate, process, store, transform, disseminate, cite and communicate information.	6.9	20.5	62.6	10.1	2.76	0.722
I use specialized search engines and meta-search engines with various mechanisms (Identify keywords, synonyms and related terms, search in more than one language...).	3.8	14.5	63.9	17.8	2.96	0.687
I understand different sources of information and can build search strategies correctly based on them.	6.2	27.3	55.7	10.7	2.71	0.738
I analyse and comment critically on information, data sources and digital content, verify the validity and timeliness of the information located.	7.0	29.3	54.3	9.4	2.66	0.743
I apply different methods and tools to manage and store information, data and digital content for easy retrieval.	6.5	28.0	55.5	10.1	2.69	0.738
I have my own strategy to organize and retrieve information and data.	7.4	27.2	54.8	10.5	2.68	0.758

The majority of students perceived themselves good in browsing, searching and filtering data, information and digital content. And there were 54.3% students who believed that they were good in the evaluation of information, data and digital content. When students were asked about managing data, 55.5% claimed they were good. In regard to information organization and retrieval of data, 54.8% thought that had reached a good level (Table 3).

The results obtained refer to communication and collaboration (Table 4) and indicate that the university students are good at using digital devices and applications to communicate with others (M = 3.00, SD = 0.661). 59.7% of the students chose good when asked about digital participation. While 56.3% perceived themselves good in terms of collaborating with others through the Internet and in forming their PLN. As for the students' citizenship engagement through digital technologies, the majority of them (61.2%) thought they were good. In relation to the collaboration through digital technologies, more than half of the students indicated themselves as good in using digital technologies and media

for teamwork (61.7%), to process their activities and projects (56.4%) and participating in online learning activities through collaborative environments (56.9%). Most of the students were well aware of behavioral norms and knowledge when using digital technology and interacting in a digital environment (M = 3.05, SD = 0.687; M = 3.06, SD = 0.660; M = 3.03, SD = 0.656). Similar results were observed in terms of students managing their digital identity: 60.5% knew well how to create and manage their profile on social media, 58.8% could manage several identities in different contexts and 63.1% indicated their good ability in controlling and protecting digital reputation.

Table 4. University students' self-perception of digital competence in communication and collaboration.

Communication and Collaboration	Very Poor	Poor	Good	Very Good	Mean	SD
I communicate and interact through a variety of digital devices and applications (SMS, email, cloud, QQ, WeChat, video conferencing).	3.2	12.2	66.0	18.6	3.00	0.661
I participate in social networks, collaborative platforms and online communities where I share knowledge, multimedia content and information.	5.0	22.5	59.7	12.8	2.80	0.718
I collaborate through the Internet with other people in my educational or professional field that form my personal learning network (PLN).	6.6	26.7	56.3	10.4	2.71	0.740
I engage with society through online participation (social, political, cultural, administrative action) and am aware of the potential of technology for citizen participation.	4.8	22.8	61.2	11.2	2.79	0.698
I use digital technologies and media for teamwork.	4.6	22.4	61.7	11.3	2.80	0.692
I use technology and collaboration tools to plan, execute and share monitoring of activities and projects.	6.0	27.4	56.4	10.2	2.71	0.728
I participate in learning activities such as MOOCs through collaborative environments.	6.2	26.4	56.9	10.5	2.72	0.734
I am familiar with the rules of conduct online or in the virtual world, such as being friendly, respecting people's privacy and being careful with my language.	3.0	12.1	61.6	23.3	3.05	0.687
I stay up to date with ethics regarding internet use.	2.7	10.7	64.4	22.1	3.06	0.660
I take care to remind my family and friends of the basic rules of behaviour on the Internet.	2.6	12.3	64.5	20.6	3.03	0.656
I know how to create and manage a public, personal and professional profile on social media.	4.5	19.6	60.5	15.4	2.87	0.716
I am able to manage several digital identities depending on the objective or context.	5.2	22.2	58.8	13.8	2.81	0.730
I pay attention to what I post online and I know how to protect my digital reputation and/or that of others.	2.6	10.2	63.1	24.0	3.09	0.661

Table 5 shows the data referring to digital content creation. It is observed that only 49.1% students perceived themselves as good in using different tools and software to create multimedia content in various formats, 36.6% indicating themselves as poor. When using different media and methods to present their idea creatively, 50.6% chose good and 35.6% thought that they were poor at it. Regarding the creation of new creative and relevant content by editing, modifying, improving and combining existing resources, 51.5% evaluated themselves as good. The results were similar in terms of understanding the basics of intellectual property, the law, and the licensing of information and digital content, with half of the students rating themselves as good (52.8%). However, in the programming section, less than half of the students thought they had a good level (45.2%) and only 43.7%

indicated that they could make well modifications to computer programs, applications, configurations and equipment as needed.

Table 5. University students' self-perception of digital competence in digital content creation.

Digital Content Creation	Very Poor	Poor	Good	Very Good	Mean	SD
I use a variety of tools and software to create multimedia content in a variety of formats.	7.7	36.6	49.1	6.7	2.55	0.732
I am able to use different media and methods to present ideas in a creative way.	6.8	35.6	50.6	7.0	2.58	0.721
I am able to edit, modify, improve and combine existing resources to create new and relevant content and knowledge.	7.0	34.6	51.5	6.9	2.58	0.722
I understand the basic knowledge and laws of intellectual property and the licensing of information and digital content when working with ICTs.	6.5	32.6	52.8	8.2	2.63	0.726
I know the basics of digital processes, understand the principles of programming and what is behind a programme.	9.4	38.5	45.2	6.9	2.50	0.759
I make modifications to computer programs, applications, configurations and equipment as needed	11.7	37.9	43.7	6.7	2.45	0.784

The results of students' perception in terms of safety are showed in Table 6. The students mostly agreed that they were good in understanding the risks associated with the use of online tools and devices (63.3%), and they reported they could protect their devices and content well (61.1%). With regard to protecting their own the personal data and privacy, the majority of the students pointed out their good level on it (M = 2.90, SD = 0.672). Regarding the health and well-being protection, most students considered themselves good in terms of being aware of the associated risks and threats (64.5%), protecting their health and well being when using the Internet and related technologies (64.8%) and being knowledgeable about the influence of the use of technology on the environment (65.5%). And 64.4% stated they could apply measures to save energy, recycle devices and contribute to environment protection.

Table 6. University students' self-perception of digital competence in safety.

Safety	Very Poor	Poor	Good	Very Good	Mean	SD
I understand the risks associated with the use of online tools and devices	4.7	19.8	63.3	12.2	2.83	0.691
I protect my equipment and multimedia content	4.3	22.5	61.1	12.1	2.81	0.695
I keep data security and protect my personal privacy.	3.5	17.2	64.5	14.7	2.90	0.672
I understand the health risks associated with the use of related technologies.	3.1	16.1	64.5	16.4	2.94	0.666
I prevent and avoid physical and mental health threats when using the Internet and multimedia devices, such as poor sitting posture and cyberbullying.	3.3	15.0	64.8	16.9	2.95	0.669
I know the positive and negative aspects associated with the use of technology on the environment.	3.1	15.3	65.5	16.1	2.95	0.659
I apply basic measures to save energy, recycle devices and protect the environment.	3.5	17.0	64.4	15.0	2.91	0.674

Data referring to the students' perception of digital competence in problem solving (Table 7) shows that less than half of the students were well versed in operating digital

equipment and identifying possible technical problems (48.7%), and 35.1% thought that they were bad at it. But when the real daily technical problem occurred, 52.3% selected good, indicating that they could solve these problems well. In terms of identifying needs and technical responses, there were 58.6% of the students rated themselves as good. When students were asked about keeping up to date with new technological developments, trends and using digital technology to innovate, only 48.5% considered themselves as good, while 35.9% indicated that they were poor at it. Then in creatively using digital technologies, 56.2% of the students confirmed that they were at a good level. Similarly, 52.1% chose good with regard to participation in events and workshops on digital creation and collaborative multimedia and digital projects. In regards to identifying gaps in digital competence, 59.2% reported that they were aware of the need to improve and update their own digital competence and to help others develop theirs.

Table 7. University students' self-perception of digital competence in problem solving.

Problem Solving	Very Poor	Poor	Good	Very Good	Mean	SD
I am familiar with the operation of digital devices and am able to identify possible technical problems.	8.1	35.1	48.7	8.2	2.57	0.755
I solve daily technical problems.	6.6	33.0	52.3	8.1	2.62	0.728
I evaluate and select appropriately a tool, device service to perform my tasks and meet my needs.	5.3	27.5	58.6	8.7	2.71	0.698
I keep myself updated on new developments and emerging technology trends, and innovate using digital technology.	7.7	35.9	48.5	7.9	2.57	0.747
I use various methods such as text, images and audio to make my expression more creative and innovative.	5.3	29.6	56.2	8.8	2.69	0.706
I actively attend events and workshops on digital creation, and participate in collaborative multimedia and digital projects.	7.4	32.9	52.1	7.7	2.60	0.736
I understand the needs to improve and update one's own competence and to help others in developing their digital competence.	4.8	24.7	59.2	11.3	2.77	0.706

3.2. Inferential Analysis

To conduct the inferential analysis, the Mann-Whitney test was applied. This section will present the factors that influence university students' perceptions of digital competence (gender, grade, residential area, previous formal training).

3.2.1. Gender

The Mann-Whitney U test was used to determine whether there were differences between male and female students in terms of the various dimensions of digital competence. Statistically significant differences were found in terms of gender in the areas of information and data literacy, digital content creation and problem solving (MW p-value = 0.000). The comparison of students' perceptions of digital competence between genders can be seen in Figure 1. Men (Median = 3.00) perceived that their digital competence level in information and data literacy section was significantly higher than that of women (Median = 2.83; MW p-value = 0.000). Women (Median = 2.50) rated themselves lower in digital content creation than men (Median = 2.67; MW p-value = 0.000). Similar results were found in problem solving, in which men (Median = 3.00) stated themselves better than women (Median = 2.71). However, there was no significant difference between genders and the p value was on the borderline of significance (MW p-value = 0.053) in the communication and collaboration section. With regard to the safety section, the results showed no statistically significant difference between the scores of the male and female groups (MW p-value = 0.709).

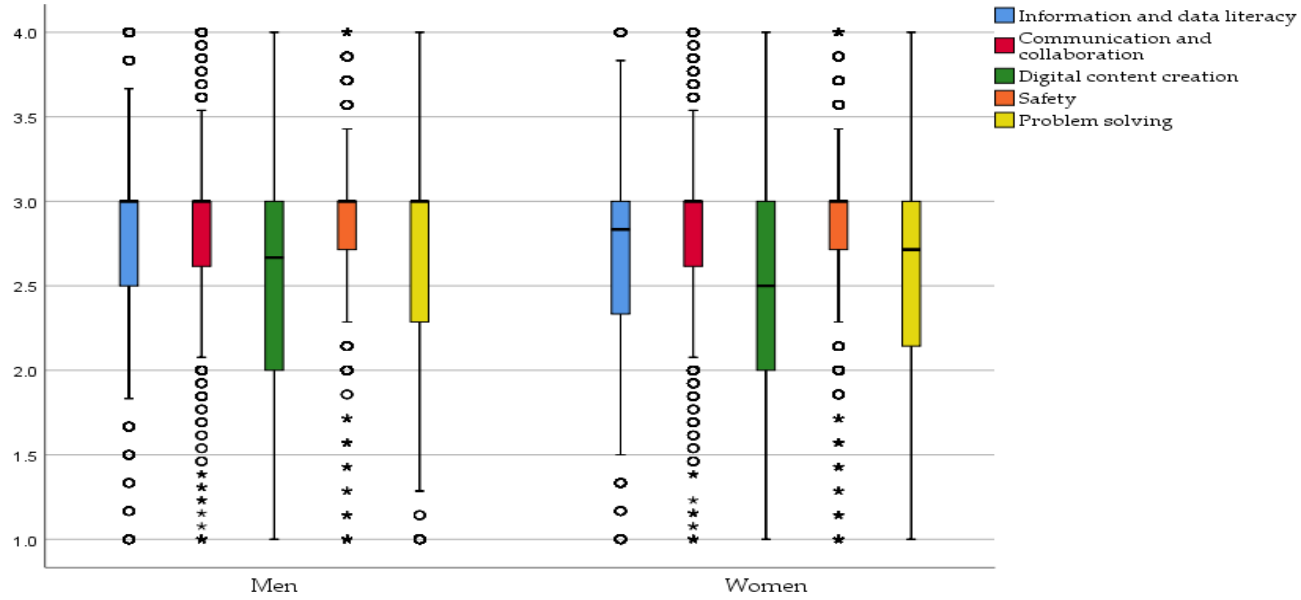

Figure 1. University students' self-perception of digital competence, by gender group.

3.2.2. Grade

Figure 2 illustrates the perceptions of different grades of university students about their digital competence. It is observed that the fourth year students (Median = 3.00) perceived themselves as more capable than the first year students (Median = 2.83; MW *p*-value = 0.000). The result of the Mann-Whitney test showed that there was a significant difference between first-year and fourth-year students' self-perceptions of their digital competence in the section of information and data literacy (MW *p*-value =0.000). In the digital content creation, the fourth year students (Median = 2.67) stated a higher competence level than the first year students (Median = 2.5; MW *p*-value =0.000). A similar result was seen in the problem solving section (MW *p*-value = 0.000). However, no statistical differences in digital competence safety dimension were found between students in different grades, since the *p* value was 0.221.

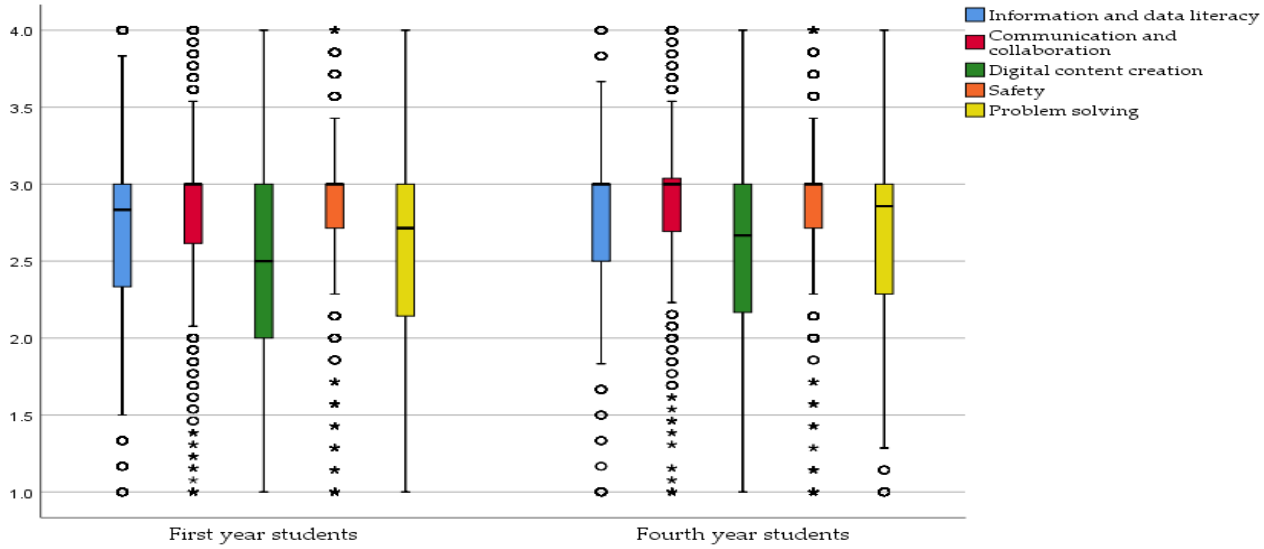

Figure 2. University students' self-perception of digital competence, by different grades.

3.2.3. Residential Area

After applying the Mann-Whitney test, the results showed that there were significant differences in five areas of self-perceptions of digital competence between students coming from different residential areas (MW *p*-value = 0.000). Students with an urban residence stated themselves better than students with a rural residence in the section of information and data literacy, communication and collaboration, digital content creation, as well as safety and problem solving (Figure 3).

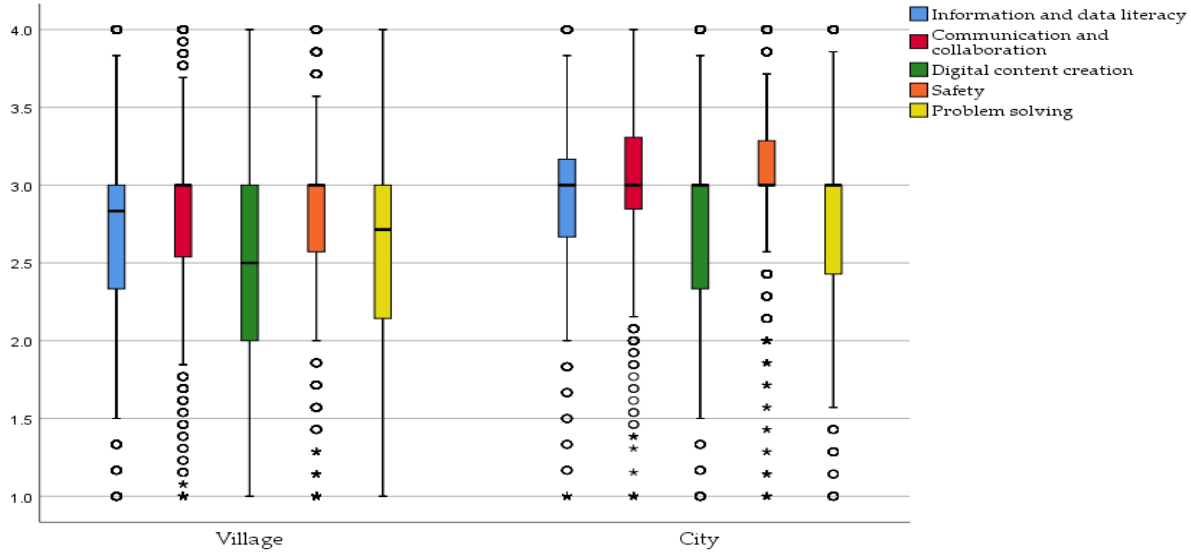

Figure 3. University students' self-perception of digital competence, by different residential areas.

3.2.4. Previous Formal Training on the Use of ICT and Digital Competence

According to the results obtained, with or without prior relevant formal training, students showed significant differences in all five areas of digital competence (MW *p*-value = 0.000). Regarding the area of information and data literacy, students with previous training (Median = 3.00) had a higher perception than those who had not received training (Median = 2.83). In the areas of communication and collaboration, digital content creation, and safety and problem solving, we found similar results (Figure 4).

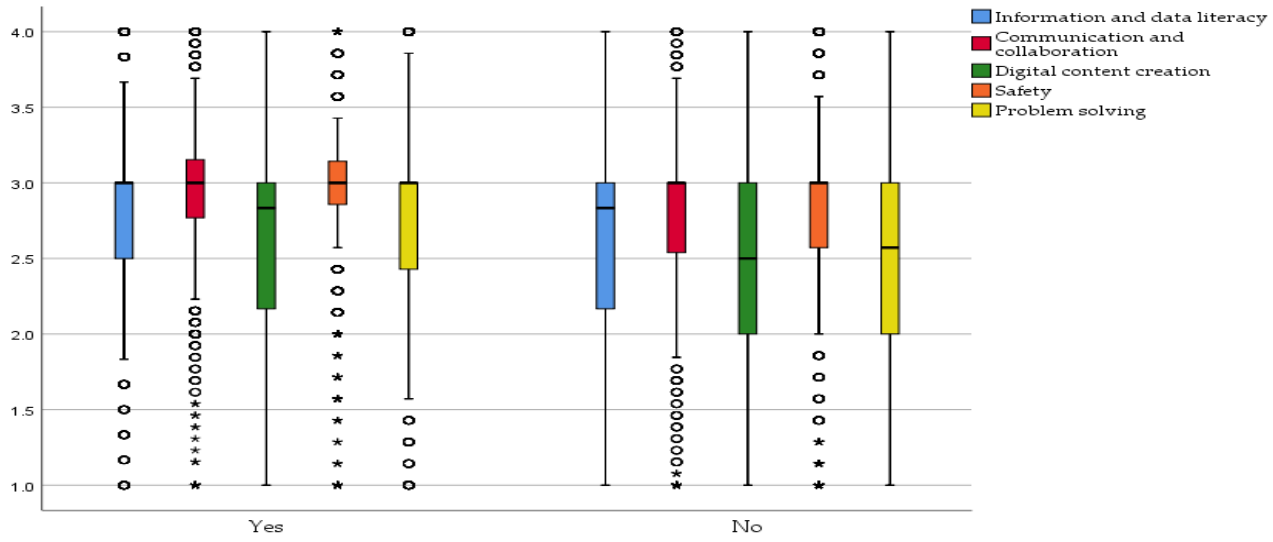

Figure 4. University students' self-perception of digital competence, by previous formal training.

4. Discussion

A shift in the educational paradigm due to the accelerating digitalization process and the impact of the COVID-19 epidemic, as well as the goals of sustainable development, make it even more certain that digital competence is a core part of students' ability to achieve an adequate professional and academic performance, to meet society's requirements and to face future challenges [34,54].

Various studies have investigated the acquisition of digital competence, teachers' digital competence perception, and examined the relationship between different dimensions [4,55,56]. This paper explores students' perceptions of their level of digital competence in the context of higher education, based on a case study of students at Gansu Agricultural University in Northwest China. Generally speaking, most students perceived their level of digital competence as positive. It was also observed that students demonstrated digital competence in several areas such as information and data literacy, communication and collaboration. We agree with [57] and [58], whose findings on university students' digital competence have led to identify that students' perception of digital competence decreased when the complexity of tasks increased. Therefore, many students need to improve their level of competence when creating digital content and programming, as well as parts of their problem-solving skills when facing technical problems and the understanding of technological trends. The results obtained were similar to the research done by [59,60]. Furthermore, students showed their positive perceptions in the safety section of digital competence, which showed contrary results to those obtained by [61]. Overall, the level of digital competence of university students still has potential for further development.

In the current scientific research, gender is one of the most widespread variables [62]. There are several studies that have examined the impact of gender on digital competence, indicating significant differences [63–65]. At the same time, there are some research studies that have obtained a contrary result that no significant differences were found regarding gender [66–70]. In this study we have verified that university men students rating themselves higher than university women students in several sections of digital competencies such as information and data literacy, digital content creation and problem solving. We therefore agree with [58,71,72] whose work indicated that men have showed a better digital competence than women. However, there are also studies showing the opposite findings against the gender stereotypes associated with digital competence [73].

As opposed to many authors who have explored age gaps in digital competence issues, only a few studies point to gaps in digital competence between different grades [74]. So, due to the small age range of the university students who were the subject of this paper, we examined the differences in perceptions of digital competence between first year and fourth year students. It has been demonstrated that students in the higher grades have showed better self-perception in all areas of digital competence, based on the Digcomp framework. As the results are similar to those reported in terms of age differences, it remains to be further investigated whether the reason for this variation is due to their age or their school training strategy.

Regarding the variable of residential area, firstly, there is still a digital divide between rural and urban areas, resulting from demographic variables such as the age and education level of the population and the connection to the international internet [75,76]. The results in this study are consistent with [77], showing that digital competence is perceived to be on average better in university students living in urban areas.

In relation to the students' previous formal training on the use of ICT and digital competence, it has been indicated that half of the university students have already received prior formal relevant training. Training in digital competence and the use of ICT does not fully cover upper secondary education prior to entering university, and the design of relevant university curricula has not spread to all majors. In agreement with [3], there is a relationship between training and students' subsequent development of digital competence. The impact of previous formal training has been confirmed by the results that students with previous formal training show a higher level of self-perception in terms of digital

competence. Similar results were obtained and mentioned by [78,79] as well. Many studies have investigated the area of educators' digital competence training that presented the training needs [80–82]. However, for students, there is a relationship between training and their subsequent development of digital competence [3].

5. Conclusions

This paper explores the perceived digital competence of a sample of university students at a university in north western China. Positive aspects of information and data literacy, communication and collaboration, security and problem solving were noted, while digital content creation was also shown to be the dimension of least awareness among the students. In addition to this, the impact of personal variables on perceptions of digital competence were examined, pointing to gender gaps, grade differences, urban-rural area differences, and the impact of prior formal training on digital competence.

The emergence of the epidemic has led to a faster and deeper penetration of multimedia technology into the education sector, making it important to understand where students' digital competence levels are at. In this paper, the results obtained not only show the students' current perceived level of digital competence, but also provide a perception of the digital competence of students in different education systems for later comparison with students in other countries or in other educational contexts. It also contributes reference data for teachers and educational institutions in developing relevant training and education strategies.

This study is not without its limitations. First, the sample was from students at the same university. Future research is recommended to expand sample diversity. Moreover, the study was based on a self-perception questionnaire rather than an objective assessment of digital competence. That is, the self-statements were subjective and therefore may not reflect the true current level of students' digital competence. It is suggested that future studies applying correlation and regression analyses to allow further exploration of the effects of the variables on digital competence and how the components of digital competence are interrelated.

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Appendix D.

Extended abstract in Spanish

VNiVERSiDAD D SALAMANCA
CAMPUS OF INTERNATIONAL EXCELLENCE

TESIS DOCTORAL

Programa de Doctorado Formación en la Sociedad del Conocimiento

Competencia digital de profesores y estudiantes universitarios: Un estudio de caso de la Universidad Agrícola de Gansu en China

Autora:

Yu Zhao

Directoras:

Dra. María Cruz Sánchez Gómez
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Resumen

Vivir hoy en día en una sociedad del conocimiento nos permite ser capaces de conocer los cambios en la estructura de la sociedad, las vinculaciones entre países y la adquisición de conocimientos, así como el desarrollo y la penetración cada vez mayor de la tecnología en todos los aspectos de nuestra vida. El brote del nuevo coronavirus (COVID-19) ha impulsado aún más la revolución en educación. El modelo educativo ha cambiado y con él llegan diversos retos. Se exige a los profesores y a los estudiantes que estén dotados de la competencia digital adecuada y de capacidad para utilizar con eficiencia diversas herramientas de las tecnologías de la información y la comunicación (TIC), especialmente en educación superior. Además, la brecha de la competencia digital se amplía, no sólo entre los países desarrollados y los países en vías de desarrollo, sino también dentro de un mismo país, debido al desequilibrio del crecimiento económico, como la enorme brecha entre el este y el oeste de China. Es muy necesario mejorar la competencia digital para afrontar mejor los desafíos, reducir la brecha digital y adaptarse a esta sociedad del conocimiento, así como al nuevo entorno de aprendizaje.

Los principales objetivos de esta tesis son: en primer lugar, presentar la definición de competencia digital en la enseñanza superior, indicar las dimensiones que se utilizan habitualmente para evaluar la competencia digital de los profesores y estudiantes universitarios, determinar el estado de la investigación en este campo e identificar las áreas de investigación futura mediante una revisión sistemática de la literatura y un estudio de mapeo. En segundo lugar, realizar un estudio empírico sobre los profesores y estudiantes universitarios de la Universidad Agrícola de Gansu, situada en el oeste de China. Para los profesores universitarios en activo, la atención se centró en la exploración de su competencia digital, el uso de las TIC por parte de los profesores y sus opiniones sobre el uso de las TIC en educación. Con respecto a los estudiantes universitarios, especialmente los de primer y último curso, se hizo énfasis en la competencia digital de los estudiantes y sus opiniones sobre las TIC; y también se incluyó su disponibilidad de recursos tecnológicos, su potencial de competencia digital y la formación previa relacionada con las TIC y la competencia digital. Además, los factores que influyen en la competencia digital para determinar sus necesidades de desarrollo han sido examinados.

Palabras clave: Competencia digital; TIC; educación superior; universidad; profesores; estudiantes; China

Abstract

Living today in the knowledge society allows us to be aware of the changes in the structure of society, the connections between countries and the acquisition of knowledge, as well as the ever-growing technological development and penetration into every aspect of our life. The outbreak of the new coronavirus (COVID-19) has further propelled the revolution in education. The educational model has changed and with it comes a variety of challenges. Teachers and students are required to be equipped with adequate digital competence and the ability to use information and communication technologies (ICTs) and the Internet proficiently, especially in higher education. Consequently, the gap of digital competence is widened, not only between developed and developing countries, but also within the same country due to the imbalance of economic growth, such as the huge gap between the east and west of China. It is of great necessity to enhance the digital competence to better meet the challenges, to narrow the digital gap and to adapt to this knowledge society as well as to the new learning environment.

The main purposes of this thesis are: firstly, to present the definition of digital competence in the higher education, to indicate the dimensions commonly used to assess university teachers and students' digital competence, to determine the state of research in this field, and to identify the areas for further research through a systematic literature review and a mapping study. Secondly, to carry out an empirical study on university teachers and students at Gansu Agricultural University in the west of China. For in-service university teachers, the focus was on the exploration of their digital competence, the use of ICTs and their attitudes towards the use of ICTs in education. For university students, especially for those freshmen and senior students, the emphasis was placed on students' digital competence and their attitudes towards ICTs; and their availability of technological resources, their potential for digital competence, and previous training related to ICTs and digital competence were covered as well. Moreover, the factors influencing digital competence were examined to determine its development needs.

Keywords: Digital competence; ICTs; higher education; University; university teachers; university students; China

1. Introducción

La sociedad actual está cambiando y evolucionando rápidamente, a un ritmo acelerado en el que convergen las telecomunicaciones, la radiodifusión y las tecnologías de la información. Las tecnologías de la información y la comunicación (TIC) están generando nuevos productos y servicios, así como nuevas formas de organización. Al mismo tiempo, a medida que los mercados se abren a la competencia, la inversión y la participación extranjera, proliferan las oportunidades de asociación, negocios y profesiones. El mundo está experimentando una enorme transformación, y los países han evolucionado gradualmente desde la sociedad industrial que marcó el siglo XX, a la era de la información y a la sociedad del conocimiento.

En el proceso de desarrollo dinámico que la tecnología de la información y la industria de la información desempeñan un papel cada vez más importante en el desarrollo económico y social, la sociedad de la información llegó a la vista de la gente (Isazadeh, 2004). El rápido progreso de las nuevas TIC ha creado nuevas condiciones para el surgimiento de la sociedad del conocimiento. Una sociedad que surgió como respuesta a la evolución social, para construir una visión pluralista, inclusiva, cohesionada y participativa de la misma, y para crear y aplicar las capacidades de identificar, producir, procesar, transformar, difundir y utilizar la información necesaria para el desarrollo humano (Bindé, 2005). A diferencia de la sociedad de la información, que se limitaba a crear y difundir datos en bruto, el papel de la sociedad del conocimiento es transformar la información en un recurso que permita a los ciudadanos responder eficazmente (Castelfranchi, 2007). La sociedad del conocimiento resume y expresa la complejidad y el dinamismo de las transformaciones sociales que se están produciendo en la sociedad moderna y al mismo tiempo sirve para analizar estas transformaciones, lo que desempeña un papel importante en el debate actual dentro del campo de las ciencias sociales.

Las tecnologías han experimentado un importante desarrollo en la última década, lo que ha permitido que se produjera su incorporación paulatina en diferentes ámbitos, entre ellos el ámbito educativo (Brown & Duguid, 2017; Dellit, 2002; Varela-Ordorica & Valenzuela-González, 2020). Actualmente, en el ámbito de la educación se percibe que no solo hay una población de inmigrantes digitales que tienen que aprender y adaptar las TIC, sino también por los nativos digitales que han crecido con la tecnología, y que forman la parte principal de la población en el campo de la educación en la actualidad, y que a su vez, se convertirán en la corriente principal de la educación en el futuro (Prensky, 2001, 2009). Como consecuencia, la brecha digital o incluso la desigualdad digital pueden aparecer debido a la maestría en el uso de las TIC, y por ello, la competencia digital se ha convertido en un factor clave para mejorar el dominio de las TIC (Ilomäki et al., 2011). Además, varios países e instituciones han respondido a este objetivo, acelerando el progreso hacia el Objetivo de Desarrollo Sostenible 4 (ODS), que es la educación de calidad propuesta por las Naciones Unidas (2015). Se han puesto en marcha diferentes planes e informes para desarrollar la educación digital con el objetivo de apoyar la adaptación sostenible y efectiva de los sistemas de educación y formación, reforzar la competencia digital y ayudar a reducir la brecha digital en ámbito educativo (Comisión Europea, 2020a, 2020b; Gobierno de España,

2020).

Además, con la aparición y el brote de la pandemia por coronavirus iniciada en diciembre de 2019 (COVID-19), y el enorme impacto en las diversas industrias que trajo consigo, también afectó notablemente a la educación. Los sistemas educativos han experimentado el mayor cambio y desafío de su historia. El impacto de la epidemia ha obligado a cerrar la mayoría de las escuelas y otros espacios de aprendizaje en todo el mundo, y la crisis ha ampliado la brecha educativa existente (UNESCO, 2020a). En respuesta, se está recomendando a muchas escuelas e instituciones que transformen la educación tradicional presencial en un modelo a distancia o en línea, y que utilicen aplicaciones y plataformas educativas abiertas para garantizar y facilitar las actividades de enseñanza y aprendizaje (UNESCO, 2020b). Se requiere que los profesores y los estudiantes, como partes esenciales de educación, estén preparados no sólo con habilidades pedagógicas, sino también con competencias adecuadas relacionadas con la tecnología digital para enfrentar estos cambios y desafíos en un nuevo escenario abierto por la COVID-19.

A pesar de que la educación offline se está retomando lentamente conforme al control de la epidemia, el avance de educación online es imparable. El entorno educativo se hace cada vez más complicado (Hatlevik y Christophersen, 2013). La educación actual necesita ser entendida y desarrollada a través del uso de las nuevas tecnologías, y la competencia digital de los participantes en educación es un factor fundamental (Caena & Redecker, 2019; Carini et al., 2006). Los profesores, como principales guías en el proceso de enseñanza y aprendizaje, deben tener una buena competencia digital, que se convierte en una contribución esencial a la del ejercicio de su profesión (Mangiri et al., 2019). Se considera que la educación superior desempeña un rol esencial para que los estudiantes adquieran habilidades para los contextos académicos y profesionales (Pérez-Mateo et al., 2014). Los estudiantes universitarios no sólo tienen que cumplir sus objetivos de aprendizaje, sino también deben adaptarse a las nuevas formas de organización de la vida social, política, económica y educativa, ya que posteriormente se incorporarán al mercado laboral. Además, en el siglo XXI, los estudiantes universitarios representan una generación que ha crecido con el espectacular desarrollo de las redes informáticas, experimentando el desarrollo sin precedentes de Internet, de la realidad virtual (RV) y de la inteligencia artificial (IA), y la exigencia de desarrollar una buena competencia digital se ha incrementado con la emergencia sanitaria producida por el COVID-19. En general, existe la necesidad de desarrollar nuevos profesionales con un amplio abanico de habilidades, con especial atención a la competencia digital (Cabero et al., 2018).

En 2006, la competencia digital fue incluida en la recomendación sobre competencias clave para el aprendizaje permanente que propone la Comisión Europea, junto con la comunicación en la lengua materna; la comunicación en lenguas extranjeras; la competencia matemática y competencias básicas en ciencia y tecnología; aprender a aprender; las competencias sociales y cívicas; el sentido de la

iniciativa y espíritu de empresa; y la conciencia y expresión culturales. La competencia digital se define como:

> el uso seguro y crítico de las tecnologías de la sociedad de la información (TSI) para el trabajo, el ocio y la comunicación. Se sustenta en las habilidades básicas de las TIC: el uso de ordenadores para recuperar, evaluar, almacenar, producir, presentar e intercambiar información, y para comunicarse y participar en redes de colaboración a través de Internet. (Comisión Europea, 2006, p. 15)

La Comisión Europea ha actualizado las ocho competencias clave para el aprendizaje permanente en 2018, entre las que se encuentran la competencia digital; la competencia en lectoescritura; la competencia multilingüe; la competencia matemática y competencia en ciencia, tecnología e ingeniería; la competencia personal, social y de aprender a aprender; la competencia ciudadana; la competencia emprendedora; y la competencia en conciencia y expresión culturales. La definición de competencia digital implica "el uso seguro, crítico y responsable de las tecnologías digitales para el aprendizaje, en el trabajo y para la participación en la sociedad, así como la interacción con estas" (Comisión Europea, 2018, p. 9). La definición de competencia digital refleja no sólo las habilidades para utilizar las tecnologías digitales, sino también el uso y la comprensión de los aspectos sociales y emocionales del uso de los dispositivos digitales y las tecnologías relacionadas. La competencia digital en el proceso de enseñanza y aprendizaje se entiende como el conocimiento, las habilidades y las actitudes asociadas a la tecnología cuando se utiliza la tecnología digital para alcanzar los objetivos y las expectativas educativas (Kim et al., 2018).

Se han propuesto diferentes estrategias para valorar y desarrollar la competencia digital de los ciudadanos, trabajadores y educadores (Centeno, 2020; Ferrari, 2012; Kluzer & Priego, 2018). En los países europeos, el Marco Europeo de competencia digital (DigComp) ha sido ampliamente comprendido y utilizado para desarrollar la competencia digital de los ciudadanos (Ferrari, 2013). DigComp es un proyecto que llevó a cabo el Joint Research Centre desde 2010 hasta 2013 con el objetivo de identificar los componentes clave de la competencia digital. Al cabo de varias fases, (mapeo conceptual, análisis de casos prácticos, consulta en línea, taller de expertos), se presentó un borrador consolidado de propuesta de marco de competencia digital, y se estableció una hoja de ruta que permitiera la realización y revisión del marco de competencia digital (Ala-Mutka, 2011; Ferrari, 2012, 2013; Janssen & Stoyanov, 2012). Varias versiones de DigComp se han presentado teniendo en cuenta el avance de las tecnologías digitales. DigComp se publicó por primera vez en 2013 con cinco áreas de competencia digital: información, comunicación, creación de contenidos, seguridad y resolución de problemas. Se actualizó en 2016 como DigComp 2.0, en donde se incluyó nuevo vocabulario y descriptores racionalizados para la competencia, manteniendo las cinco áreas de competencia digital, si bien se introdujeron modificaciones en la denominación de algunas: información y alfabetización digital, comunicación y colaboración, creación de contenidos digitales, seguridad y resolución

de problemas (Vuorikari et al. 2016). Además, se introdujeron modificaciones en las veintiuna competencias que se incluyen en estas áreas, así como en los descriptores de las mismas para simplificarlos y reducir la redundancia existente. En 2017, DigComp se desarrolló aún más hasta llegar a DigComp 2.1 con ejemplos de uso actualizados en contextos educativos y laborales y la ampliación de los tres niveles de competencia de DigComp 1.0 (básico, intermedio, avanzado) a ocho niveles de competencia (Carretero et al. 2017). Además, en la versión más reciente del DigComp, versión DigComp 2.2, publicada en marzo de 2022 se han incluido y actualizado ejemplos de conocimientos, habilidades y actitudes aplicables a cada competencia (Vuorikari et al., 2022). De igual forma, se han desarrollado una serie de marcos para contribuir al desarrollo de la competencia digital de los sujetos en diferentes ámbitos, como un Marco Europeo para Organizaciones Educativas Digitalmente Competentes (DigCompOrg) (Kampylis et al., 2015) y el Marco de cibercompetencias para los consumidores (DigCompConsumers) (Brečko et al., 2016).

En el ámbito educativo, se han presentado distintos marcos según las diferentes características de profesores y estudiantes. La Sociedad Internacional para la Tecnología en la Educación (ISTE) publicó los Estándares Nacionales de Tecnologías de Información y Comunicación para Docentes (NETS-T) y los Estándares Nacionales de Tecnologías de Información y Comunicación para Estudiantes (NETS-S), que ofrecen una hoja de ruta completa para el uso eficaz de la tecnología en las escuelas (ISTE, 2008, 2016). Hay varias propuestas de marcos que permiten analizar la competencia digital de los profesores. De entre la literatura existente sobre modelos de desarrollo de la competencia digital docente, destacan principalmente dos propuestas como son el Marco Europeo para la Competencia Digital de los Educadores (DigCompEdu) (Redecker, 2017) y el Marco Común de Competencia Digital Docente (INTEF, 2017). El DigCompEdu se articula a través de grandes propuestas de marcos internacionales para el profesorado, habiéndose elaborado a partir de trabajos previos (DigComp y DigCompOrg) y presentando 22 competencias digitales específicas para el educador, organizadas en seis áreas (Redecker, 2017). El Marco Común de Competencia Digital Docente del INTEF se desarrolla en España dentro del Marco Estratégico de Desarrollo Profesional Docente y del Plan de Cultura Digital en la Escuela, y apoya a las instituciones educativas, departamentos y educadores con una referencia descriptiva. Se divide en cinco áreas competenciales que comprenden 21 competencias que se han adaptado del DigComp 2.1 y del DigCompEdu. Ambos marcos presentan seis niveles de competencia progresiva de los educadores. Además, la Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura (UNESCO) ha propuesto un marco de competencias en TIC para profesores y un plan de estudios de alfabetización mediática e informacional para profesores (UNESCO, 2011, 2018). Por otra parte, el marco de Conocimiento del Contenido Pedagógico de la Tecnología (TPACK), que describe los conocimientos necesarios para que los profesores integren con éxito la tecnología en su enseñanza, ha sido adoptado por una amplia variedad de investigadores en el campo de la educación (Gur, 2015; Mishra y Koehler, 2006; Soler-Costa et al., 2021).

Antes de la pandemia, la competencia digital había sido mencionada y discutida mucho por los académicos (Hatlevik, et al., 2015; Røkenes & Krumsvik, 2014; Salazar Gómez et al., 2018). Ha sido un tema de interés en los diferentes estudios realizados en el ámbito educativo, ya que es una competencia clave (Ilomäki et al., 2016; Newland & Handley, 2016; Sánchez-Caballé et al., 2020). En el contexto del continuo desarrollo de las TIC y de un contexto educativo particular, el interés de los académicos por la competencia digital ha alcanzado un nuevo estatus (Sá & Serpa, 2020; Tejedor et al., 2020).

Con los cambios provocados por la pandemia y el desarrollo de las tecnologías, aparte de tener habilidades pedagógicas para enseñar, el trabajo con la tecnología digital se ha convertido en una parte fundamental del trabajo diario de los educadores. El impacto de la competencia y el juicio pedagógico de los docentes en el uso de las TIC como modelos digitales, en el proceso de enseñanza y aprendizaje sobre la calidad de la educación y la percepción de la competencia digital de los estudiantes, y su rendimiento académico, ha sido investigado en diferentes estudios. (Bai et al., 2016; Krumsvik, 2011; Starkey, 2020; Uerz et al., 2018). Para los demás protagonistas de la educación, esto es, los estudiantes, la competencia digital se relaciona positivamente con su rendimiento de aprendizaje (Hubbard, 2020; Nyikes, 2018). La brecha digital e incluso las desigualdades sociales existentes pueden profundizarse aún más debido a las condiciones asociadas a la competencia digital (Šuminas et al., 2018). Las cuestiones de competencia digital no son solo un componente de la condición digital de los participantes en el proceso educativo, sino que también son soluciones que pueden ayudar a los educadores a aliviar los problemas que han surgido en la actual sociedad del conocimiento con los efectos de la pandemia. Además, el concepto de competencia digital a veces se presenta, se compara y se discute junto con cuestiones de alfabetización digital (Spante et al., 2018). La competencia de los profesores en el uso de las TIC como parte del proceso de enseñanza tiene una fuerte conexión con la calidad de su educación.

En los últimos años, la importancia de explorar la competencia digital de profesores y estudiantes ha ganado atención en el campo de la investigación educativa, y como resultado, han aparecido diferentes estudios sobre el tema (Rodríguez-García et al., 2019). Como se ha mencionado anteriormente, la UNESCO ha presentado marcos de referencia para los profesores de todo el mundo (Marco de competencias en TIC para profesores; Currículo de alfabetización mediática e informacional para profesores). En los países occidentales se han introducido varios marcos bien desarrollados sobre la competencia digital de los ciudadanos (DigComp), de los profesores (CDCFT, DigCompEdu, NETS-T, TPACK) y de los estudiantes (NETS-S). Sin embargo, aún no se han introducido y publicado marcos específicamente diseñados para los sistemas educativos orientales, lo cual puede ser debido a que su sistema educativo es muy tradicional y se centra en la realización de exámenes teóricos y con menor peso de la práctica. Las características de los sistemas educativos de los países orientales son diferentes de las de los países occidentales, y las de los alumnos también (Ho, 2009; Sit, 2003).

Al otro lado del mundo, China tiene una gran población, siendo el país más poblado del mundo (Baidu, 2021). Es un país que cuenta con 325 millones de usuarios de educación en línea (China Internet Network Information Center, 2021). En comparación con los países occidentales desarrollados, China todavía está en proceso de informatización y digitalización. El ecosistema de la industria de la información en China ya se ha establecido, con las TIC y los desarrollos económicos y sociales profundamente integrados (Oficina General del Partido Comunista de China, 2016). Sin embargo, hasta la fecha no existe un marco específicamente diseñado para que los ciudadanos chinos evalúen su competencia digital. Aunque no se ha elaborado este marco, se han publicado y divulgado varios informes y libros azules para implementar el despliegue estratégico de la "China digital" y promover su progreso (Administración del Ciberespacio de China, 2020; Oficina de la Comisión Central de Asuntos del Ciberespacio, 2021). Además, estas publicaciones han mostrado la desigualdad en la informatización de la educación y el desarrollo digital de China (Wei y Wang, 2016). Las capacidades digitales de las personas son desiguales, lo que se refleja en la brecha informativa internacional y la brecha informativa nacional (Zhu, 2011). La brecha de información doméstica, por otra parte, se refleja entre regiones y poblaciones, y se caracteriza generalmente por un alto nivel en el sur y en este, y un bajo nivel en el norte y en el oeste (Wei y Wang, 2016). Aunque la tasa de penetración de Internet en China sigue mejorando y la brecha entre las zonas urbanas y rurales se está reduciendo (Centro de Información de la Red de Internet de China, 2021), se observa un desarrollo más lento en las regiones remotas del oeste frente a otras regiones.

En este estudio, nos centramos en la competencia digital de los profesores y estudiantes universitarios en el oeste de China, en concreto, en la Universidad Agrícola de Gansu. Universidad situada en Lanzhou, la capital de la provincia de Gansu, en el oeste de China, siendo una de las universidades clave de la región del medio oeste de China en la que el gobierno concentra su desarrollo. Los profesores y estudiantes de esta universidad han proporcionado un fuerte apoyo y recursos humanos para la construcción económica y el desarrollo social de la región occidental de China. Según el Plan de Acción para la Revitalización de la Formación del Profesorado (2018-2022), publicado por el Ministerio de Educación de China en 2018, se señala la necesidad de promover el desarrollo equitativo de la educación, fortalecer la formación del profesorado en la región del medio oeste, mejorar la calidad de la educación y el desarrollo de los estudiantes en las zonas más pobres, y seguir promoviendo una integración profunda de las tecnologías de la información y de la educación. Se trata de una región con un complejo historial educativo que es un factor importante en el desarrollo del proceso de digitalización e informatización de China (Lu, 2004).

Teniendo en cuenta la importancia de la competencia digital en el proceso educativo actual, y la brecha de desarrollo regional existente en China, es en este contexto donde surge la hipótesis que da sentido a esta investigación: la necesidad de analizar el estado del arte para poder realizar sugerencias razonadas, contrastadas y

estructuradas en el desarrollo de las competencias digitales en educación superior.

Los objetivos principales de esta tesis son:

- Determinar la competencia digital de los profesores universitarios de la Universidad Agrícola de Gansu
- Identificar la competencia digital de los estudiantes universitarios de primer y cuarto curso de la Universidad Agrícola de Gansu.

A partir de estos objetivos generales, se proponen los siguientes objetivos específicos:

- Realizar una revisión sistemática de la literatura con un estudio de Mapping sobre la competencia digital en educación superior.
- Describir la competencia digital de los profesores universitarios, con el apoyo del uso de las TIC, y sus opiniones sobre el uso de las TIC en educación.
- Analizar si existen diferencias significativas en la competencia digital de los profesores universitarios, el uso de las TIC y sus opiniones sobre el uso de las TIC en educación de acuerdo con las diferentes variables sociodemográficas.
- Describir la disponibilidad de recursos tecnológicos por parte de los estudiantes, el potencial de desarrollo de la competencia digital de los estudiantes y su formación relacionada con las TIC y la competencia digital.
- Identificar la competencia digital de los estudiantes universitarios a partir de sus experiencias y sus opiniones sobre las TIC.
- Averiguar si existen diferencias significativas de acuerdo con las variables sociodemográficas, la formación previa y los métodos de mejora de la competencia digital entre las experiencias de los estudiantes sobre la competencia digital y sus opiniones sobre las TIC.

El propósito general de este estudio es explorar y comprender la competencia digital de profesores y estudiantes en el oeste de China, a partir del ejemplo de la Universidad Agrícola de Gansu, para contribuir al futuro desarrollo de la competencia digital en esta región, señalar los factores que influyen en su competencia digital, detectar las necesidades de formación y determinar las direcciones de formación futuras, y apoyar el diseño de estrategias educativas relacionadas con el avance de la competencia digital. Se toma como punto de partida de esta área de investigación las siguientes preguntas de investigación:

- *¿Cuál es la competencia digital de los profesores universitarios de la Universidad Agrícola de Gansu para determinar sus necesidades?*
- *¿Cuál es la competencia digital de los estudiantes de primer y cuarto curso de la Universidad Agrícola de Gansu para determinar sus necesidades?*

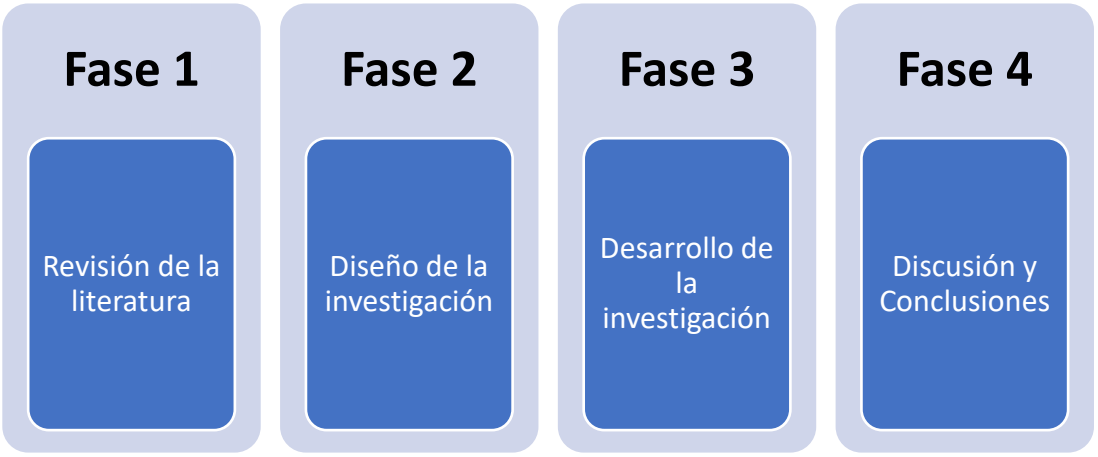
Esta tesis consta de una revisión sistemática de la literatura, un estudio empírico

realizado con los profesores universitarios y otro llevado a cabo con los estudiantes de primer y cuarto curso de la Universidad Agrícola de Gansu. Teniendo en cuenta los cambios cognitivos, se ha realizado el estudio especialmente con los alumnos de primer y cuarto curso. Con el fin de profundizar en el análisis y obtener una mejor comprensión, estos estudios tienen sus propios objetivos y preguntas de investigación, que se presentarán en sus correspondientes capítulos.

Para cumplir los objetivos de esta tesis, se siguió la siguiente metodología de investigación (Figura 1).

Figura 1

Fases de la metodología



Primero, se realizó una revisión de la literatura para comprender mejor la definición de competencia digital, identificar el estado de la investigación y determinar qué dimensiones podrían ser las más utilizadas y consideradas para evaluar la competencia digital de profesores y estudiantes, así como las posibles limitaciones de la investigación que podrían aparecer en los estudios relacionados con la competencia digital en el contexto de la educación superior. Para ello se realizó una revisión sistemática de la literatura (SLR) y un estudio de Mapping, siguiendo las pautas indicadas por García-Peñalvo (2017), García-Holgado y García-Peñalvo (2021), Kitchenham y Charters (2007) y Kitchenham et al. (2011),

En la segunda etapa, se planificó, diseñó y preparó un estudio empírico para llevarlo a cabo con los profesores universitarios y otro para estudiantes universitarios, de acuerdo con esquema presentado por Buendía et al. (1998). Considerando la Universidad Agrícola de Gansu como ejemplo, se conformaron la población y la muestra para cada estudio. Se siguieron metodologías de investigación cuantitativa. Después de diseñar cada cuestionario como instrumento de investigación, el proceso de validación fue llevado a cabo por un grupo de expertos en los campos de la metodología de la investigación, educación y lingüística.

En la tercera fase, tras validar el instrumento y revisar el cuestionario de acuerdo

con los comentarios de los expertos, se realizaron dos estudios empíricos con el fin de investigar por separado las experiencias de los profesores y los estudiantes sobre la competencia digital en una universidad del oeste de China. Los datos se recogieron, organizaron, codificaron y trataron estadísticamente. Se aplicaron análisis descriptivos e inferenciales (Van Dalen & Meyer, 1981), y posteriormente, se analizaron los resultados obtenidos.

Finalmente, en la cuarta etapa, se realizó una síntesis de los resultados obtenidos en estos estudios empíricos, realizados con profesores universitarios y estudiantes universitarios. A continuación, se resumieron y presentaron las conclusiones más importantes de la investigación basadas en los análisis de los resultados.

Esta tesis doctoral ha sido elaborada como compendio de artículos que abarcan la mayor parte del trabajo de investigación realizado. Sin embargo, no todos los capítulos incluidos en esta tesis han sido ya publicados, siendo algunos de ellos aportaciones originales.

La presente tesis se divide en tres partes. La primera parte se refiere a los aspectos teóricos y comprende el capítulo 2; la segunda parte se centra en la investigación empírica e incluye los capítulos 3 y 4; y la tercera parte consta del capítulo 5, en el que se presentan las conclusiones, las limitaciones encontradas y las perspectivas de futuras líneas de investigación.

Como se ha señalado, en el segundo capítulo, se revisa el estado del arte a través de una revisión sistemática de la literatura (SLR) y un estudio Mapping. Se examinan y analizan las investigaciones sobre la competencia digital desde 2015 hasta 2021 en el contexto de la educación superior. Esta revisión se ha publicado en la revista *Computer & Education* (Zhao, et al., 2021*)*.

La parte empírica comienza en el capítulo 3 con una investigación de las experiencias de los profesores universitarios sobre su competencia digital, tomando como caso de estudio a los profesores que trabajan en la Universidad Agrícola de Gansu. El diseño y desarrollo del estudio también se describe en este capítulo. La mayoría de los resultados de esta investigación se han publicado en la revista *Sustainability* (Zhao et al., 2021a).

El capítulo 4 presenta un estudio empírico que explora la competencia digital de los estudiantes universitarios, que, al igual que en el capítulo anterior, se desarrolla a través de una estancia de investigación en China como parte del proceso de investigación de esta tesis. La muestra del estudio procede de los estudiantes de primer y cuarto curso de la Universidad Agrícola de Gansu, situada en el oeste de China. La mayoría de los resultados de esta investigación se han publicado en la revista *Sustainability* (Zhao et al., 2021b).

Por último, en el quinto capítulo se presentan las conclusiones más relevantes derivadas de los diferentes estudios de investigación, así como las limitaciones existentes y las posibles futuras direcciones de investigación derivadas de esta tesis.

2. Estado del arte

En los últimos años, la competencia digital se ha convertido en un concepto crucial a la hora de debatir las habilidades y los conocimientos que deben tener las personas en la sociedad del conocimiento (Ilomäki et al., 2016). Sin embargo, no es un concepto normalizado y sigue sin estar claro cómo definirlo (Spante et al., 2018), ya que la competencia digital es un concepto en evolución, que se asocia con el avance de la tecnología digital, así como con los objetivos políticos a alcanzar y las expectativas de la ciudadanía.

Varios términos han sido introducidos para describir las habilidades y competencias en el uso de la tecnología digital. El concepto de competencia digital y de alfabetización digital se ha debatido con frecuencia. Existe una relación cercana entre la competencia digital y la alfabetización digital, que, aunque tienen significados diferentes, a veces se mencionan como sinónimos y se utilizan para apoyarse mutuamente (Iordache et al., 2017; Martin & Grudziecki, 2006). Se observan variaciones regionales en la citación de estos conceptos. Las investigaciones sobre competencia digital suelen realizarse en países europeos, sin contar con el Reino Unido, mientras que las de alfabetización digital se realizan en países de habla inglesa (Spante et al., 2018). Se entiende por competencia digital la habilidad de explorar y afrontar nuevas situaciones tecnológicas de forma flexible, analizar, seleccionar y evaluar críticamente datos e información, explotar las potencialidades tecnológicas para representar y resolver problemas, y construir un conocimiento compartido y colaborativo, al tiempo que se fomenta la conciencia de las propias responsabilidades personales y el respeto de los derechos/obligaciones recíprocas (Calvani et al., 2009). En otras palabras, se trata de un concepto que señala lo que debe tener hoy en día el ciudadano en una sociedad del conocimiento (Ilomäki et al., 2016). Por otro lado, la alfabetización digital tiene más tradición que la competencia digital, siendo una representación de la capacidad de una persona para realizar tareas de forma eficaz en un entorno digital (Jones-Kavalier y Flannigan, 2008). También se considera como la combinación de la alfabetización informática, la alfabetización informacional y la alfabetización mediática (Paynton, 2012). Sin embargo, en algunos países, la diferenciación entre la competencia digital y la alfabetización digital se ha difuminado por razones como la traducción (Madsen et al., 2018).

A lo largo de los últimos años, se han publicado diversas revisiones sobre la competencia digital y la alfabetización digital (Coronel et al., 2018; Esteve-Mon et al., 2020; Marta-Lazo et al., 2020; Pettersson, 2018; Spante et al., 2018; Sánchez-Caballé et al., 2020). A pesar de que estos estudios han proporcionado diferentes perspectivas para entender la competencia digital, todavía no es fácil entender completamente la competencia digital de los profesores y estudiantes en el contexto de la educación superior.

Para obtener una visión general del estado actual y el desarrollo de las competencias digitales de estudiantes y profesores en educación superior, se lleva a cabo una revisión sistemática de la literatura (SLR) y un estudio de Mapping para analizar el estado del arte (García-Peñalvo, 2017; Kitchenham, 2004; Kitchenham &

Charters, 2007; Kitchenham et al., 2011).

La revisión sistemática de la literatura recoge y analiza críticamente múltiples estudios o trabajos de investigación a través de un proceso sistemático, junto con el estudio Mapping proporciona una revisión exhaustiva de la literatura y ayuda a presentar un marco conceptual que contextualiza la competencia digital de los estudiantes y profesores de la nueva era en educación superior. Estas metodologías de revisión reúnen la información que responde a las preguntas de investigación propuestas por los autores, evalúan e interpretan el trabajo de los investigadores, académicos y profesionales e identifican las tendencias y las lagunas de la literatura en el campo elegido (Fink, 2019).

Además, las técnicas del estudio de Mapping en la revisión de la literatura complementan la SLR, las cuales son útiles al principio de la SLR como una herramienta de generación de ideas y contextualización (Proyecto CASCADE, 2012, citado en García-Peñalvo, 2017), facilitando así el proporcionar una visión general de la investigación realizada sobre un tema, y ayudando a identificar las áreas más exploradas, los autores más relevantes o el desarrollo del interés del investigador.

En comparación con la revisión bibliográfica tradicional, la SLR tiene características ordenadas, explícitas y reproducibles. Sánchez-Prieto (2018) indica que: "permite analizar grandes cantidades de documentos de manera estructurada. Así mismo, también facilita la extracción de la información necesaria para responder las preguntas de investigación siguiendo unas líneas metodológicas establecidas que permiten el registro de cada paso dado en la revisión" (p. 23).

Para llevar a cabo esta revisión bibliográfica, se siguieron los pasos de investigación propuestos por García-Peñalvo (2017) y Kitchenham y Charters (2007), y en función de ello se construyó el presente capítulo.

En la primera sección, presentamos la metodología seguida para la revisión de la literatura. En la segunda sección, recogemos y presentamos los resultados del estudio de Mapping y de la SLR, y respondemos a las preguntas de investigación. En la tercera sección, indicamos las limitaciones que surgen en esta revisión. Al final, en la última parte del capítulo indicamos las conclusiones más relevantes obtenidas. Esta revisión sistemática de la literatura se ha publicado en la revista *Computer & Education* (Zhao et al., 2021).

2.1 Metodología

En esta sección se presenta la metodología empleada para buscar y seleccionar los estudios de esta revisión bibliográfica sistemática. Seguimos las directrices de García-Peñalvo (2017) y Kitchenham y Charters (2007).

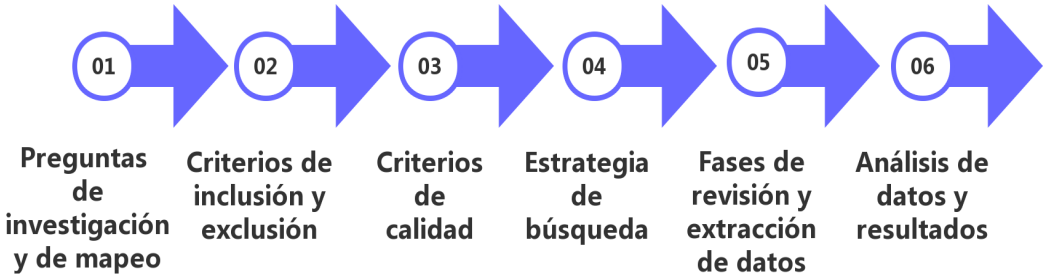
A continuación, se detallan las preguntas de investigación planteadas. Al principio de la revisión, las preguntas de investigación deben estar claramente expuestas, así como las cuestiones a responder. Se indican los criterios establecidos

para la selección y la evaluación de los estudios, y las bases de datos elegidas para la búsqueda, así como las cadenas de búsqueda. Tras revisar los artículos y valorar su calidad, presentamos las publicaciones que se incluyeron al final del proceso, junto a los resultados correspondientes.

La figura 2 muestra el proceso de la revisión (García-Peñalvo, 2017).

Figura 2

Proceso de la revisión sistemática de la literatura



2.1.1 Preguntas de investigación

En este trabajo de doctorado se formularon dos series de preguntas diferentes para el estudio de Mapping y la SLR.

El objetivo era obtener una visión general de la situación y el desarrollo de la competencia digital de profesores y estudiantes en la enseñanza superior. Para obtener resultados recientes y relevantes se han limitado los años de búsqueda de publicaciones. Se formularon las siguientes preguntas en el estudio de Mapping:

PM1. ¿Cómo ha evolucionado el número de publicaciones sobre la competencia digital a lo largo de los años 2015 a 2019?

PM2. ¿Cuáles son los autores más prolíficos en el campo de estudio?

PM3. ¿Qué tipo de publicaciones son las más habituales en el campo de estudio?

PM4. ¿En qué países se ha desarrollado un mayor número de investigaciones?

PM5. ¿Cuáles son las palabras claves utilizadas para hablar sobre la competencia digital en educación superior?

PM6. ¿Qué colectivos son analizados con mayor frecuencia?

Por otro lado, las preguntas de la SLR profundizan los análisis sobre el tema elegido convirtiéndolos en preguntas mucho más específicas y refinadas. En el siguiente apartado se encuentran las preguntas formuladas para la SLR:

PI1. ¿Cómo se define la competencia digital en función del profesorado y del

alumnado en el contexto de educación superior?

PI2. ¿Cuáles son las dimensiones que se suelen utilizar para evaluar la competencia digital de los docentes y estudiantes universitarios?

PI3. ¿Cuáles han sido los principales objetivos, metodologías y resultados de las investigaciones sobre la competencia digital en el contexto de la educación superior en los últimos siete años?

PI4. ¿Qué tipo de limitaciones existen en las investigaciones de competencia digital en educación superior?

Las preguntas del Mapping y SLR aclaran el área del problema, con lo que podemos proponer una ruta adecuada, identificar las lagunas de conocimiento y presentar las necesidades de investigación que se deben plantear en el futuro.

2.1.2 Criterios de selección

Se establecieron los siguientes criterios para seleccionar los estudios relevantes para obtener respuestas a las preguntas de investigación propuestas.

Los criterios de inclusión son:

- **CI1.** Los trabajos de investigación están relacionados con la competencia digital del profesorado o del alumnado en el contexto de educación superior.
- **CI2.** La publicación incluye estado del arte sobre la competencia digital.
- **CI3.** Los trabajos de investigación están publicados entre 2015 y 2021.
- **CI4.** Los trabajos de investigación están escritos en inglés.
- **CI5.** Los trabajos de investigación han sido publicados tras ser sometidos a un proceso de revisión de pares.
- **CI6.** La versión completa de la publicación está disponible a través de la suscripción de nuestra institución o por parte de las asociaciones de las que somos miembros.
- **CI7.** Las investigaciones siguen la estructura adecuada de una investigación de acuerdo al método de investigación.

Y los criterios de exclusión son:

- **CE1.** Los trabajos de investigación no están relacionados con la competencia digital del profesorado o del alumnado en el contexto de educación superior.
- **CE2.** La publicación no incluye el estado del arte sobre la competencia digital.
- **CE3.** Los trabajos de investigación no están publicados entre 2015 y 2021.
- **CE4.** Los trabajos de investigación no están escritos en inglés.
- **CE5.** Los trabajos de investigación han sido publicados sin someterse a un

proceso de revisión de pares.

- **CE6.** La versión completa de la publicación no está disponible a través de la suscripción de nuestra institución o por parte de las asociaciones de las que somos miembros.
- **CE7.** Las publicaciones no siguen la estructura adecuada de una investigación de acuerdo al método de investigación.

Para asegurar la calidad, hemos propuesto unos criterios de calidad a los que se someten los estudios que superan los criterios de inclusión y exclusión. Dichos criterios son los siguientes:

1. ¿Se define claramente el concepto de competencia digital?
2. ¿Los objetivos de investigación están claramente especificados?
3. ¿El estudio está diseñado para alcanzar los objetivos?
4. ¿Se describe claramente el instrumento y se fundamenta su diseño?
5. ¿Se describe claramente la muestra y la población del estudio, su tamaño es suficiente para realizar los análisis propuestos?
6. ¿Se ha respondido adecuadamente a las preguntas de investigación?
7. ¿Se describe claramente las conclusiones y están basadas en los resultados?
8. ¿Los autores discuten los problemas y limitaciones de la investigación?
9. ¿Se describe alguna sugerencia sobre competencia digital en educación superior en función del profesorado o del alumnado?
10. ¿Se presentan las líneas futuras de investigación?

En total son diez preguntas que conforman los criterios de calidad, y estas preguntas tienen tres opciones para responderse: sí (1 punto), no (0 punto) y parcial (0,5 punto). A las publicaciones se les asigna una puntuación de acuerdo a las respuestas obtenidas de acuerdo a las preguntas señaladas. Los trabajos que se incluyen en el proceso final deben obtener o superar el valor 7,5 puntos. Por lo tanto, esta puntuación es la nota de corte para la selección de los trabajos.

2.1.3 Selección de bases de datos

Se seleccionaron las bases de datos electrónicas Web of Science (WOS) y SCOPUS para realizar esta revisión sistemática de la literatura. Teniendo en cuenta que Web of Science y Scopus fueron seleccionados como las principales bases de datos para la literatura académica multidisciplinaria internacional (Aghaei Chadegani et al., 2013).

Estas bases de datos cumplen los requisitos necesarios que se mencionan por Sánchez-Prieto (2018) en el proceso de una SLR:

> La base de datos permite el uso de expresiones lógicas para realizar el proceso de búsqueda; búsquedas en todo el texto de los trabajos o en campos específicos; el acceso a los artículos a través de cuentas institucionales o suscripciones personales; y es relevante e incluye solamente trabajos de contrastada calidad. (p. 27)

2.1.4 Cadena de búsqueda

A partir de las diferentes preguntas de investigación y de los criterios de inclusión indicados anteriormente, se formularon las cadenas de búsqueda que se emplean en los buscadores. En la WOS se utilizó la cadena de búsqueda siguiente:

WOS: TS= (("digital competence*" OR "digital abilit*" OR "digital skill*") AND ("higher education" OR "universit*" OR "college*"))

Los mismos términos se aplicaron en Scopus para adaptar el operador booleano a las características del sistema de búsqueda de la base de datos, y finalmente se adoptó la siguiente la cadena de búsqueda:

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

Hay que tener en cuenta que, deliberadamente, limitamos la búsqueda de títulos, resúmenes y palabras clave en las bases de datos como estrategia de búsqueda para aumentar la precisión de la búsqueda de información (Guo and Huang 2011; Spante et al., 2018; Savolainen, 2016). Al mismo tiempo, para tener todas las publicaciones relacionadas con el tema de interés, en la cadena de búsqueda intentamos utilizar todos los términos que se relacionan con la competencia digital y la educación superior, incluyendo no solo los términos en singular, sino también en plural.

2.1.5 Proceso de selección

Se llevó a cabo el proceso de selección de revisión, dividiéndolo en tres fases.

En la primera fase, los resultados de la búsqueda en las dos bases de datos se resumieron y recopilaron en una hoja de cálculo EXCEL para registrar todo el proceso de selección. Se obtuvieron un total de 1410 documentos (765 en WOS y 645 en Scopus). Después de registrar toda la publicación obtenida, se filtraron y eliminaron 225 estudios duplicados antes de aplicar los criterios de inclusión y exclusión. Finalmente se contó con 1185 publicaciones para pasar a la siguiente fase.

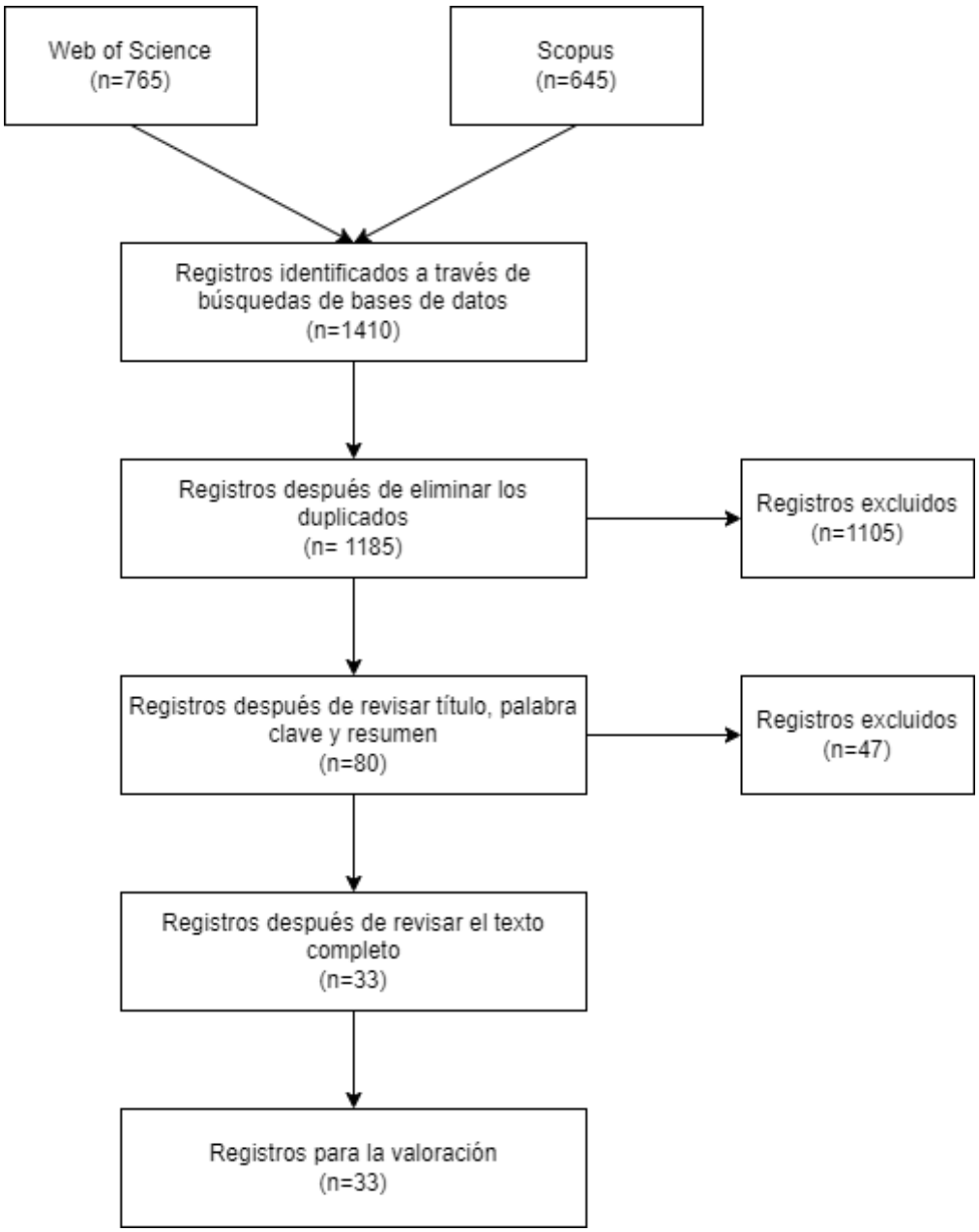
En la segunda fase, se aplicaron los criterios de inclusión y exclusión mediante la revisión del título, las palabras clave y el resumen de las publicaciones. Las publicaciones que no podían ser decididas con estos recursos se dejaban para la siguiente fase, en la que se revisaba el texto completo de la publicación y se profundizaba en el contenido aplicando nuevos criterios de calidad. En esta fase, el número de documentos se redujo a 80.

Por último, se aplicaron los criterios junto con las preguntas de calidad, se seleccionaron las publicaciones con una puntuación de 7,5 o superior y se eliminaron las publicaciones con una puntuación inferior a esta. Al final, hay 33 publicaciones seleccionadas para responder a las preguntas de investigación.

Se utilizó el flujo PRISMA para mostrar los pasos de selección de los documentos como se muestra en la Figura 3 (Pati & Lorusso, 2018).

Figura 3

Proceso de selección de documentos



2.2 Resultados

En esta sección se responde a las preguntas de investigación a través del análisis de las 33 investigaciones seleccionadas. Esta parte se formula por las preguntas planteadas que se presentan los resultados del estudio Mapping primero y luego los resultados de la SLR.

2.2.1 Resultados del estudio Mapping

Para responder a la primera pregunta del estudio Mapping, que se refiere a la evolución del número de estudios de investigación sobre la competencia digital, se analizó el año de publicación de los estudios.

A pesar de haber limitado la búsqueda de 2015 a 2021, no fue hasta 2016 cuando se recogieron las primeras publicaciones sobre la competencia digital en el contexto de la educación superior. No se mostraron publicaciones en el año de 2021, ya que no hubo publicaciones que cumplieran con los criterios de selección antes de la fecha de terminación de la búsqueda (enero de 2021). Según los resultados de las 33 publicaciones seleccionadas, hasta el año 2018, el interés por el tema de la competencia digital siguió aumentando, desde 2015 con cero publicaciones registradas hasta 2018 con un total de quince publicaciones registradas. Sin embargo, el número de publicaciones disminuyó a seis en 2019. Y el número de publicaciones relevantes llegó a 11 en 2020. En general, la investigación sobre la competencia digital en el contexto de la educación superior ha recibido una atención creciente en los últimos años.

La segunda pregunta de Mapping está centrada en los autores más relevantes de los trabajos de investigación publicados. Después de revisar los nombres de los autores de las publicaciones, encontramos que los autores con más publicaciones son Francisco David Guillén-Gámez y María José Mayorga-Fernández, con cuatro publicaciones centradas en la competencia digital en la enseñanza superior, y Tao He, que tiene tres publicaciones, prestando atención al aprendizaje digital de la educación informal.

En cuanto a la tercera pregunta PM3, que es el tipo de publicaciones más habitual en el ámbito de la investigación, destaca que todas las publicaciones se han realizado en revistas de investigación. Las revistas en las que se publicaron los estudios son diferentes. La mayoría de los artículos seleccionados (n=6) se han publicado en la revista *International Journal of Educational Technology in Higher Education*, seguida de *Sustainability*, en la que se publicaron cinco de ellos.

En cuanto a los países en los que se realizaron más investigaciones (PM4), se observa que el contexto español es el que destaca con una mayor producción científica. Le sigue China con tres publicaciones centradas en los contextos de aprendizaje informal digital, mientras que en otros países como Irlanda, Portugal y Corea del Sur se han registrado dos publicaciones. En general, los países europeos son los que han

demostrado un mayor interés por explorar la competencia digital. De los 33 estudios elegidos, siete de ellos incluían muestras de más de un país.

Respecto a las palabras clave más utilizadas en el estudio sobre la competencia digital en educación superior (PM5), tras la revisión de las 33 publicaciones seleccionadas, las palabras claves con mayor frecuencia fueron "Competencia digital" (n=19), "Educación superior" (n=13), "TIC" (n=10) y "Alfabetización digital" (n=4).

La pregunta PM6 se refiere a los colectivos más frecuentemente analizados. Entre los 33 estudios seleccionados, la mayoría se centró en los estudiantes universitarios, especialmente de las titulaciones de educación, mientras que había seis publicaciones en las que sus participantes eran profesores.

En la Tabla 1 se ofrece un resumen de las respuestas del Mapping.

Tabla 10

Resumen de las respuestas a las preguntas del Mapping

Preguntas de Mapping	Respuesta
PM1	Desde 2015 hasta 2021, aunque ningún estudio ha sido seleccionado antes de 2016, se observa una tendencia general al alza en el interés de la investigación sobre la competencia digital en educación superior.
PM2	En relación a las publicaciones analizadas, los autores que más han publicado son Francisco David Guillén-Gámez y María J. Mayorga-Fernández con cuatro publicaciones.
PM3	Todos los estudios (n=33) han sido publicados en revistas de investigación. La mayoría de los estudios seleccionados han sido publicados en la revista *International Journal of Educational Technology in Higher Education*.
PM4	En las publicaciones seleccionadas, la mayoría de los estudios sobre este tema se realizaron en España.
PM5	Las palabras clave más utilizadas en los estudios seleccionados sobre la competencia digital en educación superior han sido "competencia digital", "educación superior" y "TIC".
PM6	Los colectivos más frecuentemente analizados han sido estudiantes, especialmente de las titulaciones de educación.

2.2.2 Resultados de la SLR

La primera pregunta de la SLR se centra en explorar y resumir la definición de competencia digital en el contexto de la educación superior.

Para aclarar la definición de la competencia digital, 21 de los 33 artículos seleccionados citan tanto los trabajos de investigación como los documentos o informes de política de la Unión Europea (UE) al describir la definición de la competencia digital, siete de ellos definen la competencia digital refiriéndose simplemente a los documentos de política de la UE y cinco publicaciones hacen referencia a los trabajos de investigación anterior como una base para la definición del concepto.

Entre las publicaciones seleccionadas, la mayoría definen la competencia digital de forma general. Diez publicaciones explican particularmente el concepto de competencia digital en relación a los profesores, y cuatro publicaciones indican la competencia digital desarrollada entre los estudiantes de educación superior.

En esta revisión de la literatura, la definición de competencia digital por referencia a documentos o informes de la UE es bastante común. La siguiente definición de competencia digital presentada por Ferrari (2012) ha sido señalada en 11 artículos:

> La competencia digital es un conjunto de conocimientos, habilidades, actitudes, estrategias y concienciación que se requieren cuando se utilizan las TIC y los medios digitales para realizar tareas, resolver problemas, comunicarse, gestionar información, colaborar, crear y compartir contenidos, y compartir conocimiento de forma efectiva, eficaz, adecuada, crítica, creativa, autónoma, flexible, ética, reflexiva para el trabajo, el ocio, la participación, el aprendizaje, la socialización, el consumo y el empoderamiento. (p. 30)

El informe redactado por Ferrari (2012, 2013) ha presentado una hoja de ruta para la posible utilización y revisión de un marco de competencias digitales y ha propuesto descriptores de competencias digitales para los estudiantes de todos los niveles. En los informes de Ferrari se destaca el conjunto de competencias que necesitan los ciudadanos de hoy en día para conseguir la plena inclusión digital y la importancia de incorporar la tecnología digital en el proceso educativo.

Nueve de las publicaciones seleccionadas hacen referencia al Marco de Referencia Europeo de Competencias Clave para el Aprendizaje Permanente presentado por la Comisión Europea. Indicando que la competencia digital ha sido identificada como una de las ocho competencias clave para el aprendizaje permanente, definiendo la competencia digital como "el uso seguro y crítico de las tecnologías de la sociedad de la información para el trabajo, el ocio y la comunicación. Se sustenta en las habilidades básicas de la tecnología de la información y la comunicación: el uso de ordenadores para obtener, evaluar, almacenar, producir, presentar e intercambiar información; y para comunicarse y participar en redes de colaboración a través de Internet" (Comisión Europea, 2006, p. 15). Para responder a la necesidad de un crecimiento inclusivo y sostenible, a la cohesión social y a un mayor desarrollo de la

cultura democrática, estas ocho competencias claves para el aprendizaje permanente han sido actualizadas en 2018 (Comisión Europea, 2018). La competencia digital se entiende como "el uso seguro, crítico y responsable de las tecnologías digitales y el compromiso con ellas para el aprendizaje, el trabajo y la participación en la sociedad" (Comisión Europea, 2019, p. 10).

Además, cinco artículos se refieren al Marco Europeo de Competencias Digitales para la Ciudadanía presentado por la Comisión Europea al definir e introducir la competencia digital. Teniendo en cuenta la insuficiencia del nivel de competencia digital de los ciudadanos de la UE, el DigComp se ha establecido para identificar la competencia digital del ciudadano de la UE y convertirse en una herramienta para mejorar y apoyar la competencia digital. Ahora también se conoce como un marco de referencia para apoyar el desarrollo de estrategias y políticas y el avance de la competencia digital en un contexto más amplio. DigComp se publicó en 2013 con cinco áreas de la competencia digital, como la información, la comunicación, la creación de contenidos, la seguridad y la resolución de problemas como parte de un proyecto sobre la competencia digital y proporcionó no solo una tabla de autoevaluación, sino también una visión general descriptiva de los diferentes aspectos de la competencia digital. DigComp se actualizó en DigComp 2.0 en 2016 con nuevo vocabulario y descriptores racionalizados para la competencia, y las cinco áreas de competencia digital se han modificado y reconocido como información y alfabetización digital, comunicación y colaboración, creación de contenidos digitales, seguridad y resolución de problemas (Vuorikari et al. 2016). En 2017, DigComp 2.0 se desarrolló aún más hasta llegar a DigComp 2.1 con casos de uso en contextos de aprendizaje y empleo y la actualización de los tres niveles de competencia de DigComp 1.0 (básico, intermedio, avanzado) a ocho niveles de competencia (Carretero et al. 2017). Está estructurado por dimensiones, y dentro de estas categorías hay subcompetencias específicas que se pueden medir en ocho niveles de competencia, que van desde "básico" hasta "altamente especializado" (McGuinness & Fulton, 2019). Además, en 2022 se ha publicado la última versión DigComp 2.2, que incluye ejemplos de conocimientos, habilidades y actitudes aplicables a cada competencia y consolida documentos de referencia clave sobre DigComp (Vuorikari et al., 2022).

A partir de ello, el Marco Europeo de Competencia Digital para Educadores (DigCompEdu) ha permitido consolidar y promover este marco a nivel internacional (Gallego Arrufat et al., 2019). DigCompEdu, que fue publicado en 2017 por la Comisión Europea, proporciona un marco general y científicamente sólido que expone la importancia de la competencia digital para los educadores y apoya el desarrollo de la competencia digital específica para los educadores en todos los niveles (Comisión Europea, 2017). En DigCompEdu, la competencia digital se define como la capacidad de las personas para utilizar las tecnologías de la información y la comunicación de forma segura, crítica y creativa para alcanzar diversos objetivos relacionados con su inclusión y participación en la sociedad (Guillén-Gámez & Mayorga-Fernández, 2020a). La competencia digital del educador en DigCompEdu está identificada en seis áreas por Redecker (2017): compromiso profesional, recursos digitales, enseñanza y

aprendizaje, evaluación, empoderamiento de los estudiantes y facilitación de la competencia digital de los estudiantes (Ryhtä et al., 2020). Se propone un modelo de progresión para ayudar a los educadores a entenderse mejor a sí mismos a lo largo de seis niveles de competencia, desde el A1 (principiante) hasta el C2 (pionero), haciendo referencia al Marco Común Europeo de Referencia para las Lenguas (MCER). DigCompEdu construye un modelo de competencia digital para los educadores siguiendo una progresión lógica (Romero-Tena et al., 2020).

La Competencia Digital Docente (CDD) fue mencionada por Ortega-Sánchez et al., (2020) e indicaron que puede ser entendida como "el conjunto de conocimientos, habilidades y actitudes necesarias para ser funcional en un entorno de enseñanza digital" (p. 2). Se utiliza para ayudar a los profesores a resolver problemas en el proceso educativo mediante la integración de las TIC (Cabero-Almenara et al., 2020). Siendo conscientes de la necesidad de la formación en TDC, en el estudio de López-Belmonte et al. (2019) también se ha presentado el Marco Común de Competencia Digital Docente que fue propuesto por el Instituto Nacional de Tecnologías Educativas y de Formación del Profesorado (INTEF) de 2017. Se trata de un marco descriptivo establecido para la formación del profesorado y el proceso de evaluación y acreditación, alineado con las cinco áreas competenciales de DigComp y con objetivos de proyecto similares a DigCompEdu (Cabero-Almenara et al., 2021; INTEF, 2017). Se trata de un marco descriptivo establecido con fines de formación del profesorado y del proceso de evaluación y acreditación, con un total de 21 competencias en cinco áreas competenciales adaptadas de DigComp 2.1, teniendo objetivos de programa similares a DigCompEdu, que establece seis niveles para cada competencia, con descriptores basados en conocimientos, habilidades y actitudes (Cabero-Almenara et al., 2021). Cada una de las competencias de las cinco áreas del marco tiene tres dimensiones, desde la primaria hasta la avanzada, que son "básica" (A1, A2), "intermedia" (B1, B2) y "avanzada" (C1, C2) (INTEF, 2017).

Además de las referencias a las políticas e informes relacionados con la Comisión Europea, y la definición de competencia digital presentada por otras organizaciones internacionales, el Departamento de Educación de los Estados Unidos (1996) ha sido referido por Cote y Milliner (2017), entendiendo competencia digital como tener habilidades y destrezas informáticas para utilizar los ordenadores y otras tecnologías para mejorar el aprendizaje, la productividad y el rendimiento. En el trabajo de Romero-Tena et al. (2020), explica el trabajo teórico de la Sociedad Internacional para la Tecnología en la Educación (ISTE) con el propósito de ayudar a los educadores a convertirse en aprendices digitalmente empoderados. Bond et al. (2018) destacan que el desarrollo de las habilidades de las TIC y la competencia relacionada con lo digital y la digitalización de las instituciones de educación superior son cada vez más importantes sobre la base de los trabajos de la Organización para la Cooperación y el Desarrollo Económicos (OCDE) (2015, 2018).

Hay 21 publicaciones que describen la definición de competencia digital, utilizando tanto documentos políticos como investigaciones. Los artículos presentados

por Calvani et al. (2009, 2012) han atraído la atención a la hora de definir la competencia digital, afirmando que se trata de una combinación de habilidades concretas y no cuantificables que pueden utilizarse para explorar y afrontar nuevas situaciones tecnológicas de forma flexible (Byungura et al., 2018; He & Zhu, 2017; He et al., 2018). En el trabajo de Calvani et al. (2012) y en la definición de competencia digital propuesta por Calvani et al. (2009) se ha clasificado la competencia digital en tres dimensiones y se ha destacado la coexistencia de las dimensiones práctica, cognitiva de alto orden y socio-ética, así como la integración entre estas tres dimensiones. En tres artículos, citan los resultados de la exploración de Janssen et al. (2013) sobre la competencia digital, considerándola como un concepto diverso y descriptivo de una red de intrincados propósitos, dominios y niveles de uso de las TIC. Se presenta un carácter dinámico y transversal, y engloba habilidades cognitivas, actitudinales y técnicas que ayudan a paliar muchos de los problemas y retos de la sociedad del conocimiento (Gallego-Arrufat et al., 2019; Guillén-Gámez et al., 2020; He & Li, 2019). En el estudio de Guillén-Gámez y Mayorga-Fernández (2020a), se encuentra una comprensión similar de la competencia digital a través de su referencia a Lázaro-Cantabrana et al. (2019) y From (2017). Por otra parte, la competencia digital tal y como la presenta Larraz (2013) incluye las dimensiones informativa, tecnológica, multimedia y comunicativa, así como su asociación con la alfabetización digital, la alfabetización mediática, la alfabetización en TIC, la alfabetización informativa y la alfabetización en Internet también se reflejan en los artículos seleccionados (Esteve-Mon et al., 2019; He et al., 2018). La dimensión informativa se enfatiza en el estudio de Sales et al. (2020) haciendo referencia a la información de actualización de Clip (2018). Además, la competencia digital se describe como "valores, conocimientos y habilidades que determinan la experiencia o competencia de un individuo en una tecnología concreta" (Byungura et al., 2018, p. 32). A través de referencias a Venkatesh et al. (2003) y Hatlevik y Christophersen (2013), la competencia digital se considera como la capacidad de los estudiantes para utilizar la tecnología o la autoeficacia de las TIC, que se cree que demuestra cómo los estudiantes utilizan la tecnología digital para producir y comunicar información.

En la presente SLR, cinco publicaciones definen la competencia digital a partir de estudios de investigación. Ala-Mutka (2011) presenta una cartografía conceptual de la competencia digital. Considerándolo como referencia, el concepto de competencia digital en este trabajo se entiende como un conjunto de tecnologías relacionadas con los conocimientos, habilidades y actitudes utilizadas para identificar y analizar lo que los estudiantes deben ser capaces de lograr a través de las tecnologías digitales, y apoya el uso intencionado y eficaz de la tecnología en el trabajo académico (Blayone et al., 2018; Kim et al., 2019). En referencia a Ananiadou y Claro (2009) y Navarro et al. (2016), se considera también como competencia digital pedagógica, que consta de tres aspectos: actitudes hacia las TIC, conocimientos y uso educativo de dichas tecnologías (Guillén-Gámez & Mayorga-Fernández, 2020b). Gutiérrez Porlán y Serrano Sánchez (2016) ha realizado una introducción a la complejidad del concepto de competencia y ha utilizado la expresión competencia al explicar la definición de

competencia digital (Cebrián & Junyent, 2015; Muñoz, 2008). En otras publicaciones seleccionadas se aplica una descripción o identificación de capacidades y habilidades para presentar la competencia digital (Gutiérrez Porlán & Serrano Sánchez, 2016; He et al., 2018)

La segunda pregunta del SLR (PI2) se refiere a las dimensiones que se utilizan habitualmente para valorar la competencia digital de los profesores y los estudiantes en educación superior.

Se han mostrado varios aspectos y diferentes puntos de vista para valorar la competencia digital de estudiantes y profesores. La mayoría de las publicaciones seleccionadas utilizan una encuesta como instrumento de investigación. Al examinar y comparar las dimensiones que tienen en los instrumentos, encontramos que nueve publicaciones han seguido y establecido sobre la base de las dimensiones presentadas por DigComp 1.0 y DigComp 2.0, que incluían cinco dimensiones: información; comunicación; creación de contenidos; seguridad; resolución de problemas hasta información y alfabetización digital; comunicación y colaboración; creación de contenidos digitales; seguridad; resolución de problemas. Otras seis publicaciones utilizaron y variaron las dimensiones de sus instrumentos basándose en las dimensiones tecnológica, cognitiva y ética (Calvani et al., 2012; Janssen et al., 2013), mientras que otras publicaciones establecieron su instrumento con otros marcos teóricos desde diferentes aspectos. Las dimensiones más comunes utilizadas en el resto de las publicaciones son el uso y el conocimiento de las TIC, las capacidades relacionadas con Internet y las TIC, la experiencia relacionada con la tecnología digital y las actitudes hacia las tecnologías digitales.

Con respecto a la tercera pregunta de investigación, sobre cuáles fueron los principales objetivos, metodologías y resultados de la investigación en los estudios de la competencia digital en el contexto de la educación superior durante los últimos siete años (PI3), se investiga y explica el progreso de la investigación relacionada con la competencia digital en educación superior durante los últimos siete años.

Los objetivos de investigación de las publicaciones seleccionadas se clasifican en cinco categorías diferentes:

- Investigar y analizar la percepción y el nivel de competencia digital de los participantes en educación superior.
- Determinar los factores que pueden influir en la competencia digital.
- Conocer el impacto de la competencia digital en el rendimiento de los participantes, refiriéndose aquí especialmente a los estudiantes.
- Analizar los planteamientos pedagógicos relacionados con la competencia digital.
- Averiguar la validación del instrumento relacionado con la competencia digital.

Después de revisar y estudiar los objetivos de investigación de las publicaciones seleccionadas, los resultados indican que la mayoría de las publicaciones

seleccionadas investigan la percepción de los participantes sobre la competencia digital y su nivel. La percepción de los participantes se ha evaluado desde diversas perspectivas. Cinco publicaciones han explorado los factores que influyen en la competencia digital. Cuatro publicaciones han examinado el impacto de la competencia digital en el rendimiento de los estudiantes. Además, hay dos artículos que presentan especial su atención a los planteamientos pedagógicos implicados en la competencia digital, y otros dos artículos investigan los enfoques didácticos que intervienen en la competencia digital. Finalmente, aparecen dos artículos en que se han validado instrumentos para valorar la competencia digital.

En cuanto a los métodos aplicados en las publicaciones seleccionadas, los hemos examinado y resumido. Se observa que la mayoría de las investigaciones sobre la competencia digital en educación superior han seguido la metodología cuantitativa.

En la PI3 se han revisado e investigado los resultados de la investigación de estas 33 publicaciones. Se presentará siguiendo las categorías de objetivos de la investigación.

En los artículos que investigan la percepción y el nivel de competencia digital de profesores y estudiantes, muchos profesores y estudiantes demostraban un nivel básico y moderado, y la falta de competencia se podía observar todavía al enfrentarse a problemas complejos, mientras que la dimensión de seguridad se destaca específicamente. El género, la experiencia previa en el ámbito digital, la formación recibida, el número de proyectos de investigación e innovación realizados, la experiencia docente y el uso de la tecnología (vídeos) están indicados en los artículos que exploran los factores de impacto de la competencia digital. En los artículos que exploran el impacto de la competencia digital en el rendimiento de los estudiantes, no sólo se ha confirmado que la competencia digital y la preparación digital tienen un impacto positivo en el rendimiento académico de los estudiantes universitarios, sino que también existe una correlación positiva entre la competencia digital y el aprendizaje informal digital de los estudiantes universitarios. En cuanto al enfoque pedagógico implicado en la competencia digital, se recomienda una metodología activa, utilizando estrategias de aprendizaje autodirigido en TIC y desarrollando el aprendizaje independiente y colaborativo. Además, el cuestionario construido por Mengual-Andrés et al. (2016) ha sido presentado y el cuestionario DigCompEdu Check-In ha sido confirmado con alta fiabilidad y validez (Cabero-Almenara et al., 2020).

La cuarta pregunta (PI4) presenta el tipo de limitaciones de las investigaciones encontradas en los artículos seleccionados.

Se observa que la aplicación de los métodos de recogida de datos se ha identificado como la limitación más común entre ellos (n=14). El tamaño de la muestra también es una limitación del estudio frecuente en los artículos (n=12). Hay 17 artículos con más de una limitación de estudio, mientras que ocho artículos seleccionados no mencionan sus limitaciones de estudio.

Por último, para concluir esta sección, en la Tabla 2 se presenta un resumen de las respuestas a las cuatro preguntas de investigación propuestas en esta SLR.

Tabla 11

Resumen de las respuestas a las preguntas de la SLR

Preguntas de la SLR	Respuestas	
PI1	En las publicaciones revisadas se ofrece una definición general de la competencia digital con referencia a los documentos políticos y a las investigaciones pertinentes, que se presentan desde diferentes perspectivas. El marco propuesto en Europa ha recibido interés y atención en todo el mundo. Se puede entender que la competencia digital para los profesores es una combinación de conocimientos, habilidades, destrezas, concienciación, estrategias y actitudes relacionadas con el dominio y la integración de la tecnología en los contextos y procesos de enseñanza y aprendizaje con el fin de alcanzar los objetivos educativos. La competencia digital para los estudiantes es un conjunto de conocimientos, habilidades, actitudes, destrezas, estrategias y concienciación que permiten un uso creativo, crítico y seguro de las TIC para satisfacer diversos objetivos requeridos por los individuos y la sociedad actual.	
PI2	Las dimensiones que se suelen utilizar para valorar la competencia digital de los profesores y estudiantes universitarios son las de DigComp, y dentro de las diferentes versiones, destaca las de DigComp 2.0, como información y alfabetización digital; comunicación y colaboración; creación de contenidos digitales; seguridad; y resolución de problemas.	
PI3	Objetivos de investigación	La mayoría de las publicaciones seleccionadas investigan la percepción y el nivel de competencia digital de los participantes. Muchas de ellas exploran los factores que influyen en la competencia digital. Algunos artículos analizan el impacto de la competencia digital en el rendimiento académico de los estudiantes. El resto se centran en la pedagogía implicada en la competencia digital y en la validación de instrumentos relacionados con la competencia digital.
	Métodos de investigación	La mayoría de las publicaciones seleccionadas han seguido una metodología cuantitativa mediante la distribución de cuestionarios. El modelo de ecuaciones estructurales por mínimos cuadrados parciales (PLS-SEM) se ha aplicado en cuatro artículos para examinar el

		impacto de la competencia digital en el aprendizaje informal.
	Resultados de investigación	La competencia digital de los profesores y estudiantes de la enseñanza superior se encuentra en un nivel básico o moderado, y es inadecuado cuando los problemas se vuelven complejos. Se señalan los factores que afectan a la competencia digital. Se observa una correlación positiva entre la competencia digital y el rendimiento de los estudiantes. Se presenta la aplicación de métodos de enseñanza apropiados en la competencia digital y se introduce una herramienta más fiable y válida para evaluar la competencia digital en la enseñanza. Todo ello ha proporcionado una visión más refinada de la competencia digital en educación superior.
PI4	Los métodos de recogida de datos, el tamaño de la muestra y la falta de datos son los tipos de limitaciones de investigación más frecuentes en los estudios relacionados con la competencia digital en la enseñanza superior en los últimos siete años.	

2.3 Limitaciones

Esta revisión tiene algunas limitaciones de investigación. En primer lugar, hay que señalar que las bases de datos utilizadas en esta revisión sistemática de la literatura, a pesar de ser las más representativas, no incluyen todas las publicaciones existentes sobre el tema. Podrían haberse incluido bases de datos más amplias, como CNKI (China National Knowledge Infrastructure) y EBSCO HOST.

En segundo lugar, hay que mencionar que hemos limitado el año de publicación en nuestra búsqueda para destacar los resultados de los últimos años. En el proceso de decisión de los términos de búsqueda, a veces los términos no son fáciles de seleccionar y hay que utilizar otro tipo de análisis para determinarlos (Marcos-Pablos & García-Peñalvo, 2018, 2019). Teniendo en cuenta la especialidad del término "competencia digital", a la hora de realizar la búsqueda con las palabras clave, se ha intentado incluir todos los términos relacionados para garantizar la exhaustividad.

En tercer lugar, nos hemos centrado en las publicaciones escritas en inglés y no se han representado los artículos sobre competencia digital en educación superior en otros idiomas.

En cuarto lugar, hay que considerar el sesgo de publicación como una limitación en la revisión sistemática de la literatura, que puede conducir a un mayor número de

investigaciones con resultados positivos (Egger et al., 1997).

Por último, como otras revisiones de la literatura, las revisiones sistemáticas se consideran limitadas por la subjetividad de la revisora. Para reducir potencialmente el sesgo propio en la selección de los estudios con respecto a la calidad, se recomienda que las futuras revisiones sistemáticas de la literatura cuenten con al menos dos personas que revisen los artículos utilizando criterios de evaluación y que, además, se registren todos los pasos desde la búsqueda de publicaciones hasta la selección y extracción de datos de los artículos para garantizar la reproducibilidad, la repetitividad y mantener la transparencia del estudio.

2.4 Conclusiones

Los resultados del Mapping ayudan a completar la revisión sistemática de la literatura resumiendo las informaciones claves de las publicaciones. La mayor parte de las investigaciones sobre este tema se han realizado en España, y a nivel regional, la mayoría se realizan en europea. Los investigadores de las publicaciones seleccionadas han preferido investigar la competencia digital de los estudiantes en lugar de la de los profesores, ya que los estudiantes son los principales sujetos de la educación. Además, en el estudio de Mapping se han identificado las revistas con mayor probabilidad de ser utilizadas para la difusión de los artículos y se presentan los autores más relevantes sobre el tema. Además, según las respuestas a las preguntas planteadas, aunque el número de publicaciones disminuye en el año 2019, es evidente que el interés por la competencia digital en educación superior crece de forma generalizada. Los autores e investigadores la investigan desde diversas perspectivas con diferentes temáticas.

Esta revisión ha proporcionado una introducción y comprensión de cómo se ha definido y aplicado el concepto de competencia digital en educación superior, y ofrece una visión general de la investigación actual sobre competencia digital en contextos de educación superior, en relación con los objetivos de la investigación, los métodos de investigación, los instrumentos de investigación, los resultados y las limitaciones existentes. Se perfilan los avances y tendencias de la investigación relacionados con la competencia digital en educación superior en los últimos siete años.

En primer lugar, cabe señalar que, aunque la definición de la competencia digital puede presentarse desde diversas perspectivas, las publicaciones estudiadas la han definido a un nivel macro haciendo referencia, tanto a documentos políticos, como a los artículos de investigación pertinentes. El marco propuesto en Europa ha recibido atención mundial y ha contribuido a una mejor comprensión de la competencia digital y de su progreso.

En segundo lugar, se han presentado las dimensiones que se utilizan habitualmente para realizar el diseño educativo de la competencia digital en educación superior, destacando las áreas de DigComp 2.0: información y alfabetización digital, comunicación y colaboración, creación de contenidos digitales, seguridad y resolución

de problemas.

La formación previa, la posesión de TIC, el acceso a Internet, el uso y la actitud hacia las herramientas digitales han sido de especial importancia a la hora de diseñar el instrumento de investigación. Los avances tecnológicos, la digitalización y la informatización han penetrado en el ámbito educativo, el brote de la pandemia del COVID-19 y los cambios en los modelos educativos exigen a los estudiantes, a los profesores, e incluso a los futuros profesores, una competencia digital que les permita afrontar estos retos (Sánchez y Trigueros, 2017). Estas observaciones nos dan sugerencias para la exploración futura y la creación de una herramienta para valorar la competencia digital en las universidades, en términos de construcción de la dimensión.

En tercer lugar, a la luz de las respuestas a las preguntas presentadas, se revisaron y analizaron en profundidad las 33 publicaciones seleccionadas. En cuanto a la finalidad, la mayoría de las investigaciones sobre competencia digital en el contexto de educación superior se centran en las percepciones de los profesores y de los estudiantes, y en sus niveles de competencia digital, especialmente por parte de los estudiantes. En cuanto a los métodos de investigación, los métodos de investigación cuantitativos mediante cuestionarios han sido los más empleados en estos estudios. En cuanto a los resultados de las investigaciones realizadas en los últimos siete años, parece que, en general, la competencia digital de los profesores y estudiantes universitarios se encuentra en un nivel básico o medio. Algunos participantes tienen un buen rendimiento en ciertas áreas como la comunicación y la colaboración, pero cuando la complejidad y la dificultad de las preguntas aumentan, los encuestados se muestran menos capaces. La seguridad es también un punto al que profesores y estudiantes deben prestar más atención en el futuro. También se enumeran los factores que pueden influir en la competencia digital y, además, se comprueba la influencia positiva de la competencia digital en el rendimiento de los estudiantes, así como se presentan avances pedagógicos positivos en materia de competencia digital. La descripción y presentación de la validación del instrumento de competencia digital ayudará a crear futuras herramientas de evaluación o investigación sobre este tema. Los resultados obtenidos se consideran una evidencia y una base para las estrategias educativas, que pueden ayudar a mejorar la calidad de la educación, recordar a los profesores que se adapten a la innovación educativa y promover la participación e inmersión de los estudiantes.

Así mismo, se han podido resumir las limitaciones surgidas en la investigación anterior para tratar de evitarlas en futuras investigaciones, señalándose la aplicación del método de recogida de datos, el tamaño de la muestra y la falta de datos.

Esta revisión sistemática de la literatura identifica las lagunas de la investigación y se perciben algunas áreas susceptibles de ser exploradas en futuros estudios:

Participantes en la investigación fuera de Europa. Se sugiere que se preste atención al desarrollo de la competencia digital en países fuera de Europa. El marco propuesto por la UE sobre las competencias digitales está bien establecido y sigue

perfeccionándose, y la mayoría de los estudios pertinentes han explorado las competencias digitales en el contexto de la educación superior europea. Se sugiere que la atención se dirija a otras partes del mundo, como Asia, donde existe tanto una gran población educada, como un sistema educativo muy diferente al occidental. Es valioso investigar la competencia digital en educación superior de las regiones y países asiáticos, lo que puede ayudar a realizar estudios y comparaciones transculturales en el futuro.

Profesores universitarios en activo. Además de los estudiantes, la competencia digital de los profesores es un tema de investigación permanente en el futuro. Merece la pena seguir explorando la competencia y el dominio digital de los profesores en activo como líderes de las actividades de enseñanza y aprendizaje continuas bajo la influencia de los procesos sociales y las pandemias.

La evaluación del nivel de competencia digital real. En lugar de comprender las percepciones de los profesores y los estudiantes sobre la competencia digital, la evaluación de los niveles reales de competencia digital de estos participantes es un área de interés para futuras investigaciones.

Planteamientos pedagógicos relacionados con la competencia digital y la validación de instrumentos relacionados con la competencia digital. A partir de los resultados de este informe, se observa que son pocos los artículos que han investigado los planteamientos pedagógicos relacionados con la competencia digital y la validación de los instrumentos. Se recomienda seguir explorando los planteamientos pedagógicos para integrar mejor la competencia digital en la enseñanza y el aprendizaje, a fin de ejercer un impacto positivo, así como crear instrumentos más fiables para analizar y evaluar la competencia digital.

Estudios correlaciones. Es necesario avanzar en la investigación de los factores que influyen en la competencia digital y profundizar en las relaciones entre estas variables independientes y dependientes.

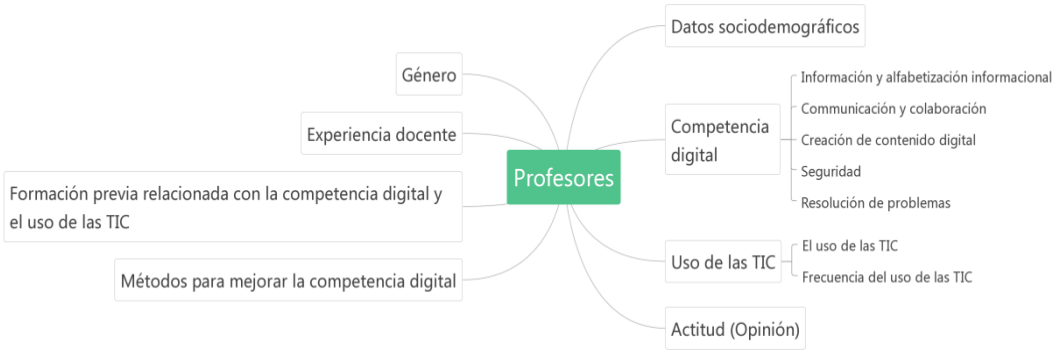
3. Exploración de la competencia digital de los profesores universitarios de la Universidad Agrícola de Gansu

Después de realizar una revisión de la literatura para comprender la definición de competencia digital y las lagunas de la investigación en los últimos años, decidimos ampliar nuestro horizonte a la región asiática. Teniendo en cuenta el rápido desarrollo de la tecnología en los últimos años, el progreso de la informatización y la digitalización de la educación en China, la enorme población educada en China, el desarrollo desigual de las regiones dentro de China, y que se han realizado pocos estudios sobre este tema en las zonas subdesarrolladas, decidimos explorar la competencia digital de los profesores y estudiantes universitarios en el oeste de China y ayudar a construir sus perfiles digitales. Se eligió la Universidad Agrícola de Gansu como sujeto de estudio.

La investigación presentada en este capítulo se centra en dos partes principales. La primera parte presenta la competencia digital de los profesores en activo a través de sus experiencias en competencia digital, sus usos de las TIC y sus opiniones sobre el uso de las TIC en la Universidad Agrícola de Gansu, en el oeste de China. La segunda parte presenta el impacto que tienen sobre dichos factores el género de los profesores, la experiencia docente, la formación previa relacionada con la competencia digital y el uso de las TIC y los métodos para mejorar la competencia digital. La figura 4 muestra un resumen de las variables relevantes para esta investigación.

Figura 4

Resumen de las variables relacionadas con el estudio del profesorado



La mayor parte de los resultados relacionados con la competencia digital de los profesores han sido publicados en *Sustainability* (Zhao et al., 2021a).

3.1 Objetivos

La realización de un estudio para identificar la competencia digital de los profesores de la Universidad Agrícola de Gansu, a través de sus experiencias de la competencia digital, con el apoyo de sus usos de las TIC y sus opiniones sobre las TIC,

fue el objetivo general que guía esta investigación. También se ha presentado en el capítulo un análisis de la relación entre la detección y definición de problemas prácticos y el desarrollo de procesos metacognitivos, lo que permite que se produzcan cambios y desarrollos desde la perspectiva de los propios participantes (Pérez Escoda, 2015).

El significado de este estudio es comprender y promover el desarrollo de la competencia digital de los profesores de educación superior en las regiones menos desarrolladas, para asegurar la óptima implementación de las herramientas tecnológicas y contribuir a la mejora de la calidad de la educación. Los resultados obtenidos proporcionarán datos fiables a la hora de realizar la formación pertinente y formular estrategias de desarrollo. Con esta consideración como punto de partida, los objetivos de investigación de este estudio son:

- Describir las experiencias en competencia digital de los profesores universitarios.
- Identificar el uso de las TIC por parte de los profesores universitarios y su frecuencia de uso.
- Conocer las opiniones de los profesores universitarios sobre el uso de las TIC en educación.
- Analizar si existen diferencias significativas entre las experiencias de los profesores universitarios sobre la competencia digital y las variables como el género, la experiencia docente, la formación previa y los métodos para el desarrollo de la competencia digital en profundidad en educación superior.
- Explorar el impacto del género, la experiencia docente, la formación previa y los métodos para desarrollar la competencia digital de los profesores universitarios en el uso de las TIC y su frecuencia.
- Investigar si el género, la experiencia docente, la formación previa y los métodos para desarrollar la competencia digital de los profesores universitarios influyen en sus opiniones sobre la aplicación de las TIC en educación.

Para permitir una mejor comprensión, este estudio intenta responder a esta pregunta principal de investigación con tres sub-preguntas.

PI1. ¿Cuál es la competencia digital de los profesores universitarios de la Universidad Agrícola de Gansu para determinar sus necesidades?

PI2. ¿Cuál es el dominio y la frecuencia de uso de las TIC por parte de los profesores?

PI3. ¿Qué opiniones tienen los profesores sobre el uso de las TIC en educación?

PI4. ¿Qué factores podrían influir en la competencia digital de los profesores universitarios, sus usos de las TIC y sus opiniones sobre el uso de las TIC en educación?

3.2 Metodología

Con los objetivos de investigación establecidos, este estudio ha empleado una metodología cuantitativa, no experimental, descriptiva e inferencial (Arnal et al., 2021; Hernández et al., 2014; Kerlinger & Lee, 2002). De esta manera, no hay control ni manipulación de las variables, lo que ocurre de forma natural y los datos se registran y describen tal y como se obtienen de la realidad (Bisquerra, 2004). Se investiga la relación entre estas variables para señalar su carácter correlativo (McMillan & Schumacher, 2005).

Para la recogida de datos, se ha aplicado una encuesta en línea, que puede ayudar a generalizar los resultados a una población específica (Buendía et al., 1998). En lugar de incluir a todos los profesores y estudiantes de todas las universidades del oeste de China, este estudio ha recogido información de los profesores de una universidad del oeste de China, lo que garantiza que la muestra sea adecuada y representativa para el análisis inferencial. Estos métodos permiten recoger información fáctica detallada que describe una situación concreta (Dalen & Meyer, 1981).

3.3 Instrumento

El instrumento utilizado para la recogida de información en esta investigación ha sido un cuestionario, elaborado para el profesorado universitario, que se ha adaptado a partir de un instrumento de autoevaluación de la competencia digital basado en el CDCFT y de un cuestionario diseñado para el profesorado para valorar su nivel de uso y apropiación de las TIC (Taquez et al., 2017; López et al., 2019).

El cuestionario se redactó originalmente en español y se tradujo al chino para los participantes en la investigación. Se elaboró un borrador que incluía todos los ítems que se consideraron necesarios para llevar a cabo el estudio. La validez del instrumento se analizó desde dos perspectivas: la validez de contenido, mediante un análisis racional por parte de un panel de jueces, y la validez empírica, mediante un análisis factorial exploratorio. Con la colaboración de expertos en el campo de la metodología de la investigación y estadística, pedagogía, tecnología educativa y lingüística, se comprobaron las características y la validez externa. Para finalizar esta fase, se analizaron las aportaciones de los expertos y se realizaron cambios en el instrumento. Se midió el alfa de Cronbach para conocer la consistencia interna de la encuesta. El cuestionario ha conseguido una consistencia interna de $\alpha = 0{,}974$. El coeficiente alfa de esta encuesta sugiere que los ítems tienen una consistencia interna relativamente alta.

Este cuestionario incluyó 56 ítems y se dividió en cuatro secciones (Tabla 3). Los ítems han consistido en preguntas cerradas, de opción múltiple, abiertas y de escala ordinal tipo Likert de 1 a 4 para evitar posibles efectos negativos de la aplicación del cuestionario.

Tabla 12

Estructura del cuestionario para profesores universitarios

Datos sociodemográficos y de identificación	Edad; género; experiencia docente; facultad; situación del tutor; número de clases que imparte; tipo de clases que imparte; tipo de formación sobre las TIC y competencia digital, cómo se adquiere y mejora la competencia digital y motivación para utilizar las TIC.
La competencia digital	Información y alfabetización informacional; comunicación y colaboración; creación de contenidos digitales; seguridad y resolución de problemas.
El uso de las TIC	Uso de las TIC, frecuencia de uso de las TIC.
Actitud	Opiniones sobre el uso de las TIC en educación.

3.4 Población y muestra

La población de este estudio está compuesta por 1.226 profesores que trabajan en la Universidad Agrícola de Gansu.

La muestra final de este estudio estaba compuesta por 536 profesores de diferentes facultades de la Universidad Agrícola de Gansu (China). Se trata de una muestra representativa y aleatoria, que ha sido confirmada por la fórmula propuesta por Cea D'Ancona (2001) con un margen de error del 5%, de la que el 61,2% eran mujeres y el 38,8% hombres, con edades comprendidas entre los 23 y los 68 años.

3.5 Recogida y análisis de datos

La recogida de datos se realizó en China durante el curso académico 2019-2020. El cuestionario se completó de forma digital a través de la plataforma Qualtrics y se compartió con los profesores en activo de la Universidad Agrícola de Gansu a través de los códigos QR y los enlaces creados por Qualtrics. El cuestionario fue anónimo.

El análisis estadístico se realizó con el Paquete Estadístico para las Ciencias Sociales (SPSS v.26). Se han llevado a cabo diferentes tipos de análisis para cumplir los objetivos del estudio y responder a las preguntas de la investigación. En primer lugar, se realizaron análisis descriptivos calculando la media y la desviación estándar de los ítems y presentando la frecuencia y el porcentaje de las respuestas válidas. En segundo lugar, se realizaron análisis inferenciales, utilizando estadísticas no paramétricas debido a que los datos seguían una distribución no normal, ya que se comprobó la normalidad mediante la prueba de Kolmogorov-Smirnov al nivel de significación del 5% y se encontraron p-valores de 0,05 en todos los casos. Se aplicó la prueba no paramétrica U de Mann-Whitney para la variable de género y formación

previa, y la prueba no paramétrica Kruskal-Wallis para la variable de experiencia docente y diferentes métodos para mejorar la competencia digital.

3.6 Resultados

Esta sección presenta los resultados del estudio en el que se distribuyó el cuestionario a los profesores de la Universidad Agrícola de Gansu y está divido en dos partes. La primera parte presenta los resultados obtenidos mediante los análisis descriptivos de los datos. La segunda parte muestra los resultados de los análisis inferenciales.

3.6.1 Descriptivos

En cuanto a la competencia digital de los profesores, los resultados obtenidos indican que las valoraciones de los profesores sobre las áreas de información y alfabetización informacional, comunicación y colaboración y seguridad son altas, mientras que más de la mitad de los profesores consideran que ellos son buenos en área de resolución de problemas, y no se perciben muy capaces en el área de creación de contenidos digitales.

Los resultados descriptivos de la exploración del uso de las TIC del profesorado indican que la mayoría de los profesores utilizan bien el correo electrónico, los programas de comunicación, las herramientas de búsqueda de información, las herramientas clásicas de Office, los repositorios institucionales, las herramientas de captura de pantalla y las plataformas de contenidos audiovisuales ($M>3,00$). Sin embargo, más de la mitad de estos profesores se sienten abrumados por el uso de las redes sociales, las herramientas de colaboración en red, los editores de audio, el editor de vídeo, las plataformas de gestión del aprendizaje, los marcadores sociales, los sistemas de respuesta en tiempo real, los sistemas de gestión de contenidos, las herramientas de gestión de fuentes y revisión de citas, las herramientas de detección de coincidencias y las herramientas para crear cuestionarios ($M<2.5$).

Los resultados obtenidos en el análisis descriptivo muestran que los profesores utilizaban con alta frecuencia el correo electrónico, el software de comunicación, las herramientas de búsqueda de información, las herramientas clásicas de Office, las herramientas de creación de contenidos, los repositorios institucionales, las herramientas de captura de pantalla y las plataformas de contenidos audiovisuales ($M>3.00$). Y hay muchos profesores que nunca o rara vez utilizaron herramientas de redes colaborativas, marcadores sociales, sistemas de respuesta en tiempo real, sistemas de gestión de contenidos y herramientas de gestión de fuentes y revisión de citas ($M<2.00$).

En cuanto a las opiniones de los profesores, los resultados del análisis descriptivo indican que los profesores de la Universidad Agrícola de Gansu tienen opiniones positivas sobre el uso de las TIC en las actividades educativas.

3.6.2 Inferenciales

Primero, se ha investigado si las cinco áreas de la competencia digital, el uso de las TIC, y la frecuencia de uso de las TIC, y las opiniones de los profesores sobre el uso de las TIC en las actividades educativas difieren en función del género. Se observa que los profesores se consideran mejor que las profesoras en cinco áreas de la competencia digital, así como en el uso de las TIC.

Segundo, las diferencias existentes en las cinco áreas de la competencia digital, el uso de las TIC y la frecuencia de uso de las mismas, así como las opiniones de los profesores sobre el uso de las TIC en las actividades educativas por parte de las distintas experiencias docentes han sido analizado. En general, los profesores con menos experiencia docente se han sentido más competentes en las áreas de comunicación y colaboración, creación de contenidos digitales, seguridad y resolución de problemas. Se han obtenido resultados similares en el uso de TIC del profesorado, la frecuencia de uso de estas TIC y sus opiniones.

Tercero, las diferencias entre los profesores que han recibido formación previa en relación con la competencia digital y el uso de las TIC se han explorado mediante la prueba U de Mann-Whitney. Los profesores que han recibido formación sobre la adquisición de la competencia digital y el aprendizaje del uso de las TIC se creen más capaces en sus experiencias en la competencia digital, en el uso de las TIC y en la frecuencia de uso de dichas herramientas.

Cuarto, se ha analizado la influencia de diferentes métodos para desarrollar la competencia digital en las cinco áreas de la competencia digital de los profesores, el uso de las TIC, la frecuencia de uso de las TIC y sus opiniones. Respecto a la comunicación y la colaboración, la creación de contenidos digitales y la resolución de problemas en la competencia digital, los profesores que han desarrollado la competencia digital a través de cursos tradicionales, cursos en línea y seminarios se consideran mejores que los profesores cuya competencia digital se ha mejorado a través del autoaprendizaje. Los profesores que realizan cursos en línea utilizan las TIC con más frecuencia que los que tienen clases tradicionales, asisten a seminarios y estudian por su cuenta.

3.7 Conclusiones

Existen varias características personales y contextuales que influyen en el desarrollo de la competencia digital (Cebrián-Cifuentes et al., 2021). La realización de este estudio ha proporcionado una herramienta válida para valorar la competencia digital del profesorado universitario y el uso de las TIC. Ha ayudado a conocer la competencia digital de los profesores universitarios en la Universidad Agrícola de Gansu en el oeste de China, sus usos de las TIC y sus opiniones sobre el uso de las TIC en sus actividades pedagógicas. En este estudio, hemos identificado varios factores que influyen en la competencia digital y en el uso de las TIC, que nos

proporcionan información y conocimientos útiles para mejorar la competencia digital y el uso de las TIC, y para ayudar a construir estrategias de desarrollo en el futuro.

Los profesores se perciben a sí mismos como buenos en las áreas de información y alfabetización informacional, comunicación y colaboración, seguridad y resolución de problemas, pero muestran un nivel bajo en la de creación de contenidos digitales. Ellos son buenos en el uso de TIC comunes y clásicas, y utilizan con frecuencia herramientas de comunicación y ofimáticas, pero en general muestran un bajo nivel de conocimientos y uso de herramientas relacionadas con la creación de contenidos o la realización de trabajos colaborativos. Sin embargo, las opiniones de los profesores sobre el uso de las TIC en las actividades de enseñanza y aprendizaje siguen siendo positivas.

Por un lado, se ha confirmado la brecha de género con diferencias en la competencia digital y el uso de TIC entre profesores y profesoras. Lo mismo ocurre con los profesores con distintas experiencias docentes, con diferencias en su competencia digital sentidas en cuanto a las áreas de comunicación y colaboración, creación de contenidos digitales, seguridad y resolución de problemas, y diferencias en el uso de las TIC, la frecuencia de uso y las opiniones sobre el uso de las TIC en las actividades educativas.

Por otro lado, se ha reconocido la importancia de la formación previa sobre la competencia digital y las TIC. Los diferentes métodos para mejorar la competencia digital tienen un impacto en las áreas de comunicación y colaboración, creación de contenidos digitales y resolución de problemas, así como la frecuencia en el uso de las TIC. La importancia de los cursos sistemáticos ha sido identificada.

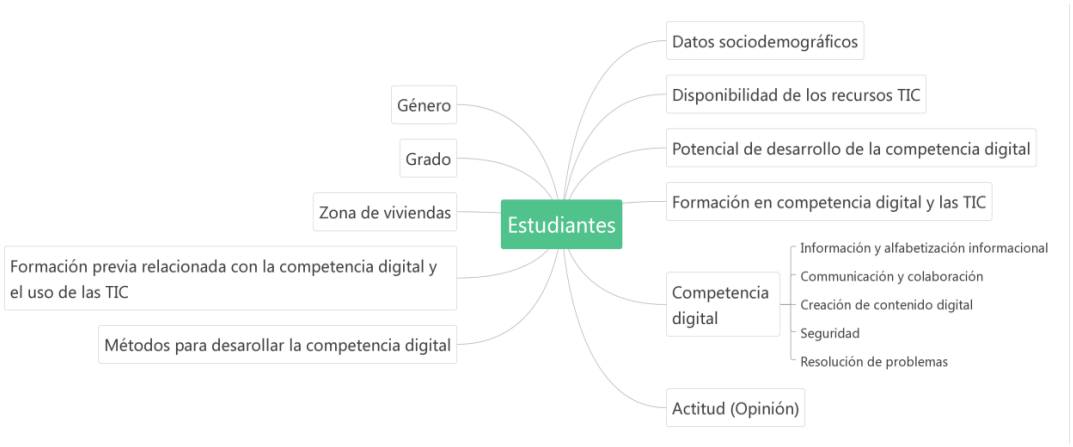
Los resultados de este estudio señalan que el desarrollo de la competencia digital de los profesores sigue siendo un reto que la comunidad educativa debe abordar. La exploración de la relación entre estas variables pone de manifiesto la importancia de la formación, contribuye al establecimiento de estrategias para el desarrollo de la competencia digital de los profesores, lo que nos permite ser más propositivos en la futura formación de los profesores o en el desarrollo de estrategias de enseñanza, desarrollar programas de formación eficaces para diferentes poblaciones y ayudar a reducir la emergente brecha digital.

4. Exploración de la competencia digital de los estudiantes universitarios de la Universidad Agrícola de Gansu

La investigación presentada en este capítulo se centra en dos partes. La primera parte presenta los datos sociodemográficos de los estudiantes universitarios de primer y cuarto curso, su disponibilidad de recursos TIC, el potencial de desarrollo de la competencia digital a través de la conexión a Internet, la conectividad y las preferencias de uso de los estudiantes, la formación relacionada con las TIC y la competencia digital, la competencia digital y sus opiniones sobre el uso de las TIC. La segunda parte presenta las diferencias entre el género de los estudiantes, el nivel de grado, la zona de residencia, la formación formal previa en el uso de las TIC y la competencia digital y los métodos de mejora de la competencia digital entre la competencia digital de los estudiantes y sus opiniones sobre las TIC. La Figura 5 presenta un resumen de las variables relevantes para esta investigación.

Figura 5

Resumen de las variables relacionadas con el estudio del alumnado



Los resultados relacionados con la competencia digital de los estudiantes universitarios se han publicado en la revista *Sustainability* (Zhao et al., 2021b).

4.1 Objetivos

El objetivo general de este estudio es identificar la competencia digital de los estudiantes universitarios desde varias perspectivas, basándose en el ejemplo de la Universidad Agrícola de Gansu, situada en una región menos desarrollada de China. No sólo se trata de investigar las experiencias en competencia digital de los estudiantes, sino también en detectar cualquier necesidad de formación y proporcionar la orientación y el apoyo necesarios en el desarrollo de actividades educativas y de formación relativas a la competencia digital, y ayudar a integrar las TIC en las actividades de enseñanza y aprendizaje, desarrollar futuras políticas educativas y promover la educación digital informativa basada en la comprensión del impacto de la competencia digital.

Teniendo en cuenta lo mencionado, en este estudio se plantean los siguientes

objetivos específicos:

- Explorar la disponibilidad de recursos TIC de los estudiantes.
- Describir el potencial de desarrollo de la competencia digital de los estudiantes.
- Conocer la formación de los estudiantes en relación con las TIC y la competencia digital.
- Identificar la competencia digital de los estudiantes universitarios.
- Determinar las opiniones de los estudiantes universitario sobre el uso de las TIC.
- Analizar el impacto del género de los estudiantes universitarios, el grado, la zona de residencia, la formación previa y los métodos de desarrollo de la competencia digital en su competencia digital.
- Investigar el impacto del género, el grado, la zona de residencia, la formación previa y los métodos de desarrollo de la competencia digital de los estudiantes en sus opiniones sobre el uso de las TIC.

Estos objetivos también se concretan en las siguientes preguntas de investigación que guían el estudio empírico referido a los estudiantes universitarios:

PI1. ¿Cuál es la disponibilidad de recursos técnicos para los estudiantes, su potencial para desarrollar la competencia digital y su formación previa relacionada con las TIC y la competencia digital?

PI2. ¿Cuál es la competencia digital de los estudiantes de primer y cuarto curso de la Universidad Agrícola de Gansu para determinar sus necesidades?

PI3. ¿Qué opiniones tienen los estudiantes sobre las TIC?

PI4. ¿Qué factores podrían influir en la competencia digital de los estudiantes universitarios y sus opiniones sobre las TIC?

4.2 Metodología

Para llevar a cabo este estudio, se ha empleado una metodología cuantitativa con un diseño no experimental ex-post-facto. Las variables no se modificaron (Simon & Goes, 2013). Esta investigación se basa en un estudio por encuesta, utilizando técnicas de análisis descriptivo e inferencial para los diferentes estratos de la muestra considerados en este estudio. Las variables y sus relaciones se estudian mediante su carácter correlacional (McMillan & Schumacher, 2005).

4.3 Instrumento

El instrumento utilizado para este estudio ha sido un cuestionario adaptado de un cuestionario de diagnóstico para estudiantes universitarios presentado por Martínez et

al. (2010) y del instrumento de autoevaluación Ikanos basado en el DigComp del proyecto Ikanos que ayuda a definir el perfil digital y dar una indicación del nivel de competencia digital basado en las cinco áreas de competencia del modelo DigComp.

Se elaboró un borrador que incluía todos los ítems que se consideraban necesarios para cumplir los objetivos del estudio. La validación del instrumento fue revisada por un panel de expertos que analizó la validez de contenido y se aplicó un análisis factorial exploratorio para completar la validez del constructo. El cuestionario se redactó inicialmente en español y se tradujo al chino, teniendo en cuenta la lengua materna de los participantes. Las características y la validez externa del cuestionario han sido examinadas por expertos en los campos de la metodología de la investigación y la estadística, la pedagogía, la tecnología educativa y la lingüística. A continuación, el cuestionario fue revisado de acuerdo con las recomendaciones de los expertos. Se midió la fiabilidad del instrumento. El coeficiente Alfa de Cronbach alcanzó un valor de 0,978, lo que representa un nivel de fiabilidad muy alto (Thorndike, 1997).

El cuestionario está compuesto por 70 ítems y se divide en seis secciones (Tabla 4). Los ítems se componen de preguntas cerradas, de opción múltiple y de escala ordinal tipo Likert de 4 intervalos, con la intención de evitar desviaciones. Los participantes deben responder a todas las preguntas de acuerdo con su situación real.

Tabla 13

Estructura del cuestionario para estudiantes universitarios

Datos sociodemográficos y de identificación	Edad; sexo; grado; zona de residencia; carrera y motivo de elegir la carrera.
Disponibilidad de recursos TIC	Dispositivo de conexión a Internet; equipo y dispositivo propios; conexión a Internet en el campus y equipo y dispositivo disponibles en la facultad.
Potencial de desarrollo de la competencia digital	Frecuencia de conexión a Internet; conexión del dispositivo a Internet y motivación para utilizar las TIC.
Formación relacionada con la competencia y las TIC	Formación anterior sobre la competencia digital y el uso de las TIC; métodos para seguir mejorando la competencia digital; experiencia de participación en clases virtuales y nivel de uso del ordenador.
La competencia digital	Información y alfabetización digital; comunicación y colaboración; creación de contenidos digitales; seguridad y resolución de problemas.
Actitud	Opiniones sobre las TIC.

4.4 Población y muestra

Para el estudio, la población estaba formada por 4.223 estudiantes de primer curso y 4.045 de cuarto de varias facultades de la Universidad Agrícola de Gansu (China), con un total de 8.268 estudiantes.

La muestra de la investigación fue una muestra representativa y aleatoria. Todos los miembros de la población tenían la misma probabilidad de ser seleccionados. Para la determinación del tamaño de la muestra probabilística representativa de la población mencionada, se aplicó la fórmula propuesta por Cea D'Ancona (2001).

La muestra final estuvo formada por 3.136 estudiantes de primer curso y 2.940 de cuarto, con un total de 5.164 estudiantes de entre 15 y 30 años, lo que garantizaba el tamaño mínimo requerido con un margen de error del 5% y era lo suficientemente representativa como para poder extraer conclusiones amplias. El 56,9% de los estudiantes eran mujeres y el 43,1% hombres. En relación con la zona de residencia, la mayoría de ellos vivía en las zonas rurales (70,5%), mientras que el 29,5% vivía en las zonas urbanas.

4.5 Recogida y análisis de datos

La recogida de datos se realizó en el curso 2019-2020 en China. El cuestionario se completó digitalmente a través de la plataforma Qualtrics y se distribuyó a los estudiantes de primer y cuarto curso, compartiendo el código OR creado por este software. El cuestionario era anónimo. Antes de contestar el cuestionario, los profesores supervisores explicaron el propósito del estudio y pidieron la colaboración de los estudiantes.

Los datos obtenidos han sido analizados con el Statistical Package for the Social Sciences (v.26). En todos los análisis se utilizó un nivel de confianza del 95%. Se realizó un análisis estadístico descriptivo de todas las respuestas, calculando la media y la desviación estándar. Para conocer mejor las variables personales que determinan la competencia digital de los estudiantes universitarios, se realizaron varios análisis estadísticos inferenciales. Se llevaron a cabo análisis para determinar si existían diferencias significativas en sus experiencias en la competencia digital debido al género, el grado, la zona de residencia y la formación previa. Según la prueba de Kolmogorov-Smirnov, no había normalidad en las distribuciones. Se empleó la prueba no paramétrica U de Mann-Whitney para la variable dual, y la prueba de Kruskal-Wallis para la variable, métodos de desarrollo posterior de la competencia digital.

4.6 Resultados

Esta sección presenta los resultados del estudio en el que se distribuyó el cuestionario a los estudiantes de primer y cuarto curso de la Universidad Agrícola de Gansu y se presenta en dos partes. La primera parte contiene los resultados obtenidos mediante los análisis descriptivos de los datos. La segunda parte muestra los resultados de los análisis inferenciales.

4.6.1 Descriptivos

Para conocer la disponibilidad de recursos TIC de los estudiantes, se les ha preguntado por la conexión a Internet de sus dispositivos, y la mayoría ha respondido que dispone en ella. En cuanto a los equipos y dispositivos que tienen en casa o en las residencias estudiantiles, la mayoría de los estudiantes tienen móviles y portátiles en casa o en las residencias estudiantiles, pero muchos de ellos no poseen computadoras de escritorio o tabletas en sus casas o residencias estudiantiles. Cuando se pregunta a los estudiantes sobre su conexión a Internet en el campus, la mayoría de ellos han confirmado su conexión a Internet en el campus. En cuanto a los equipos de los estudiantes en la facultad, la mayoría de los estudiantes pueden utilizar computadores de escritorio y portátiles en su facultad.

Respecto al potencial de desarrollo de la competencia digital, se ha medido la frecuencia de uso de Internet de los estudiantes, los resultados muestran que más de la mitad de estos estudiantes utilizan Internet todos los días y varias veces al día. Los estudiantes han sido preguntados por los dispositivos que utilizan generalmente para conectarse a Internet, y la mayoría de los estudiantes respondieron que utilizan sus teléfonos para conectarse a Internet. En relación con la motivación de los estudiantes para utilizar las TIC, muchos de ellos utilizan las TIC por diversas motivaciones. La mayoría de ellos utilizaba las TIC para el entretenimiento, las actividades de estudio y las actividades laborales.

Los estudiantes han sido preguntados sobre la formación en materia de TIC y competencia digital. En cuanto a la formación pasada sobre la competencia digital y las TIC, más de la mitad de ellos no han tenido dicha formación. Con respecto a los diferentes métodos para mejorar su competencia digital, los estudiantes que han desarrollado su competencia digital a través de cursos escolares son más de la mitad. Además, la mayoría de estos estudiantes han participado en cursos de formación virtual. Sobre el Examen Nacional de Rango Informático (NCRE, 2022), que es un sistema nacional chino de examen de competencia informática para la comunidad con objeto de probar los conocimientos y habilidades en aplicaciones de la computadora de los candidatos de la prueba, y que tiene cuatro niveles, entre estos estudiantes, la mayoría no han aprobado o participado en el examen NCRE.

En cuanto a las experiencias en la competencia digital de los estudiantes, se señalan que los estudiantes consideran que tienen una buena competencia en las áreas de información y alfabetización digital, comunicación y colaboración, seguridad y resolución de problemas, junto con la indicación de una menor confianza en el área de creación de contenidos digitales.

En relación con los resultados descriptivos de las opiniones de los estudiantes sobre las TIC, la mayoría de ellos han tenido una opinión positiva sobre las TIC y muestran un gran interés por las TIC.

4.6.2 Inferenciales

En primer lugar, la influencia del género de los estudiantes en su competencia digital y sus opiniones sobre las TIC ha sido analizada. Se observan diferencias estadísticamente significativas en las áreas de la competencia digital como información y alfabetización digital, creación de contenidos digitales, resolución de problemas y las opiniones de los estudiantes sobre las TIC. Los hombres muestran una mayor valoración de estas dimensiones y opiniones más positivas sobre las TIC que las mujeres.

En segundo lugar, se analizan las diferencias entre la competencia digital y las opiniones de los estudiantes con distintos grados. Se constata que existen diferencias significativas entre los estudiantes de primer curso y los de cuarto en cuanto a las áreas de información y alfabetización digital, comunicación y colaboración de datos, creación de contenidos digitales, resolución de problemas y sus opiniones sobre las TIC, en ellas, los de cuarto superan a los de primer curso.

En tercer lugar, se estudia si las experiencias en competencia digital de los estudiantes y sus opiniones sobre las TIC difieren en función de sus zonas de residencia. Los estudiantes universitarios que viven en zonas urbanas se consideran mejores en las cinco áreas de la competencia digital que los estudiantes de zonas rurales, al igual que suceden en sus opiniones sobre las TIC.

En cuarto lugar, Se examinan las diferencias entre la competencia digital y las opiniones sobre las TIC de los estudiantes, de acuerdo con la formación previa relacionada. Los estudiantes que han recibido formación previa sobre competencia digital y TIC, se consideran más capaces en todas las áreas de competencia digital que los que no han recibido formación previa, resultados similares también se observan en cuanto a sus opiniones sobre las TIC.

Por último, los estudiantes que estudian en grupo y aprenden por sí mismos se consideran mejores en el área de información y alfabetización digital. En cuanto al área de comunicación y colaboración, los estudiantes que estudian por su cuenta tienen una opinión más positiva. Respecto a la creación de contenidos digitales de los estudiantes, se comprueba que los estudiantes que mejoran su competencia digital en grupo se creen mejor que los otros. En relación con la resolución de problemas, los estudiantes que desarrollan su competencia digital mediante el estudio grupal que supone el aprendizaje colaborativo se consideran más capaces.

4.7 Conclusiones

Los resultados generados a partir de estos análisis inferenciales pretenden ayudar a establecer las bases para planificar y proporcionar estrategias de actuación para mejorar la competencia digital.

Primero, casi todos los estudiantes están conectados a Internet, utilizando

principalmente móviles y portátiles en los dormitorios, mientras que los dispositivos proporcionados en la escuela son principalmente ordenadores de escritorio. Los estudiantes suelen estar conectados principalmente por medio de sus móviles, y los estudiantes usan Internet para actividades de entretenimiento, estudio y trabajo. En cuanto a la formación relacionada con la competencia digital y las TIC, más de la mitad de los estudiantes no tienen ninguna formación formal en este ámbito, y los que quieren mejorar su competencia digital optan principalmente por asistir a cursos escolares o estudiar por ellos mismos. La mayoría de ellos tienen experiencia en participar en clases virtuales. La mayoría de los estudiantes aún no han realizado o superado los exámenes de nivel de informática ofrecidos por el gobierno.

En cuanto a la competencia digital de los estudiantes universitarios, los estudiantes destacan los aspectos positivos de las áreas de información y alfabetización digital, comunicación y colaboración, seguridad y resolución de problemas, mientras que los estudiantes resultan ser los que menos conocimientos tienen en el área de creación de contenidos digitales. Con respecto a las opiniones sobre las TIC, la mayoría de las respuestas recibidas son positivas.

Además, los resultados generados por los análisis inferenciales de este estudio han determinado la persistencia de una brecha de género en ciertas áreas de competencia digital por parte de los estudiantes, así como también se ha confirmado la brecha de grado, y las diferencias entre zonas urbanas y rurales. Se señala el impacto positivo y la importancia de la formación previa. El análisis inferencial de los diferentes métodos utilizados en el desarrollo de la competencia digital demuestra la necesidad de centrarse en el aprendizaje independiente y colaborativo a la hora de desarrollar la competencia digital de los estudiantes en el futuro.

5. Conclusiones, limitaciones y prospectiva

Los resultados se han discutido en los capítulos anteriores y en los artículos correspondientes a cada estudio. En este capítulo se resumirán las aportaciones e implicaciones educativas más importantes de esta tesis doctoral. También se presentarán en esta parte las limitaciones encontradas en la realización de estas investigaciones y las orientaciones ofrecidas para futuras investigaciones.

5.1 Aportaciones e implicaciones

El objetivo de esta investigación doctoral es explorar el estado de la competencia digital de profesores y estudiantes de una Universidad en el oeste de China, identificando sus experiencias en competencia digital y determinando los factores que influyen en la competencia digital, utilizando la Universidad Agrícola de Gansu como un ejemplo. Los resultados obtenidos pueden utilizarse en proyectos posteriores, para revelar el estado de la competencia digital de profesores y estudiantes en las regiones occidentales menos desarrolladas de China, y pueden ayudar a desarrollar programas de formación y estrategias educativas adecuadas según sea necesario.

Esta sección interpretará los principales resultados obtenidos y se centrará en las aportaciones resultantes del estudio empírico de esta investigación, que se divide en dos partes: profesores y estudiantes, en el orden de las preguntas de investigación planteadas.

5.1.1 Aportaciones en relación a los profesores

El objetivo principal del estudio empírico del profesorado es determinar la competencia digital de los profesores universitarios en la Universidad Agrícola de Gansu.

Se han identificado las siguientes preguntas de investigación para orientar el estudio empírico con respecto a los profesores:

> **PI1.** ¿Cuál es la competencia digital de los profesores universitarios de la Universidad Agrícola de Gansu para determinar sus necesidades?
>
> **PI2.** ¿Cuál es el dominio y la frecuencia de uso de las TIC por parte de los profesores?
>
> **PI3.** ¿Qué opiniones tienen los profesores sobre el uso de las TIC en educación?
>
> **PI4.** ¿Qué factores podrían influir en la competencia digital de los profesores universitarios, sus usos de las TIC y sus opiniones sobre el uso de las TIC en educación?

En primer lugar, de las cinco áreas de la competencia digital, los profesores se consideran buenos en información y alfabetización informacional, comunicación y colaboración, seguridad y resolución de problemas. Las respuestas de los profesores sobre la creación de contenidos digitales son más bajas que en las otras dimensiones y demuestran tener, por tanto, menos confianza en la creación de contenidos digitales.

Se destacan las necesidades de desarrollo y formación en el ámbito de la creación de contenidos digitales. Es posible que la formación diseñada anteriormente para los profesores se haya concentrado en los conocimientos teóricos, teniendo menos en cuenta el desarrollo de contenidos digitales y las prácticas relacionadas.

En segundo lugar, la mayoría de los profesores son conscientes de la necesidad de utilizar las TIC gracias a su experiencia personal o a sus conocimientos, y muchos se ven animados por su experiencia académica. La mayoría de los profesores dominan el uso de los programas informáticos de comunicación, búsqueda de información y ofimática más habituales. El uso que hacen de estas herramientas es elevado, al igual que el de las herramientas de creación de contenidos.

Para que los profesores se familiaricen y adquieran destrezas en el uso de las TIC, es necesario que tengan los objetivos y los escenarios de aplicación adecuados. Es cierto que los profesores utilizan algunas TIC, pero el verdadero potencial pedagógico de las TIC aún no se ha puesto de manifiesto (Guillén-Gámez et al., 2019; Tømte et al., 2015). Nuestras prioridades formativas futuras se informan en base a los resultados obtenidos, es decir, facilitar la comunicación, el trabajo colaborativo, la producción de contenidos multimedia y las herramientas de ayuda pedagógica deben ser el principal énfasis de la formación del profesorado en el uso de las TIC, y los contenidos deben estar contextualizados para el profesorado, integrando los objetivos educativos y desarrollando ejercicios y escenarios de trabajo adecuados para alcanzar de forma efectiva los objetivos formativos.

En tercer lugar, las opiniones de los profesores sobre el uso de las TIC en las actividades educativas son bastante positivas. Esto indica que los profesores reconocen el impacto positivo de las TIC en las actividades de enseñanza y aprendizaje, y están dispuestos a utilizarlas en sus propias actividades docentes.

En cuarto lugar, los resultados obtenidos de los análisis inferenciales revelan la existencia de una diferencia de género y de experiencia docente. A partir de estos resultados, es necesario replantear los programas de formación del profesorado, con contenidos formativos específicos y adaptados al grupo objetivo, teniendo en cuenta las variables analizadas (Cabero-Almenara, et al., 2022; Roussinos & Jimoyiannis, 2019). Los proyectos o programas de formación del profesorado deberían diseñarse y desarrollarse con el objetivo de la igualdad de oportunidades tanto para hombres como para mujeres, salvando la brecha digital de género ya existente; y proporcionando una especial generalización de la competencia digital y asistencia en el uso de las TIC para los profesores con larga experiencia docente.

La importancia y el significado de la formación relacionada con la competencia digital y el uso de las TIC han sido afirmados. Varias investigaciones en diferentes contextos educativos han confirmado la escasez de competencias digitales de los profesores (Domingo-Coscolla et al., 2020; Valdivieso Guerrero & Gonzáles Galán, 2016). Junto con los resultados de este estudio, se ha detectado la necesidad de organizar una formación pertinente para los profesores. Las instituciones educativas deben reforzar la formación permanente del profesorado, así como mejorar la

formación inicial del mismo, para fomentar la competencia digital en la enseñanza (Garzón Artacho et al., 2020).

Además, según los resultados obtenidos del impacto de los diferentes métodos de mejora de la competencia digital de los profesores sobre sus experiencias en competencia digital, el uso de las TIC, la frecuencia de uso y las actitudes, resulta efectiva la formación sistemática.

Por un lado, los cursos tradicionales y en línea tienen en común que ambos tienen un marco sistemático de aprendizaje y requieren mucho trabajo, y es importante en ambos entornos dar y recibir retroalimentación. Por otro lado, los seminarios, pueden ofrecer la oportunidad de interactuar con expertos en un campo concreto, donde se pueden debatir temas relevantes sobre una materia determinada. Quienes participan en los seminarios suelen conocer la información más reciente y las nuevas habilidades relacionadas con el tema. Teniendo en cuenta todo esto, a la hora de diseñar la formación y los programas para mejorar la competencia digital de los profesores y el uso de las TIC, el primer paso es averiguar a quién hay que formar y cuáles son las necesidades de formación, y se recomienda seguir un marco sistemático, crear escenarios y conexiones que sean relevantes para el trabajo de los profesores, recibir comentarios de los participantes durante la formación y programar seminarios basados en necesidades específicas para facilitar la comunicación entre los expertos y los participantes.

5.1.2 Aportaciones en relación a los estudiantes

La interpretación y la contribución de los resultados se presentarán en el orden de las preguntas de investigación planteadas, que han dado lugar al estudio empírico de los estudiantes universitarios:

> **PI1**. ¿Cuál es la disponibilidad de recursos técnicos para los estudiantes, su potencial para desarrollar la competencia digital y su formación previa relacionada con las TIC y la competencia digital?
>
> **PI2.** ¿Cuál es la competencia digital de los estudiantes de primer y cuarto curso de la Universidad Agrícola de Gansu para determinar sus necesidades?
>
> **PI3.** ¿Qué opiniones tienen los estudiantes sobre las TIC?
>
> **PI4.** ¿Qué factores podrían influir en la competencia digital de los estudiantes universitarios y sus opiniones sobre las TIC?

Primero, los resultados sobre la disponibilidad de recursos tecnológicos para los estudiantes muestran que los dispositivos que poseen los estudiantes son principalmente teléfonos móviles y ordenadores portátiles. Aunque la mayoría de los estudiantes pueden conectarse a Internet en el campus, el nivel de cobertura aún no ha llegado al cien por cien. Los dispositivos proporcionados por la facultad son principalmente ordenadores de sobremesa y portátiles.

Los resultados de la disponibilidad de recursos TIC para los estudiantes indican la necesidad, no sólo de mejorar la cobertura de la red del campus, sino también de añadir otros tipos de dispositivos que la facultad pueda proporcionar. Hay que tener en cuenta el tipo de dispositivos que poseen los estudiantes cuando se realizan actividades educativas en línea. Además, si se quiere proporcionar recursos digitales o desarrollar la competencia digital de los estudiantes universitarios, es necesario organizarlos a partir de las características de los dispositivos de los que disponen.

Con respecto al potencial de los estudiantes universitarios para el desarrollo de la competencia digital, más de la mitad de los estudiantes se conectan a Internet muchas veces al día. La mayoría de ellos se acostumbra a conectarse a Internet a través de sus teléfonos móviles. Los estudiantes utilizan las TIC principalmente para entretenerse y para realizar tareas de estudio y trabajo.

La orientación del desarrollo de la competencia digital de los estudiantes universitarios debe considerar las preferencias de conectividad de los estudiantes, con ejercicios y cursos que puedan adaptarse a las características de los móviles con contenidos entretenidos y con fines de aprendizaje. Al mismo tiempo, es fundamental difundir y promover el uso de otras TIC, de manera que las diferentes herramientas puedan ser seleccionadas en función de los objetivos de las tareas que los estudiantes tienen que completar, en lugar de elegir singularmente solo una de ellas.

Como se ha mencionado en el capítulo anterior, se ha preguntado a los estudiantes sobre la formación relacionada con las TIC y la competencia digital. Es evidente que más de la mitad de los estudiantes no han recibido formación previa en este ámbito. Muchos de ellos desarrollan su competencia digital asistiendo a cursos escolares. Aunque la mayoría ha tenido experiencia en participar en clases virtuales, la mayoría no ha realizado o superado el examen NCER, que mide el nivel de uso del ordenador.

Se confirma que la formación relacionada con las TIC y la competencia digital de los estudiantes universitarios de la Universidad Agrícola de Gansu es insuficiente. Los estudiantes que desean mejorar su competencia digital, siguen tratando de asistir a los cursos pertinentes en la escuela, lo que refuerza la necesidad de que las instituciones realicen la formación pertinente o lleven a cabo programas relacionados. Además, se anima a los estudiantes universitarios a realizar el examen de ERNC, que les ayudará en sus futuros estudios y en su experiencia laboral. Las universidades deberían poner en marcha cursos o seminarios de formación pertinentes para ayudar a los estudiantes a obtener este certificado.

Segundo, en cuanto a la valoración de la competencia digital de los estudiantes, la mayoría de ellos tienen una consideración positiva de la competencia digital en cuanto a la información y alfabetización digital, la comunicación y la colaboración, y la seguridad. Sin embargo, muestran una baja experiencia en cuanto a la resolución de problemas. Y los resultados señalan que, de estas cinco dimensiones, la opinión de los estudiantes en cuanto a su nivel en la creación de contenidos digitales es más baja.

La mayoría de los estudiantes que participaron en la investigación son "nativos

digitales", según la definición de Prensky (2007, 2009). Explorar si su competencia digital resulta verdaderamente adecuada para los nativos digitales es uno de los debates habituales. Como mencionan Sánchez-Caballé et al. (2020), el uso de herramientas digitales no les dota automáticamente de competencia digital. Se puede concluir que todavía hay margen de mejora en las capacidades de los estudiantes para integrar conocimientos y contenidos previos, crear y editar nuevos contenidos, generar expresión creativa, producción de medios y programación, así como en sus capacidades para resolver diversos problemas que se presentan en el uso e interacción con la tecnología. Los estudiantes universitarios de la Universidad Agrícola de Gansu en el oeste de China cuentan con un nivel básico o intermedio de competencias relacionadas con la adaptación al desarrollo social y la penetración tecnológica, pero su competencia digital disminuye cuando aumenta la complejidad de la tarea.

Tercero, en cuanto a las opiniones de los estudiantes sobre las TIC, en general han sido positivas. La mayoría de los estudiantes han mostrado su interés por las TIC y son conscientes del papel que desempeñan en sus estudios. Se reiteran las necesidades de formación de los estudiantes y se propone mejorar la disponibilidad de los recursos digitales y de las TIC.

Cuarto, según los resultados de los análisis inferenciales, se han encontrado algunas diferencias en cada una de las cinco áreas de competencia digital u opiniones sobre las TIC, en función de las variables analizadas, como el género, el grado escolar, la zona de residencia, la formación previa relacionada con la competencia digital y el uso de las TIC, y los métodos para seguir desarrollando la competencia digital.

En este sentido, se han señalado los aspectos de la competencia digital que deben ser mejorados, explorando las diferencias que clarifican las necesidades de mejora de los distintos grupos de estudiantes y ayudando a los profesores e instituciones a establecer estrategias y guías educativas eficaces. Los resultados del análisis inferencial en relación con la zona de residencia pueden proporcionar un dato de referencia que demuestra la importancia de avanzar en las competencias digitales en las zonas rurales, contribuyendo a los grandes esfuerzos para promover la equidad educativa. En cierta medida, subraya la importancia de promover enérgicamente las estrategias de informatización de la educación en la Universidad Agrícola de Gansu en el oeste de China.

Además, se afirma la necesidad urgente de poner en marcha programas de formación para los estudiantes sobre cómo utilizar las TIC y desarrollar su competencia digital. Mientras tanto, debería darse prioridad a los programas de formación introductoria relacionados, incluso antes de la entrada de los estudiantes en la universidad.

De acuerdo con los métodos para el desarrollo de la competencia digital, se han estudiado las diferencias entre la competencia digital y las opiniones sobre las TIC de los estudiantes universitarios. A diferencia de los resultados obtenidos por los profesores, se hace énfasis en el aprendizaje colaborativo y autónomo de los estudiantes. Se recomienda un plan de estudios sistemático cuando el objetivo de la

formación es promover la comunicación y la colaboración de los estudiantes y la seguridad digital para un uso seguro y responsable de Internet.

Además de cumplir con los objetivos planteados al inicio del estudio, cabe destacar que los estudios realizados durante esta tesis doctoral han permitido avanzar en tres de las cinco áreas de interés identificadas en el segundo capítulo.

5.2 Limitaciones

A lo largo del proceso de investigación se han encontrado ciertas limitaciones que deben tenerse en cuenta para futuros estudios.

En primer lugar, el tamaño y la diversidad de la muestra, lo que puede limitar la generalización de los resultados. Se recomienda ampliar el tamaño de la muestra e investigar a profesores de diferentes universidades, como se haría en un estudio orientado a los estudiantes.

En segundo lugar, los estudios tanto de docentes como de estudiantes se fundamentan en cuestionarios de autopercepción en los que se presentan sus perfiles digitales, en lugar de medir los verdaderos niveles de competencia digital de docentes y estudiantes. Los autoinformes de los participantes podrían ser subjetivos y su verdadero nivel de competencia digital podría no quedar reflejado.

La tercera limitación es que estos estudios sólo exploran los factores influyentes que aportan diferencias en la competencia digital de los profesores, sus usos de las TIC y sus opiniones sobre el uso de las TIC en las actividades educativas, y señalan las variables que podrían influir en la competencia digital de los estudiantes y en sus opiniones sobre las TIC. Se sugiere que en futuros estudios se aplique el análisis de correlación y regresión para identificar y analizar más las asociaciones o relaciones entre las variables.

5.3 Líneas futuras de investigación

Una vez señaladas las implicaciones y limitaciones de estos estudios, en esta sección se esbozarán las futuras líneas de investigación.

- Realizar entrevistas a los profesores y a los estudiantes para conocer mejor las dificultades que han encontrado y las razones de su reticencia a la hora de desarrollar las competencias digitales y de utilizar las TIC en educación.
- Realizar un análisis comparativo a través de muestras de diferentes regiones de China. Identificar más detalles sobre las diferencias en el desarrollo de la competencia digital y el uso de las TIC por los docentes y los estudiantes en el este y el oeste de China.
- Realizar un análisis comparativo entre una muestra de docentes y estudiantes chinos y otra muestra de docentes y estudiantes de la Unión Europea para estudiar en profundidad los efectos de los valores culturales. Para explorar

las diferencias en el desarrollo de la competencia digital en diferentes contextos culturales e investigar si la variable del contexto cultural tiene un impacto en el desarrollo de la competencia digital en educación superior.

- Diseñar instrumentos para evaluar el nivel de competencia digital de los docentes y de los estudiantes por separado, que se ajusten al sistema educativo oriental.
- Diseñar y realizar un instrumento o experimento que pueda contribuir a determinar el verdadero nivel de competencia digital de los docentes y los estudiantes.

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Appendix E.

Questionnaire for university teachers

University of Salamanca

Block I. Socio-demographic data

1. Age: ___

2. Gender:
   Male □ Female □

3. Teaching experience:
   □ Less than five years
   □ Five to ten years
   □ Ten to nineteen years
   □ Twenty to twenty-nine years
   □ Over thirty years

4. Faculty: ___

5. Are you a Master or PhD supervisor?
   Yes □ No □

6. Number of courses you teach: ___

7. Types of courses you teach:
   □ Compulsory Courses
   □ Restricted Courses
   □ Public Courses
   □ Public Electives
   □ Others

8. Have you received formal training related to digital competence and ICTs? (The concept, related knowledge, the use…)
   Yes □ No □

9. How do you develop and improve your digital competence?
   □ Traditional Courses
   □ Online Courses
   □ Seminars
   □ Self-study

10. What is your motivation for using ICTs? (Multiple choice)
   □ Compulsory demand from the department.
   □ Review of studies or experience presented in other academic contexts.
   □ My own experience and knowledge.
   □ Recommendations from friends or colleagues.
   □ Recommendation from students.

Block II. Digital competence

(1=Very bad, 2=Bad, 3=Good, 4=Very good)

Area 1: Information and data literacy

	1	2	3	4
I find relevant and interesting sources of information for the teaching.				
I am aware of the restrictions of published copyrighted educational resources.				
I evaluate the quality of the online educational resources for accuracy and consistency with the curriculum.				
I use social media to organize resources for teaching purposes.				

Area 2: Communication and collaboration

	1	2	3	4
I create digital work environments to communicate with my students.				
I organize interaction activities through digital tools and share these activities with information accompanied by images, links and videos.				
I select educational content and resources that are found in different social media and virtual communities.				
I identify digital services according to their educational usefulness.				
I participate in virtual communities and social networks actively for the purpose of updating and achieving professional development.				
I use a variety of digital media to generate resources and knowledge in collaboration with other teachers or with my students.				
I participate actively in collaborative network projects.				
I teach students to recognize cultural diversity and appropriate behavior in various digital contexts depending on the target audience.				
I help students learn how to manage their digital identity				
I update my professional teaching profile reflecting the educational tasks that I carry out.				

Area 3: Digital content creation

	1	2	3	4
I create websites where multimedia educational contents adapted to the learning needs of students are published.				
I rework digital sources and turn them into new and creative digital content, and I can license them appropriately.				
I reuse the digital content of virtual teaching communities creatively.				
I know the regulations that apply to the use of online educational materials and I know how to license my own digital production.				
I tailor the advanced features of digital media to students' personal learning styles and interests.				

Area 4: Security

	1	2	3	4
I update and protect my devices frequently.				
I know how my private data is collected and used.				
I maintain an active attitude in managing and protecting my own digital identity and that of my students.				
I know and I can apply prevention protocols for social and psychological conflict situations in the use of digital media.				
I know the positive and negative effects of the use of technology on the environment.				

Area 5: Problem solving

	1	2	3	4
I can solve non-complex technical problems with the help of a manual or available technical information.				
I can critically evaluate the different possibilities that digital environments, digital tools and digital services could provide to solve teaching work related tasks.				
I can use technologies to analyze my daily work needs and manage innovative solutions.				
I try to use emerging digital technologies to help me keep up with the times and to fill possible gaps in the digital competence that I need for my teaching and professional development.				

Block III. The use ICTs in education

Area 1. Using ICTs

(1=Very bad, 2=Bad, 3=Good, 4=Very good)

Assess your level of proficiency in the following computer systems/programs/applications:	1	2	3	4
E-mail				
Forums				
Chat				
Videoconferencing				
Social networking				
Collaborative networking tools				
Information search tools				
Office Tools				
Image editors				
Audio editors				
Video editors				

Content creation tools				
Learning Management Platforms				
Digital file management spaces				
Social bookmarking				
Institutional repositories				
Real-time response systems				
Content management systems				
Source management and citation review tools				
Match detection tools				
Screen capture tools				
Audiovisual content platforms				
Tools for creating questionnaires				

Area 2. Frequency of using ICTs

(1=Never, 2=Seldom, 3=Often, 4=Very often)

Assess how often you use the following computer systems/programs/applications:	1	2	3	4
E-mail				
Forums				
Chat				
Videoconferencing				
Social networking				
Collaborative networking tools				
Information search tools				
Office Tools				
Image editors				
Audio editors				
Video editors				
Content creation tools				
Learning Management Platforms				
Digital file management spaces				
Social bookmarking				
Institutional repositories				
Real-time response systems				
Content management systems				
Source management and citation review tools				
Match detection tools				
Screen capture tools				
Audiovisual content platforms				
Tools for creating questionnaires				

Block IV. Attitude towards ICTs in education

(1=Strongly disagree, 2= Disagree, 3=Agree, 4=Strongly agree)

The following is a series of statements about the use of ICT, please make your choice based on your real situation:	1	2	3	4
By integrating ICTs in my classes, students are more willing to learn.				
ICTs facilitate personal and detailed monitoring of each student in my class.				
The use of ICTs makes it easier for me to provide timely feedback to students.				
I have sufficient skills to search for, select and manage information available on the Internet.				
ICTs are an essential support for collective knowledge building activities in networks and learning communities.				
ICTs favor the development of educational projects that promote self-learning.				
ICTs favor the development of educational projects that promote collaborative learning				
ICTs favor the development of research activities involving students.				
ICTs favor the dissemination of educational projects.				
ICTs facilitate self-evaluation of teaching activities.				
ICTs facilitate the improvement of teaching activity.				
ICTs facilitate the generation of innovative educational strategies.				
ICTs are essential for lifelong learning.				
ICTs facilitate the analysis of students' academic performance.				
I am clear about the goals I want to achieve with regard to the use of ICTs in my teaching work.				
I consider the use of ICTs to be fundamental in the work and professional development of teachers.				

Appendix F.

Data from research on university teachers

Table F1

Teachers' socio-demographic characteristics

	Number	Mean
Age	536	38.69
Gender		**%**
Man	208	38.8
Woman	328	61.2
Teaching experience		
Less than 5 years	138	26
5-9 years	106	20
10-19 years	177	33
20-29 years	86	16
More than 30 years	29	5
Supervisor for postgraduate or doctoral students		
Yes	110	20.5
No	426	79.5
Number of courses taught		
One	103	19.2
Two	154	28.7
Three	145	27.1
Four or more	134	25
Type of courses taught (Multiple choice)		
Compulsory professional courses	377	70.3
Professional Elective Courses	231	43.1
Public Courses	170	31.7
Public Elective Courses	46	10.4
Others	49	9.1
Previous training related to digital competence and the use of ICTs		
Yes	378	70.5
No	158	29.5
Approaches to further developing digital competence		
Traditional class	64	11.9
Online class	128	23.9
Seminar	167	31.2
Self-study	177	33
Motivations for using ICTs (Multiple choice)		
Friends' or colleagues' recommendation	187	34.9
Review of studies or experiences presented in other academic	262	48.9
Personal experience and knowledge	438	81.7
Students' recommendation	67	12.5
Job requirements	127	23.7

Table F2

Descriptive results of teachers' digital competence

		Mean	Standard Deviation (SD)	Very bad	Bad	Good	Very good
Information and data literacy	I find interesting sources of information for the teaching.	2.88	0.634	3.0	17.9	67.4	11.8
	I am aware of the restrictions of published copyrighted educational resources.	3.05	0.665	2.1	13.6	61.8	22.6
	I evaluate the quality of the online educational resources for accuracy and consistency with the curriculum.	2.88	0.649	3.0	19.2	57.1	20.7
	I use social media to organize resources for teaching purposes.	2.96	0.719	3.0	16.8	65.5	14.7
Communication and collaboration	I create digital work environments to communicate with my students.	2.92	0.655	3.0	16.8	65.5	14.7
	I organize interaction activities through digital tools and share these activities with information accompanied by images, links and videos.	3.00	0.670	1.5	17.9	59.7	20.9
	I select educational content and resources that are found in different social media and virtual communities.	3.02	0.641	1.1	16.0	62.3	20.5
	I identify digital services according to their educational usefulness.	2.86	0.683	2.6	23.5	59.3	14.6
	I participate in virtual communities and social networks actively for the purpose of updating and	2.72	0.736	4.7	30.8	52.2	12.3

	achieving professional development.						
	I use a variety of digital media to generate resources and knowledge in collaboration with other teachers or with my students.	2.80	0.692	3.2	26.5	57.6	12.7
	I participate actively in collaborative network projects.	2.62	0.716	5.2	36.2	50	8.6
	I teach students to recognize cultural diversity and appropriate behavior in various digital contexts depending on the target audience.	2.82	0.687	3.2	24.4	59.3	13.1
	I help students learn how to manage their digital identity	2.58	0.719	6.7	35.1	51.3	6.9
	I update my professional teaching profile reflecting the educational tasks that I carry out.	2.89	0.608	1.7	19.4	67.0	11.9
Digital content creation	I create websites where multimedia educational contents adapted to the learning needs of students are published.	2.23	.807	19.2	43.3	33.0	4.5
	I rework digital sources and turn them into new and creative digital content, and I can license them appropriately.	2.58	.767	7.6	36.0	46.8	9.5
	I reuse the digital content of virtual teaching communities creatively.	2.41	.761	10.4	44.2	39.0	6.3
	I know the regulations that apply to the use of online educational materials and I know how to license my own digital production.	2.50	.781	11.2	34.5	47.6	6.7
	I tailor the advanced features of digital media to	2.49	.799	10.3	39.4	41.2	9.1

	students' personal learning styles and interests.						
Safety	I update and protect my devices frequently.	2.65	.757	6.3	33.4	49.4	10.8
	I know how my private data is collected and used.	2.87	.682	2.6	22.8	59.7	14.9
	I maintain an active attitude in managing and protecting my own digital identity and that of my students.	2.90	.701	3.7	18.8	61.2	6.2
	I know and I can apply prevention protocols for social and psychological conflict situations in the use of digital media.	2.74	.704	5.0	26.1	58.8	10.1
	I know the positive and negative effects of the use of technology on the environment.	3.00	.601	1.9	12.3	69.6	16.2
Problem solving	I can solve non-complex technical problems with the help of a manual or available technical information.	2.82	.667	3.5	22.0	63.1	11.4
	I can critically evaluate the different possibilities that digital environments, digital tools and digital services could provide to solve teaching work related tasks.	2.68	.676	3.9	32.1	56.0	8.0
	I can use technologies to analyze my daily work needs and manage innovative solutions.	2.68	.680	4.1	22.1	55.8	8.0
	I try to use emerging digital technologies to help me keep up with the times and to fill possible gaps in the digital competence that I need for my teaching and professional development.	2.72	.683	3.9	29.3	57.5	9.3

Table F3

Descriptive results of teachers' uses of ICTs

Teachers' uses of ICTs	Mean	Standard Deviation (SD)	Very bad	bad	Good	Very good
E-mail	3.44	0.580	0.4	3.3	48.5	47.8
Forums	2.62	0.807	8.8	32.8	46.5	11.9
Chat	3.38	0.612	0.9	4.1	51.1	43.9
Videoconferencing	2.68	0.817	8.2	30.0	47.6	14.2
Social networking	2.46	0.918	16.2	35.3	35.1	13.4
Collaborative networking tools	2.15	0.820	21.8	46.3	26.7	5.2
Information search tools	3.29	0.624	1.5	4.6	57.1	36.8
Office tools	3.23	0.599	0.9	6.2	61.6	31.3
Image editors	2.51	0.820	10.5	39.0	39.9	10.6
Audio editors	2.33	0.829	16.1	42.5	34.1	7.3
Video editors	2.24	0.823	18.3	45.5	29.9	6.3
Content creation tools	2.76	0.797	6.5	26.9	50.6	16.0
Learning Management Platforms	2.29	0.836	17.7	42.7	32.7	6.9
Digital file management spaces	2.62	0.799	8.0	33.8	46.1	12.1
Social bookmarking	2.11	0.825	23.7	46.5	24.6	5.2
Institutional repositories	3.03	0.763	4.1	15.1	54.1	26.7
Real-time response systems	2.08	0.799	24.6	46.8	24.8	3.8
Content management systems	2.14	0.827	23.5	43.1	28.9	4.5
Source management and citation review tools	2.10	0.856	25.4	45.3	22.8	6.5
Match detection tools	2.42	0.878	16.2	36.0	37.7	10.1
Screen capture tools	3.18	0.706	2.8	9.0	55.2	33.0
Audiovisual content platforms	3.02	0.741	3.7	15.1	56.4	24.8
Tools for creating questionnaires	2.41	0.883	15.7	39.0	34.1	11.2

Table F4

Descriptive results on the frequency of teachers' uses of ICTs

Frequency of teachers' uses of ICTs	Mean	Standard Deviation (SD)	Never	Seldom	Often	Very often
E-mail	3.57	0.696	0.7	9.7	21.5	68.1
Forums	2.45	1.018	20.3	33.5	27.2	19.0
Chat	3.76	0.582	1.1	4.3	12.5	82.1
Videoconferencing	2.50	1.001	18.8	30.8	31.7	18.7
Social networking	2.34	1.103	28.5	29.5	21.1	20.9
Collaborative networking tools	1.86	0.959	46.5	28.5	17.5	7.5
Information search tools	3.66	0.650	0.8	7.6	16.2	75.4
Office Tools	3.81	0.471	0.2	2.8	12.9	84.1
Image editors	2.58	0.999	14.7	35.1	27.2	23.0
Audio editors	2.28	0.953	22.6	39.7	25.0	12.7
Video editors	2.21	0.960	26.5	37.9	24.2	11.4
Content creation tools	3.07	1.023	9.9	19.2	24.6	46.3
Learning management platforms	2.18	1.081	35.3	27.8	21.1	15.8
Digital file management spaces	2.63	1.043	15.3	33.4	23.9	27.4
Social bookmarking	1.82	0.978	49.8	26.1	15.9	8.2
Institutional repositories	3.35	0.890	5.0	13.1	23.7	58.2
Real-time response systems	1.76	0.962	53.7	23.7	15.3	7.3
Content management systems	1.92	1.041	47.0	24.8	17.0	11.2
Source management and citation review tools	1.91	1.054	48.3	24.7	14.9	12.1
Match detection tools	2.32	0.956	21.5	38.4	26.9	13.2
Screen capture tools	3.33	0.846	3.5	14.0	28.2	54.3
Audiovisual content platforms	3.17	0.859	3.6	19.2	34.1	43.1
Tools for creating questionnaires	2.15	0.971	31.2	32.3	27.0	9.5

Table F5

Descriptive results of teachers' attitudes towards the use of ICTs in education

Teachers' attitudes towards the use of ICTs in education	Mean	Standard Deviation (SD)	Strongly disagree	Disagree	Agree	Strongly agree
By integrating ICTs in my classes, students are more willing to learn.	2.97	0.626	1.3	17.4	64.7	16.6
ICTs facilitate personal and detailed monitoring of each student in my class.	2.99	0.585	0.6	15.7	67.5	16.2
The use of ICTs makes it easier for me to provide timely feedback to students.	3.06	0.539	0.6	10.0	72.4	17.0
I have sufficient skills to search for, select and manage information available on the Internet.	3.16	0.517	0.4	5.6	72.0	22.0
ICTs are an essential support for collective knowledge building activities in networks and learning communities.	3.11	0.535	0.6	7.6	71.8	20.0
ICTs favor the development of educational projects that promote self-learning.	3.06	0.589	1.1	11.0	68.3	19.6

ICTs favor the development of educational projects that promote collaborative learning	3.10	0.531	0.9	6.9	73.7	18.5
ICTs favor the development of research activities involving students.	3.04	0.571	0.9	11.6	70.1	17.4
ICTs favor the dissemination of educational projects.	3.14	0.521	0.5	6.0	72.8	20.7
ICTs facilitate self-evaluation of teaching activities.	3.00	0.582	0.6	15.3	67.9	16.2
ICTs facilitate the improvement of teaching activity.	3.01	0.594	0.9	14.2	67.5	17.4
ICTs facilitate the generation of innovative educational strategies.	3.04	0.588	1.5	11.0	69.8	17.7
ICTs are essential for lifelong learning.	3.10	0.574	1.1	8.6	69.4	20.9
ICTs facilitate the analysis of students' academic performance.	3.10	0.552	0.7	8.6	70.9	19.8
I am clear about the goals I want to achieve with regard to the use of ICTs in my teaching work.	3.06	0.538	0.8	9.3	72.9	17.0
I consider the use of ICTs to be fundamental in the work and	3.12	0.547	0.9	6.7	71.5	20.9

professional development of teachers.						

Appendix G.

Questionnaire for university students

University of Salamanca

Block I. Socio-demographic data

1. Age: ___

2. Gender:
   Male □ Female □

3. Do you live in a rural or urban area?
   Rural area □ Urban area □

4. What's your major:
   □ Liberal arts
   □ Science
   □ Engineering
   □ Agronomy
   □ Management
   □ Economics

5. What is your grade?
   First year □ Fourth year □

6. Why did you choose this major?
   □ Development prospects
   □ Personal preference
   □ Major reputation
   □ Others

Block II. Availability of technological resources

7. Do you have Internet connection on your equipment and devices?
   Yes □ No □

8. If you have these equipment and devices in your home or student dormitory?

	Yes	No
Desktop		
Laptop		
Mobile hard drives		
Mobile phone		
Tablet		
Smart TV		

9. Do you have Internet access available on campus?
   Yes □ No □

10. Are the following equipment and devices available in your school or faculty?

	Yes	No
Desktop		
Laptop		

Mobile hard drives		
Smart TV		

Block III. Potential for digital competence development

11. How often do you use the Internet?
    - □ Every day, several times a day
    - □ Every day
    - □ Several times a week
    - □ Occasionally
    - □ I do not normally use the Internet

12. What device do you usually use to connect to the Internet?
    - □Desktop
    - □Mobile phones
    - □Tablet
    - □Various, depending on time and situation

13. What's your motivations for using ICTs? (Multiple choice)
    - □For entertainment
    - □For academic activities
    - □For work activities
    - □For management and administration activities
    - □As a communication tool (Internet)
    - □As a tool for sharing (documents, photos)
    - □Self-training/self-assessment
    - □Others

Block IV. ICT and digital competence related training

14. Have you received past training on digital competence and ICTs?
    Yes □ No □

15. How do you further develop your digital competence?
    - □Self-study
    - □School courses
    - □Seminar
    - □Group study

16. Have you participated in virtual classes?
    Yes □ No □

17. Have you taken and passed the National Computer Rank Examination (NCRE)?
    - □Level 1
    - □Level 2
    - □Level 3
    - □Level 4
    - □Not taken or passed

Block V. Digital competence

Area 1. Information and data literacy

	1	2	3	4
I use ICTs to search, locate, select, organize, evaluate, process, store, transform, disseminate, cite and communicate information.				
I use specialized search engines and meta-search engines with various mechanisms (Identify keywords, synonyms and related terms, search in more than one language...).				
I understand different sources of information and can build search strategies correctly based on them.				
I analyze and comment critically on information, data sources and digital content, verify the validity and timeliness of the information located.				
I apply different methods and tools to manage and store information, data and digital content for easy retrieval.				
I have my own strategy to organize and retrieve information and data.				

Area 2. Communication and collaboration

	1	2	3	4
I communicate and interact through a variety of digital devices and applications (SMS, email, cloud, QQ, WeChat, video conferencing).				
I participate in social networks, collaborative platforms and online communities where I share knowledge, multimedia content and information.				
I collaborate through the Internet with other people in my educational or professional field that form my personal learning network (PLN).				
I engage with society through online participation (social, political, cultural, administrative action) and am aware of the potential of technology for citizen participation.				
I use digital technologies and media for teamwork.				
I use technology and collaboration tools to plan, execute and share monitoring of activities and projects.				
I participate in learning activities such as MOOCs through collaborative environments.				
I am familiar with the rules of conduct online or in the virtual world, such as being friendly, respecting people's privacy and being careful with my language.				
I stay up to date with ethics regarding internet use.				
I take care to remind my family and friends of the basic rules of behaviors on the Internet.				

I know how to create and manage a public, personal and professional profile on social media.				
I am able to manage several digital identities depending on the objective or context.				
I pay attention to what I post online and I know how to protect my digital reputation and/or that of others.				

Area 3. Digital content creation

	1	2	3	4
I use a variety of tools and software to create multimedia content in a variety of formats.				
I am able to use different media and methods to present ideas in a creative way.				
I am able to edit, modify, improve and combine existing resources to create new and relevant content and knowledge.				
I understand the basic knowledge and laws of intellectual property and the licensing of information and digital content when working with ICTs.				
I know the basics of digital processes; understand the principles of programming and what is behind a program.				
I make modifications to computer programs, applications, configurations and equipment as needed				

Area 4. Safety

	1	2	3	4
I understand the risks associated with the use of online tools and devices.				
I protect my equipment and multimedia content.				
I keep my data security and protect my personal privacy.				
I understand the health risks associated with the use of related technologies.				
I prevent and avoid physical and mental health threats when using the Internet and multimedia devices, such as poor sitting posture and cyberbullying.				
I know the positive and negative aspects associated with the use of technology on the environment.				
I apply basic measures to save energy, recycle devices and protect the environment.				

Area 5. Problem solving

	1	2	3	4
I am familiar with the operation of digital devices and am able to identify possible technical problems.				
I solve daily technical problems.				
I evaluate and select appropriately a tool, device service to perform my tasks and meet my needs.				
I keep myself updated on new developments and emerging technology trends, and innovate using digital technology.				
I use various methods such as text, images and audio to make my expression more creative and innovative.				
I actively attend events and workshops on digital creation, and participate in collaborative multimedia and digital projects.				

Block VI. Attitude towards ICTs

(1=Strongly disagree, 2= Disagree, 3=Agree, 4=Strongly agree)

	1	2	3	4
I find it easy to use ICTs.				
I am interested in ICTs.				
I think that the theoretical training received to use ICTs is sufficient.				
It is easy to get access to technological resources.				
I think that the existing equipment at my university is sufficient.				
The resources available in my university are sufficient with regard to quality.				
Students are used to using ICTs in their learning activities.				
ICTs provide an essential support for students' activities.				
ICTs significantly improve students' learning.				
ICTs promote knowledge creation.				
ICTs promote students' autonomous learning.				
ICTs enhance collaborative learning.				
ICTs facilitate self-assessment.				
ICTs promote communication between students and teachers.				

Appendix H.

Data from research on university students

University of Salamanca

Table H1

Students' socio-demographic characteristics

	Number	**Mean**
Age	5164	20.15
Grade		**%**
The first year	3136	60.7
The fourth year	2940	56.9
Gender		
Man	2224	43.1
Woman	2940	56.9
Residential area		
Rural	3634	70.5
Urban	1530	29.5
Major		
Liberal arts	1117	21.6
Science	644	12.5
Engineering	615	11.9
Agronomy	1875	36.3
Management	693	13.4
Economics	220	4.3
Reason for choosing major		
Development prospects	851	16.5
Personal preference	1093	21.2
Major reputation	452	8.8
Others	2768	53.6

Table H2

Descriptive results of students' availability of technological resources

Availability of technological resources			
		Number	**%**
Connectivity of equipment			
Yes		5044	97.7
No		120	2.3
Owned equipment and devices at home or in the dormitory			
Desktop	Yes	1465	28.4
	No	3699	71.6
Laptop	Yes	3710	71.8
	No	1454	28.2
Mobile hard drives	Yes	2105	40.8
	No	3059	59.2
Mobile phone	Yes	4944	95.7
	No	220	4.3
Tablet	Yes	1257	24.3
	No	3907	75.7
Smart TV	Yes	2510	48.6
	No	2654	51.4
Campus networking			
Yes		5029	97.4
No		135	2.6
Equipment and devices available in faculty			
Desktop	Yes	4005	77.6
	No	1159	22.4
Laptop	Yes	3447	66.8
	No	1717	33.2
Tablet	Yes	2043	39.6
	No	3121	60.4
Smart TV	Yes	2525	48.9
	No	2639	51.1

Table H3

Descriptive results of students' potential for digital competence development

Potential for digital competence development		
	Number	**%**
Frequency of connecting to the Internet		
Every day, several times a day	2777	53.8
Every day	2070	40.1
Several times a week	114	2.2
Occasionally	115	2.2
I do not normally use the Internet	88	1.7
Devices connected to the network		
Desktop	141	2.7
Mobile phones	3788	73.3
Tablet	13	0.3
Various, depending on time and situation	1222	23.7
Motivations for using ICTs (Multiple choice)		
For entertainment	2029	39.3
For academic activities	4509	87.3
For work activities	3043	58.9
For management and administration activities	830	16.1
As a communication tool (Internet)	1673	32.4
As a tool for sharing (documents, photos)	2035	39.4
Self-training/self-assessment	963	18.6
Others	866	16.8

Table H4

Descriptive results of students' ICT and digital competence related training

ICT and digital competence related training		
	Number	**%**
Past training on digital competence and ICTs		
Yes	2557	49.5
No	2607	50.5
Methods of further developing digital competence		
Self-study	1933	37.4
School course	3050	59.1
Seminar	122	2.4
Group study	59	1.1
Virtual classes participation experience		
Yes	3887	75.3
No	1277	24.7
Level of computer usage (NCRE)		
Level 1	183	3.5
Level 2	773	15.
Level 3	20	0.4
Level 4	18	0.3
Not taken or passed	4170	80.8

Table H5

Descriptive results of students' digital competence

		Mean	Standard Deviation (SD)	Very bad	Bad	Good	Very good
Information and data literacy	I use ICTs to search, locate, select, organize, evaluate, process, store, transform, disseminate, cite and communicate information.	2.76	0.722	6.9	20.5	62.6	10.1
	I use specialized search engines and meta-search engines with various mechanisms (Identify keywords, synonyms and related terms, search in more than one language...).	2.96	0.687	3.8	14.5	63.9	17.8
	I understand different sources of information and can build search strategies correctly based on them.	2.71	0.738	6.2	27.3	55.7	10.7
	I analyze and comment critically on information, data sources and digital content, verify the validity and timeliness of the information located.	2.66	0.743	7.0	29.3	54.3	9.4
	I apply different methods and tools to manage and store information, data and digital content for easy retrieval.	2.69	0.738	6.5	28.0	55.5	10.1
	I have my own strategy to organize and retrieve information and data.	2.68	0.758	7.4	27.2	54.8	10.5

Communication and collaboration	I communicate and interact through a variety of digital devices and applications (SMS, email, cloud, QQ, WeChat, video conferencing).	3.00	0.661	3.2	12.2	66.0	18.6
	I participate in social networks, collaborative platforms and online communities where I share knowledge, multimedia content and information.	2.80	0.718	5.0	22.5	59.7	12.8
	I collaborate through the Internet with other people in my educational or professional field that form my personal learning network (PLN).	2.71	0.740	6.6	26.7	56.3	10.4
	I engage with society through online participation (social, political, cultural, administrative action) and am aware of the potential of technology for citizen participation.	2.79	0.698	4.8	22.8	61.2	11.2
	I use digital technologies and media for teamwork.	2.80	0.692	4.6	22.4	61.7	11.3
	I use technology and collaboration tools to plan, execute and share monitoring of activities and projects.	2.71	0.728	6.0	27.4	56.4	10.2
	I participate in learning activities such as MOOCs through collaborative environments.	2.72	0.734	6.2	26.4	56.9	10.5
	I am familiar with the rules of conduct online or in the virtual world, such as being friendly, respecting people's privacy and being careful with my language.	3.05	0.687	3.0	12.1	61.6	23.3

	I stay up to date with ethics regarding internet use.	3.06	0.660	2.7	10.7	64.4	22.1
	I take care to remind my family and friends of the basic rules of behaviors on the Internet.	3.03	0.656	2.6	12.3	64.5	20.6
	I know how to create and manage a public, personal and professional profile on social media.	2.87	0.716	4.5	19.6	60.5	15.4
	I am able to manage several digital identities depending on the objective or context.	2.81	0.730	5.2	22.2	58.8	13.8
	I pay attention to what I post online and I know how to protect my digital reputation and/or that of others.	3.09	0.661	2.6	10.2	63.1	24.0
Digital content creation	I use a variety of tools and software to create multimedia content in a variety of formats.	2.55	0.732	7.7	36.6	49.1	6.7
	I am able to use different media and methods to present ideas in a creative way.	2.58	0.721	6.8	35.6	50.6	7.0
	I am able to edit, modify, improve and combine existing resources to create new and relevant content and knowledge.	2.58	0.722	7.0	34.6	51.5	6.9
	I understand the basic knowledge and laws of intellectual property and the licensing of information and digital content when working with ICTs.	2.63	0.726	6.5	32.6	52.8	8.2
	I know the basics of digital processes; understand the principles of programming	2.50	0.759	9.4	38.5	45.2	6.9

	and what is behind a program.						
	I make modifications to computer programs, applications, configurations and equipment as needed.	2.45	0.784	11.7	37.9	43.7	6.7
Safety	I understand the risks associated with the use of online tools and devices.	2.83	0.691	4.7	19.8	63.3	12.2
	I protect my equipment and multimedia content.	2.81	0.695	4.3	22.5	61.1	12.1
	I keep my data security and protect my personal privacy.	2.90	0.672	3.5	17.2	64.5	14.7
	I understand the health risks associated with the use of related technologies.	2.94	0.666	3.1	16.1	64.5	16.4
	I prevent and avoid physical and mental health threats when using the Internet and multimedia devices, such as poor sitting posture and cyberbullying.	2.95	0.669	3.3	15.0	64.8	16.9
	I know the positive and negative aspects associated with the use of technology on the environment.	2.95	0.659	3.1	15.3	65.5	16.1
	I apply basic measures to save energy, recycle devices and protect the environment.	2.91	0.674	3.5	17.0	64.4	15.0
Problem solving	I am familiar with the operation of digital devices and am able to identify possible technical problems.	2.57	0.755	8.1	35.1	48.7	8.2
	I solve daily technical problems.	2.62	0.728	6.6	33.0	52.3	8.1

	I evaluate and select appropriately a tool, device service to perform my tasks and meet my needs.	2.71	0.698	5.3	27.5	58.6	8.7
	I keep myself updated on new developments and emerging technology trends, and innovate using digital technology.	2.57	0.747	7.7	35.9	48.5	7.9
	I use various methods such as text, images and audio to make my expression more creative and innovative.	2.69	0.706	5.3	29.6	56.2	8.8
	I actively attend events and workshops on digital creation, and participate in collaborative multimedia and digital projects.	2.60	0.736	7.4	32.9	52.1	7.7

Table H6

Descriptive results of students' attitudes towards ICTs

Students' attitudes towards ICTs	Mean	Standard Deviation (SD)	Strongly disagree	Disagree	Agree	Strongly agree
I find it easy to use ICTs.	2.67	0.669	3.9	32.3	56.4	7.4
I am interested in ICTs.	2.92	0.582	2.4	14.1	72.7	10.8
I think that the theoretical training received to use ICTs is sufficient.	2.61	0.688	4.8	36.6	51.6	7.0
It is easy to get access to technological resources.	2.69	0.668	3.9	31.0	57.4	7.7
I think that the existing equipment at my university is sufficient.	2.71	0.667	4.5	27.4	60.6	7.5
The resources available in my university are sufficient with regard to quality.	2.70	0.672	4.7	28.2	59.8	7.3
Students are used to using ICTs in their learning activities.	2.89	0.594	2.8	15.7	71.7	9.8
ICTs provide an essential support for students' activities.	2.94	0.582	2.5	12.8	73.2	11.5
ICTs significantly improve students' learning.	2.91	0.595	2.7	14.5	72.0	10.8
ICTs promote knowledge creation.	2.92	0.589	2.6	13.9	72.4	11.1

ICTs promote students' autonomous learning.	2.88	0.607	2.8	16.5	70.3	10.4
ICTs enhance collaborative learning.	2.92	0.588	2.5	14.1	72.4	11.0
ICTs facilitate self-assessment.	2.91	0.591	2.6	14.3	72.3	10.8
ICTs promote communication between students and teachers.	2.91	0.603	2.7	15.1	70.8	11.4